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The purpose of *the Oikos - The Zimbabwe Ezekiel Guti University Bulletin of Ecology, Science Technology, Agriculture and Food Systems Review and Advancement* is to provide a forum for scientific and technological solutions based on a systems approach and thinking as the bedrock of intervention.

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Contents

Oikos: Insights into Science, Technology and Societal Advancement

EDITORIAL

Abstract

The article seeks to explain the meaning and understanding of Oikos within the science, technology and advancement in Zimbabwe. It is derived from '*oikos*', a Greek word which means different things to different people depending on the context, environment, cultural context and country. A desktop review and contextual and textual analysis were used. There is a need for education in universities to advance and enhance science and technology in the global future. It argues that there is a need for innovation and a good behaviour relationship between African youth and technology in the 21st century.

Keywords: knowledge; innovation; education; Africa; relationship and habitation

INTRODUCTION

Oikos means "habitation" and -ology manner "the look at of". So ecology commenced because of the study of where things live. The phrase has been interchangeably used with the environment. *Oikos* is a monthly peer-reviewed medical magazine overlaying studies on the subject of ecology. It is published using Wiley-Blackwell on behalf of the Nordic Foundation Oikos. Since 2011, Dries Bonte has been the editor-in-chief (Ghent University, 2011). Oikos is ancient Greek for the household(Nobis and Wohlgemuth, 2004; Wals, 2019; Borisova, 2015; Farmer, 2017; Nobis and Wohlgemuth, 2004; Wals, 2019)

INTERPRETATIONS CONSIDERING THE CHANGING WORLD

The American Association for the Advancement of Science (AAS), has the capacity to apply clinical information and techniques of analysing for non-public and public purposes. The argument is that our picks within the application of technical expertise are intricately tied up to dangers and benefits, social change-offs, fee judgment and

compromise. Scientific literacy involves the capability to use medical understanding daily. Therefore, technological literacy is an accessory to clinical literacy as this involves a better comprehension of cutting-edge technology, its capacities, scope and boundaries, fundamental principles, theories and social impact. This knowledge of technology can better be grasped through the philosophy of schooling if one wants to sanitise, compare and analyse scientific concepts, theories, legal guidelines and generalisations. It will enhance standard ethics and good judgment of medical and technological development. With its vital nature, the philosophy of schooling will help engineer a kind of medical and technological improvement that will be socially and culturally relevant and accountable. It will also encourage important wondering within the scientists and technologists to pass a protracted way to reshape their awareness.

The Southern African Development Community (SADC) Protocol on Science, Technology and Innovation was discussed in 2008 to improve systems. It stresses the significance of technology and generation for accomplishing sustainable and equitable socio-monetary growth and poverty eradication. To promote sustainable science, research and improvement in Africa, the most critical and strategic element is in appointing schooling and educational institutions as critical equipment closer to this purpose (Ekenam *et al.*, 2010). This is anchored on the logic that the sustained prosperity of a state depends on the level and state of its training gadget. Education empowers people and maximises countrywide highbrow assets to sustain social and financial development for the benefit of many. The study advocates for the power usage of training and educational institutions for the attainment of sustainable improvement through science and technology studies.

International technological knowledge had been included in human culture. As a basic social manner, science and generation have become vital in the 21st century. Therefore, the social justification for his or her development has been both highbrow and cloth. Through science, a man is supposed to have a better understanding of nature, surroundings and society. They also are speculated to liberate man from the chain of superstition and lack of awareness. Technology began to "offer us absolute management over the cloth global". From

this, 'man' obtained total liberation "from tough work, starvation and poverty" (Umoren, 1996). Despite the guarantees of science and technology, Africa remains an insignificant spectator in the crucial sphere of human endeavour. This is due to the high illiteracy charge (lack of right education) in African nations, inclusive of Nigeria, Niger, Burkina Faso, Kenya, Ethiopia and Cameroon, among others. Some troubles have to do with conceptual and cultural practices that have hampered and frustrated efforts made at bringing about scientific and technological development in African international locations.

There is a dearth of the best quantity of technical, clinical, professional and managerial employees to implement such programmes. As a result, maximum African international locations like Nigeria according to Umoren (1996) are at risk, due to societal erosion with the aid of the rising tide of mediocrity, posing a fundamental risk to the future of the continent. She argues that since Africa is generating a scientifically and technologically illiterate population, Africa cannot obtain technological development. This should result in what Umoren (1991) defined as a lack of knowledge or worry about technological knowledge and technology. To lack such in the 21st Century leads to the production of techno-peasant residents who, according to Prewitt as quoted via Umoren (1997), are people bewildered and intimidated using brand-new strategies and languages of technology and technology.

The creation of the information primarily based economic system has purchased knowledge important and research has indicated a correlation between advanced understanding and aggressive gain as postulated by Teece *et al*. (1997) in their look at dynamic managerial competencies. They recommend that aggressive gain is properly decided with the aid of the organisational talents and centre competencies and their applications in place of the differences in enterprise characteristics (Pugh, 2016). The concept then is to mix the specialised understanding embedded in people otherwise referred to as human capital, with precise organisational activities to permit innovation (Hill *et al.*, 2014). Thus, technological competencies (TCs) are now stated as a vital useful resource for advanced overall performance. An assessment of the technology age in Africa ranked Zimbabwe 54th inside the era achievement index (TAI), which is very

low considering that studies have proven that the TCs region is key to monetary boom and the benefits and consequences of world technological advances are growing (Pugh, 2016). The TAI displays the ranges of technological progress and capability in phrases of the creation of technological capabilities. This is the potential to innovate, the diffusion of recent innovations, the diffusion of current innovations and the human skills essential for generation improvement. Little is understood about the improvement of TCs on account that Zimbabwe's financial woes began in the year 2000, which saw several businesses close down (Teece *et al.*, 1997; Pugh, 2016).

The Ministry of Science and Technology Development and its portfolio changed 2013 to a new setup, the Department of Science and Technology in the Ministry of Higher and Tertiary Education, Innovation, Science and Technology Development (Kraemer–Mbula and Scerri, 2015). In 2013, the authorities accepted four countrywide studies priorities proposed by the Research Council of Zimbabwe:

- The social sciences and humanities.
- Sustainable environmental and resource management.
- Promoting and maintaining good health; and
- The national security of Zimbabwe.

Zimbabwe has a long research tradition dating back a century. History has been affected by the Zimbabwean economic crisis that has led to an exodus of university students and professionals in key areas of expertise (medicine, engineering and so on) (*ibid*.). More than 22% of Zimbabwean tertiary students were completing their degrees abroad in 2012 in comparison to a 4% average for sub-Saharan Africa as a whole (Lemarch and Schneegans, 2014).

DIMENSION AND SCOPE

A fundamental need for improvement of technology,research and national development is to set up a sound instructional system (Ekenam *et al.*, 2010). This instructional device ought to be anchored on a valid philosophical basis that encourages partnership for change of humans, thoughts and guide facilities. Universities and studies institutes in extraordinary African international locations ought to enhance their relevance to society through the improvement of partnerships with the local people, enterprises and country-wide

research facilities (Kraemer–Mbula and Scerri, 2015). Educational institutions ought to be open to satisfy the needs of neighbourhood industries, humans, and the environment, updating their research programmes and sports to satisfy the practical needs of society. Local studies and improvement should be as selective as possible with the intention of managing scarce assets (Umoren, 1996).

With a legitimate philosophy of schooling, medical and technological research and pastimes are refocused closer to the enhancement of the situations of lifestyles. It will help to test the detrimental inclinations of some sciences and technologies. The philosophy of schooling directed at bringing about a brand-new clinical subculture in African countries will go a long way to preserve the continent's herbal surroundings (Ekenam *et al.*, 2010). -New scientists and IT specialists could be knowledgeable to obey the herbal legal guidelines and maintain its concepts. Life in the new techno-lifestyle will be sacred and no longer concerned with experimentation based totally on trial and error techniques.

Traditional interpretations of the format of the *oikos* in Classical Athens were divided into male and female spaces with an area called the *gynaikon* or *gynaikonitis* women's chores that include cooking and textiles (Andrianos, 2018) and a place for men referred to as the *andron*. It has been argued that, instead of dividing the household area into "male" and "female" spaces, it is best to look at areas as being non-private or open to all. In this model, access to the private areas is reserved for the family while public areas are for visitors (Farmer, 2017). Initially, the *kyrios* of an *oikos* might have been the husband as head of the family. However, when a son came of age, he became the *kyrios* (Foxhall, 1989). A new *okios* was formed when a son received their inheritance from their fathers upon the death of the father of before (Patterson, 2009). Therefore, a new oikois would have been shaped in every age and would continue to be perpetuated through marriage and childbirth.

The Second Science and Technology Policy cites sectorial regulations focasing on biotechnology, data and conversation technology (ICTs), space sciences, nanotechnology, indigenous knowledge structures,

technologies yet to emerge and medical solutions to emergent environmental challenges (Lemarchand, and Schneegans, 2014). The policy makes provisions for setting up a National Nanotechnology Programmeme. Zimbabwe has a National Biotechnology Policy that dates back to 2005 (Maclurcan, 2005). Despite poor infrastructure and a lack of human and financial assets, biotechnology studies are better established in Zimbabwe than in maximum sub-Saharan African locations. s. The Policy asserts that the authorities dedicate a minimum of 1% of GDP to Gastroesophageal reflux disease (GERD), focusing a minimum of 60% of college education on growing talents in science and technology and ensuring that faculty students commit at least 30% of their time to study technological topics (Kraemer–Mbula and Scerri, 2015).

Zimbabwe has a rather nicely-developed countrywide infrastructure and a long-status way of life of promoting research and improvement (R&D) as evidenced by the levy imposed on tobacco growers (Lemarch and Schneegans, 2014). To accomplish international appeal, Zimbabwe will need a high level of accuracy in some of the structural weaknesses. Although the infrastructure is in the vicinity to harness R & D to Zimbabwe's socio-economic improvement, universities and studies institutions lack the monetary and human sources to promote R&D and the present-day regulatory surroundings hinder the transfer of the latest technologies to the business sector (Kraemer–Mbula and Scerri, 2015; Maclurcan, 2005).

The improvement timetable for 2018, the Zimbabwe Agenda for Sustainable Economic Transformation, excluded targets for increasing the wide variety of scientists and engineers, or the staffing requirements for industry and other effective sectors. The lack of coordination and coherence among governance structures has also brought about a multiplication of research priorities and negative implementation of current regulations (Lemarch and Schneegans, 2014).

Schooling turns into a condition- sine-qua-non for the improvement of the technological era. This calls for massive training considering the requirements of the 21st century where people ought to"have the savvy

to explore, recognise and to some degree control their destiny inside the society", that is redesigned by way of technology. There is a desire for this schooling to have a philosophical base on the way to define the focal point of the brand-new clinical and technological society. This education will sell and recommend medical literacy and the practical software of clinical information to result in societal development.

Science and technology improvement is a vital condition for the non-violent social improvement of the African continent. The sustainability of technological improvement calls for human and economic sources. This education demand which is taken as a condition-sine-qua-non for sustainable development of technology ought to be based on a philosophy of training so one can help to reshape and refocus medical and technological improvement. This is anchored on the importance of information in the improvement of society and the financial system, that technological knowledge plays a pivotal role.

REFERENCES

Lemarchand, G. A., Schneegans, Susan (eds) (2014). *Mapping Research and Innovation in the Republic of Zimbabwe* (PDF). Paris: UNESCO. pp. Volume 2. GO-SPIN Profiles in Science, Technology and Innovation.

Kraemer-Mbula, E., Scerri, M. (2015). Southern Africa. In: UNESCO Science Report: Towards 2030 (PDF). Paris: UNESCO. pp. 535–555.

Teece, D.J. (2010). *Technological Innovation and the Theory of the Company: The Role of Enterprise-Level Knowledge, Complementarities, and Dynamic Capabilities*. London: Elsevier

Andrianos, L. A. (2018). Ecumenical Theology of Hope for the Common Oikos and the Greed Line as the Principle of Sustainability. *The Ecumenical Review, 70*(4), 600-616.

Baker, C. M. (1997). *Rebuilding the house of Israel: Gendered bodies and domestic politics in Roman Jewish Galilee, c. 135-300* CE. Duke University

Farmer, J. A. (2017). One or Two Things I Know About Us: Narrative Strategies for Autoethnography, Self-Representation and Healing in Four Memoirs by Poor-white Women from the US South.

Fowlkes, D. W. & Verster, P. (2006). Family (oikos) Evangelism for reaching forward caste Hindus in India. *Verbum et ecclesia, 27*(1), 321-338.

Green, M. (2004). Evangelism in the early church. Wm. B. Eerdmans Publishing.

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. International Journal of science education, 29(11), 1347-1362.

American Association for the Advancement of Science. (1994). Benchmarks for science literacy. Oxford University Press.

Ekanem, S. A., Ekanem, R. S., Ejue, J. B., & Amimi, P. B. (2010). Science and technology research for sustainable development in Africa: the imperative of education. African Research Review, 4(3).

Kraemer–Mbula, E., & Scerri, M. (2015). 20. Southern Africa, UNESCO SCIENCE REPORT.

Foxhall, L. (1989). Household, gender and property in classical Athens. The Classical Quarterly, 39(1), 22-44.

Patterson, C. B. (2009). The family in Greek history. Harvard university press.

Maclurcan, D. (2005). Nanotechnology and Developing Countries–Part 2: What Realities? Online Journal of Nanotechnology, 1.

Nobis, M., & Wohlgemuth, T. (2004). Trend words in ecological core journals over the last 25 years (1978–2002). Oikos, 106(2), 411-421.

Wals, A. E. (2019). Sustainability-oriented ecologies of learning: A response to systemic global dysfunction. In Ecologies for Learning and Practice (pp. 61-78). Routledge.

Borisova, T. (2015). On the Problem of the Transmission and the Ensuing Adoption of the Byzantine Acrostic in the Early Ecclesiastical Slavonic Hymnography. Fragmenta Hellenoslavica, 2, 113-136.

Hill, L. A., Brandeau, G., Truelove, E., & Lineback, K. (2014). Collective genius: The art and practice of leading innovation. Harvard Business Review Press.

Pugh, L. (2016). Change management in information services. Routledge.

The Impact of Water Shortages on the Provision of Education: A Case Study of Secondary Schools in Norton Urban, Zimbabwe

ONIAS MUSANIWA, GODFREY JAKACHIRA, BERNARD CHINGWANANGWANA AND PFUURAI CHIMBUNDE[1]

Abstract

Zimbabwean urban areas have been experiencing erratic water supplies for some years, impacting negatively on the livelihoods of its people. The study sought to establish the impact of water shortages on the provision of education in Norton, Zimbabwe. Water shortages have affected Norton residents for years and the need to understand the impact of water shortages on the provision of education in secondary schools influenced the researchers to carry out this study. This qualitative case study was informed by the Sustainable Livelihoods Approach (SLA). Purposive sampling was used to come up with a sample of 15 participants, comprising learners and teachers. Data were generated through semi-structured interviews and focus group interviews which were analysed thematically. The findings of the study established that the failure by the council to supply adequate water to schools has resulted in a lack of drinking water and poor sanitation. The study further revealed learners travel long distances in search of alternative sources of water, hence a lot of valuable time is lost. It also emerged that water shortages have disrupted agricultural activities in schools despite the introduction of Agriculture as a compulsory subject.

Keywords: water, urbanity, agriculture, health, emancipation

INTRODUCTION

Water is a basic human right and access to it is very important for development. Access to water promotes human development as it is in

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line with one of the Sustainable Development Goals (SDGs), Goal 6. This goal aims to increase the effectiveness of water utilisation across all sectors and ensure a sustainable supply of fresh water to address water shortages and reduce the number of people suffering from these shortages by 2030 (United Nations, 2018). Despite this projection, there is a prevalent phenomenon that the world is experiencing an increasing water crisis affecting the well-being of millions of people. Fast-growing populations, urbanisation, agricultural expansion and climate change all contribute to greater competition and inadequacy of water resources (Abraha, Tibebu & Ephrem, 2022; Mulwa, Zhuo & Fanginou, 2021). A study by Choi, Chong, Kim & Ryu (2016) in Korea established that about four billion people, nearly two-thirds of the population of the world, face severe water scarcity and over two billion live in countries experiencing high water stress. Furthermore, Malik, Yaser, and Abubakar (2012) assert that despite the massive increase in the provision of water facilities over the past few decades, large numbers still suffer from water-related diseases including the physical, social and economic burdens associated with water scarcity. From another point of view, UNICEF and the WHO (2012) estimated that one billion people worldwide are without reliable supplies of water and over two billion lack basic sanitation. In addition, Nayar (2013) argues that, against a global investment of over $15 billion in water, 1.1 billion people are without clean drinking water, 2.6 people lack adequate sanitation and 1.8 million die yearly from water-related diseases. Thesestatistics show the gravity of the phenomenon under study.

Water scarcity limits access to safe water for drinking and for practising basic hygiene at home, in schools and healthcare facilities. When water is scarce, sewage systems fail and the threat of contracting diseases like cholera, increases (Kunguma, 2009). This water shortage is a puzzle to the urban population that depends on water supply from the municipality. Water shortages have had several negative impacts. They generally result in strict water rationing, further causing an increase in diseases such as typhoid, dysentery and cholera as people are not able to flush their toilets.

Most studies done so far have a thrust on the factors influencing water shortages in urban areas and the impact on the populace in general. A study by Gambe and Dube (2015) focused on water woes in Harare,

Zimbabwe and the implications on gender and policy. Research done by Mangizvo *et al.* (2016) explored the vulnerability and resilience in the face of water shortages in Mkoba 19 in Gweru City, Zimbabwe. Gondo, *et al.* (2020) analysed factors influencing domestic water consumption in Karoi, Zimbabwe. Another research undertaken by Museum (2021) looked at urban struggles over water scarcity in Harare. Thus the research sought to explore the impact of water shortages on the provision of education in secondary schools in Norton Urban, Zimbabwe, in light of the introduction of the competence-based curriculum. There has been little attention on the impact of water shortages on the provision of education in urban areas hence the study explores this phenomenon in the provision of education in secondary schools in Norton Urban, Zimbabwe.

THEORETICAL FRAMEWORK

The SLA improves the understanding of people's livelihoods (Serrat, 2017). It draws on the main factors that affect poor people's livelihoods and the common links between these issues. The SLA is used as a mapping instrument to improve the understanding of people's livelihoods and focuses on factors that affect human development. The SLA framework focuses on the organisational factors that inhibit or improve livelihood opportunities and demonstrates how they associate with one another. The approach does not replace other tools involved in development but makes the connection between people and the conducive environment that influences the outcomes of the livelihood strategies (*ibid*.).

The SLA identifies five types of assets, namely human, social, natural, physical and financial capital. According to Serrat (2017), human capital comprises skills, education, knowledge, competencies to work, nutrition and good health. Good health and nutrition are considered to be prerequisites for sustainable livelihoods. In the context of this study, for education to be fully implemented, learners need to have good nutrition and be in a state of good health. Furthermore, the scholar views social capital as the resources people utilise to make a living that embraces relationships that may begin within the family to the community at large, either formally or informally. The approach also identifies natural capital as one of the assets people use comprising

land, forests, waterand air, among others, in shaping livelihoods. In line with this study, this may imply that inadequate water supplies may have a negative bearing on the provision of education. Physical capital is one of the key assets in sustaining livelihoods which incorporate transport, communication, energy, shelter, waterand sanitation systems (*ibid.)*. In this study, this may mean that insufficient water and sanitary provision may affect the effective implementation of the curriculum in schools. Finally, access to financial resources has been noted as the other basic tenet of the SLA, referred to as financial capital. Sufficient financial resources boost the livelihoods of people. If these assets are fully met, there will be positive livelihood outcomes noticed with the sustainable use of resources, high incomes, good well-being, less vulnerability and food security. The opposite is true if the assets are not fully met in terms of water supply which may affect the provision of education as their health could be impacted and there could be food insecurity and high levels of vulnerability.

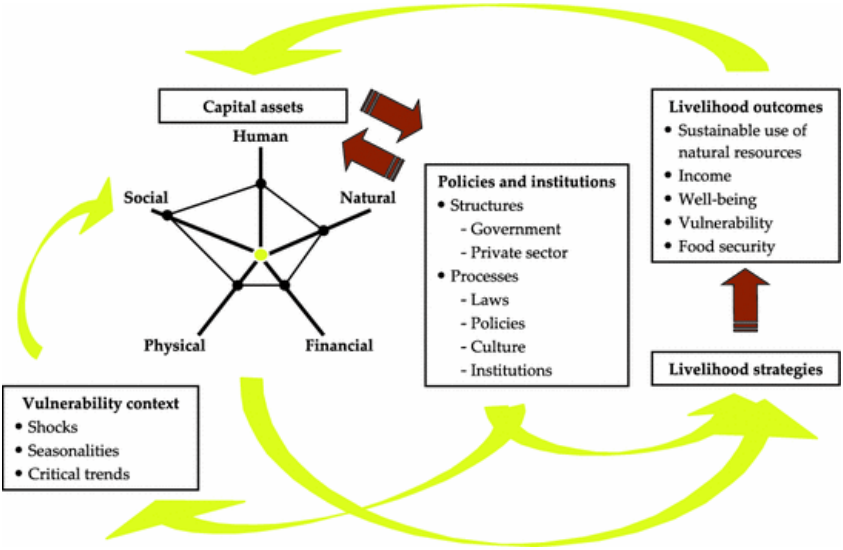

Figure 1: The sustainable livelihoods approach in diagram form; Adapted from Serrat (2017) The Sustainable Livelihoods Approach

The sustainable livelihood approach in Figure 1 shows the main components of SLA and how they are connected. It promotes people's

access to sustainable use of the resources for poverty reduction and encourages understanding of coping strategies that can be used in the community to eradicate the stresses of a certain problem. Thus, the study aims at establishing the impact of water shortages on the provision of education.

IMPORTANCE OF WATER

Dinka (2018) asserts that water is connected to every form of life on earth. This implies that water is essential for society's development and for maintaining health systems. Water sustains domestic activities such as cooking, sanitation, washing, livestock rearing, crop production and brick moulding. A study by Makwara and Tavuyanago (2012) in six urban councils in Zimbabwe indicated that water is important in promoting the Millennium Development Goal (MDG) of eradicating extreme poverty and hunger as access to water enhances agricultural productivity. Water is very essential for agricultural activities as it will enhance development in the communities. Hove and Tirimboi (2011) in their study conducted in Harare, show how important water is to human life as they pointed out that several deaths in Zimbabwe are because of water shortages in many towns. The shortage of enough clean water has led to the outbreak of communicable diseases like cholera, typhoid and diarrhoea which makes water to be a basic necessity as it reduces the outbreak of such water-borne diseases. Also, when there is enough water, they will be good health service delivery in hospitals and improved sanitation in communities.

Several factors have been linked to the shortage of water in urban centres. Some of the notable causes attributed to this phenomenon are urban population increase, financial constraints, interference in local governance and changing climatic conditions.

In a study done by Musemwa (2008) in Bulawayo, water shortages have been attributed to an increase in the urban population as people migrate from the rural provinces in search of employment. It is significant to note that as the number of people increases and incomes rise, there will be an upward trend in water demand. The United Nations (2017) established that the world's population was at 7.5 billion and was projected to add 2.3 billion more people by 2050. Water

shortages occur when water demand is higher than the capacity water of accessible in cases when there is an increase in population (Nhlanhla, 2020). This shows that water shortages are increased by rapidly growing urban areas which place pressure on water sources. The existing water purification infrastructure becomes overwhelmed with the ever-rising urban population as the demand outstrips supply. Financial challenges have contributed much to water shortages in urban centres. Most of the chemicals for the treatment of water are imported and very expensive, resulting in a huge challenge for a country facing extreme foreign currency shortages. Harare's water supply comes from Lake Chivero and it is extremely polluted with raw sewage and requires a large number of chemicals for treatment (Makwara and Tavuyanago, 2012). Due to financial constraints, urban councils have failed to refurbish old water processing plants and even expand them. Hove and Tirimboi (2011) assert that water shortages in urban areas are due to old and dilapidated infrastructure since most cities draw their water from reservoirs that were constructed way before Zimbabwe attained independence. This has resulted in the leaking of water pipes due to age and they were not renewed.

Political interference in the governance of local authorities and lack of political will have contributed to the shortage of water in towns and cities. This is supported by Makwara and Tavuyanago (2012) who state that the political situation in Zimbabwe from 2000 to the present day, has seriously affected service delivery. The study by Nhapi (2009) in Harare found that locals believed that councillors lacked the knowledge to improve the entire urban service delivery system, particularly the appalling water situation in various municipalities. Furthermore, Nhapi (*ibid.*) indicated that Harare cannot overcome its water problem under the current setting as it has failed to increase rates to economic levels owing to heavy lobbying by residents and interference by the government. Large amounts of money are allocated to the water sector, including foreign aid and are often either embezzled or completely stolen through corrupt practices (Chiremba, 2010). This reflects mismanagement by authorities, which impacts negatively critical services such as the provision of adequate safe water, worsening the plight of residents in terms of service delivery.

Changing climate conditions have culminated in severe water shortage crises of. The ever-changing climate conditions have caused water shortages that have negative effects on human health due to inadequate water supplies for drinking, farming and bathing (Abedin, *et al.*, 2019; World Health Organisation, 2009). Resultantly, people suffer from communicable diseases such as diarrhoea, dysentery and cholera due to health risks associated with climate-related water shortages. In addition, WaterAid (2012) postulates that when natural disasters such as floods, storms, cyclones, poor rainfall, sea level rise and droughts occur, it affects supply systems of water and contaminates water sources. This affects individuals as they become victims of the enduring crises of water shortages for drinking and domestic uses. Also, high temperatures and weather conditions affect the availability and distribution of rainfall, river flows and groundwater, further weakening water quality (United Nations, 2020). This implies that the frequently changing weather patterns have a negative bearing on water supplies for various household and commercial uses.

THE IMPACT OF WATER SHORTAGES

Sanitation issues range from the management of human waste from households and safe food handling before distribution. A large number of people die each year from water sanitation and hygiene-related diseases which could be reduced with access to safe water or sanitation. Lack of clean water increases the risk of diarrhoeal diseases such as cholera, typhoid, fever and dysentery and other water-borne tropical diseases (WHO, 2022; Mangizvo *et al.,* 2016). Water scarcity can also lead to diseases such as trachoma (an eye infection that can lead to blindness), plague and typhus (WHO, 2021). Water shortages in urban centres expose learners in schools to the mentioned diseases which may impact negatively the provision of education. The prevalence of water shortages has resulted in high levels of absenteeism among girls during their monthly periods, becoming a barrier to education for girls already facing huge obstacles (UNICEF, 2022). Not only limited to that but Jéquier and Constant (2010) state frequent lack of drinking water also is not healthy as it results in general body weakness. This condition, emanating from lack drinking of water, impacts on teaching and learning process. Improved water,

sanitation and hygiene practices lead to improved health for the general populace. It reduces disease, malnutrition and injury from water collection and stress.

Seasonal and chronic water scarcity is identified as a key challenge to Africa's development effort (UNESCO, 2019). The depletion of several aquifers and climatic changes are further threats to water availability and agricultural productivity (*ibid.*). In school settings, Chikoore and Bowora (2011) assert that agriculture lessons were hardest hit by the shortages as they required more water for their practical tasks to be sustainable, forcing teachers to theorise the teaching. Reliable access to water in sufficient quantities and quality for a healthy life is critical for agricultural food production, creating an enabling environment for good nutrition.

The impact of water insecurity is greatly reflected in the increased stress that people have to endure to get water during periods of scarcity. In times of water scarcity, particularly in low-income countries, women and girls often have to walk long distances to search for clean water to enable them to perform their daily household chores (UNICEF, 2021). According to UNICEF (2016), a study of 24 sub-Saharan countries established that when the collection time is more than 30 minutes, an estimated 3.36 million children and 13.54 million adult females were responsible for water collection. Furthermore, it emerged from a study done by Arku (2010) in Ghana that water sources generally were located about two to four kilometres away from the participants' homes with women and girls having to travel on foot to collect water. Burdened daily by water collection, women and girls spend large amounts of time carrying heavy vessels and walking long distances. This affects learners in schools as reinforced by UNICEF (2022) in that, time spent collecting water is time away from school, thereby denying girls a chance to build a better future. Under such circumstances, the provision of education may be compromised.

RESEARCH METHODOLOGY

The study adopted the qualitative research approach in exploring the impact of water shortages on the provision of education in secondary schools. The researchers generated data from teachers and learners

who were experiencing the impact of water shortages in the teaching and learning process. In this study, data were generated from two selected secondary schools. Therefore, the bigger the number of cases involved in a study, the larger the variation across cases and the more credible the research results are (Gustafsson, 2017) on the impact of water shortages on the provision of education. Through the adoption of the multi-case design, the researchers were able to generate in-depth data that gave a reflection of the research problem. The study population comprised five secondary schools, all secondary school teachers and learners in the Norton Urban Cluster. Non-probability purposive sampling was used to select the two secondary schools, five teachers and 10 learners.

RESULTS

SANITATION AND HEALTH CHALLENGES

The study revealed that as a result of persistent water shortages, learners in secondary schools are subjected to poor sanitation which culminated in various health challenges. The participants noted the outbreak of diseases such as typhoid, cholera and dysentery. According to the participants, this situation resulted in high levels of absenteeism among learners, impacting negatively their academic performance. It was also found that some girls miss school due to poor sanitation during their menstrual period. One of the teachers had this to say, 'The critical water shortages have affected the provision of education as sometimes there are outbreaks of communicable diseases like typhoid which greatly affect school attendance.' Furthermore, one of the learners asserted, 'With the continuous shortage of water at our school, sometimes learners are affected by dysentery and when I am experiencing my monthly period, I choose not to go to school.

In addition, one School Head stated, 'Due to the prevalent water shortages at our school, learners are exposed to poor sanitation as toilets may go for days without being cleaned exposing learners to diseases hence we sometimes send them back home early".

The views proffered by the participants indicate that the shortage of water in urban areas has a negative bearing on the effective provision

of education in secondary schools due to poor sanitary conditions that culminate in the outbreak of diseases. This concurs with the views of the WHO (2022) and Mangizvo *et al*. (2016) who point out that these shortages expose learners to diseases resulting in high levels of absenteeism. A critical analysis indicates that an inadequate supply of water in urban secondary schools has become a barrier to the effective provision of education. Good water supplies result in better health and therefore better school attendance, with positive longer-term consequences for their lives. Concerning the SLA under the physical assets, adequate supplies of water and sanitation systems have a positive impact on the livelihoods of people. Furthermore, the SLA states that good health is basic for the attainment of positive livelihoods as noted in the human capital asset. However, in the context of this study, it implies that the shortage of water and sanitary systems affects the proper provision of education as learning and teaching are always disrupted due to health hazards to which learners are exposed.

DISRUPTED AGRICULTURAL ACTIVITIES

It emerged from the study that water shortages experienced in urban areas have also affected the full implementation of the competence-based curriculum which has a thrust in agriculture. The participants revealed that the teaching and learning of agriculture have become a challenge as a result of these water shortages as learners cannot fully undertake practical activities such as gardening and poultry production. To support this view, one of the teachers asserted that, 'With the recurring water crisis, the teaching of agriculture has become more theoretical, compromising the implementation of the competence-based curriculum.' One learner lamented, 'We are no longer carrying out practical tasks in agriculture because of lack of water to sustain the activities, hence focusing much on theory.' Another teacher had this to say, 'The persistent shortage of water in urban schools has forced schools to abandon agricultural projects that are a source of revenue to supplement levies paid by parents.'

The researchers noted that with the high prevalence of water shortages in urban schools the implementation of a competence-based

curriculum has been compromised taking into consideration the fact that practical activities cannot be sustained without adequate water.

Chikoore and Bowora (2011) reinforce this by highlighting that agriculture lessons were the most affected by the shortages as they required more water for their practical tasks to be sustainable, forcing teachers to theorise the teaching. This implies that learners produced by the education system will not be fully equipped with skills in line with the expectations of hands-on experience, hence they cannot be fully self-reliant. It can be argued that the intended learning outcomes are affected by the lack of water. Under human capital, the SLA asserts that education, knowledge, skills and competencies are critical in attaining good livelihoods. This has not been fully achieved due to water shortages as the facilitators have resorted to more theorising the teaching without practical lessons in agriculture, thereby impacting the acquisition of knowledge, skills and competencies to work. The SLA also mentions high income as one of the outcomes of fully met assets. However, with the disruption of agricultural activities due to water shortages, schools have lost in terms of revenue generation, compromising the provision of education, as they will be less revenue to procure teaching and learning materials.

TIME WASTAGE IN SEARCH OF WATER

The study found that a lot of time is lost in search of water by the learners before and after school. It was revealed that this is the case because the learners walk long distances to fetch water from other sources. Resultantly, prime learning time is lost as they spend it searching for water making them lose lessons as they are late for school. Fatigue from the long search for water impacts the learners' performance as they come to school tired meaning that their concentration level will be very low. The study further established that learners absent themselves from school as they travel long distances in search of water. To substantiate this, one of the learners pointed out that, 'I get up as early as four in the morning to fetch water from wells and boreholes before going to school and sometimes I miss lessons as I return home late due to long queues.'

Another learner concurred by stating, 'I go for long distances in search of water. By the time you arrive home, you will be very tired and you always get to school late missing some subjects.' One teacher echoed that, 'With these perennial water shortages in urban schools, most learners come to school late or never attend school as time is wasted searching for water.'

These situations have compromised the provision of education to secondary school learners as they are now spending much of their precious learning time searching for water for domestic use. This is supported by UNICEF (2022) which argues that time spent fetching water is time away from school thereby denying girls a chance to build a better future. Boys are not spared either. The performance of learners has been greatly affected to such an extent that low pass rates have been attained. If there were normal water supplies, such scenarios would not occur. This implores the relevant stakeholders to play a pivotal role in addressing the challenges associated with water shortages to ensure adequate provision of education. Education has been viewed as critical in human capital in the SLA in improving the livelihoods of people. In the context of this study, the provision of education has not been well addressed as a result of the water shortages as learners absent themselves from school or arrive late after walking long distances in search of water, resulting in tiredness.

LACK OF DRINKING WATER

The study established that water shortages in urban areas have resulted in a lack of drinking water in secondary schools. With this lack of drinking water, academic performance has been affected as learners are subjected to high levels of dehydration which make them weak resulting in low concentration levels, especially when temperatures are too high. Under such circumstances, learners are not motivated to learn. One of the learners echoed, 'The supplies for drinking water are erratic so much that we are exposed to dehydration which makes us weak to pay attention in class.' A teacher from one of the selected secondary schools asserted that 'With the short supply of drinking water most of the learners show signs of poor concentration in lessons which result in low pass rates.' The responses from the participants indicate that inadequate drinking water in schools

interferes with learning to an extent that desired academic results are not attained. In health terms, a lack of adequate drinking water is not tolerated.

This is in agreement with the views proffered by Jéquier and Constant (2010) who state that insufficient drinking water results in. Due to fatigue, learners cannot focus much on learning affecting their performance in school work. In line with the informing theory under human capital, good health is a must for better livelihoods. However, in this study, it has been noted thatwater shortages have resulted in a lack of drinking water which has affected the well-being of learners and has a bearing on their learning.

CONCLUSION AND RECOMMENDATIONS

The study concluded that the persistent water shortage in urban areas has, to a larger extent, affected the provision of education in schools. This has been noticed through poor sanitation where learners are sometimes sent back home early to guard against disease outbreaks as toilet facilities would be unusable, thereby losing precious learning time. In some instances, learners are exposed to diseases, leading to absenteeism. In addition, lack of drinking water makes learners lose concentration during lessons as they become exhausted leading to the attainment of weak passes. Furthermore, the researchers noticed that, at a point where agriculture has been introduced as a compulsory subject from primary school to tertiary level, the teaching has been more of theory as practical tasks cannot be carried out. This is due to the incessant water shortages resulting in learners failing to acquire the basic skills for self-sustenance.

RECOMMENDATIONS:

- The Ministry of Primary and Secondary Education (MoPSE) should introduce a programmep that ensures that every school has a permanent reliable source of safe and clean water to avert challenges associated with the provision of quality education.
- Schools should partner with local authorities and the corporate world to ensure that they have access to adequate safe and clean water for sanitation, drinking and sustainable

agricultural projects in line with the competence-based curriculum.

- School Development Committees should come up with initiatives that call for permanent solutions to the supply of water in schools such as the provision of high-capacity water reservoirs to facilitate effective teaching and learning.
- Non-Governmental Organisations should be engaged in the drilling of boreholes and provision of water reservoirs in schools to ensure constant supplies. This will create a friendly teaching and learning environment for the attainment of learning outcomes.
- MoPSE should constantly team up with the Ministry of Health, Child Care and Welfare in monitoring the sanitary conditions caused by the shortage of water to alleviate disease outbreaks that impact learner performance.

REFERENCES

Abedin, M.A., Collins, A.E., Habiba, U. & Shaw, R. (2019). Climate change, water scarcity and health adaptation in South Western Coastal Bangladesh. *International Journal of Disaster Risk Science*, 10:28-42.

Abraha T, Tibebu, A and Ephrem, G. (2022) Rapid Urbanization and the Growing Water Risk Challenges in Ethiopia: The Need for Water Sensitive Thinking. *Front. Water* 4:1-19.

Arku, F. S. 2010. "Time Savings from Easy Access to Clean Water: Implications for Rural Men's and Women's Well-Being."*Progress in Development Studies* 10:233-246.

Braun, V., Clarke, V. & Terry, G. (2014).In Rohleder P. & Lyons A. (Eds.).*Qualitative Research in Clinical and Health Psychology: Thematic Analysis*. London: Macmillan. Briggs. 45-113.

Chikoore, M.R. & Bowora, J. (2011).The impact of water shortages on educational delivery in selected schools in Harare East District.*Zimbabwe Journal of Educational Research*,23(3): 259-275.

Chiremba, T. (2010). Probe Team Exposes Kadoma Corruption. *The Sunday Mail*, Zimbabwe. (Sunday, March 14).

Choi,G.W., Chong,K.Y., Kim, S.J &Ryu,T.S. (2016). SWMI: New paradigm of water resources management for SDGs. Smart Water,1(3):1-12.

Dinka, M.(2018). Safe drinking water: Concepts, benefits, principles and standards. *IntechOpen*, 163-182.

Evangelinou-Yiannkis, A. (2017). A reflection on the methodology used for a qualitative longitudinal study. *Issues in Educational Research*, 27(2): 269-284.https://www.iier.org.au/iier27/evangelinou

Flick, U. (2019).*Introduction to qualitative research.*6th ed. Thousand Oaks: SAGE.

Gambe, T.R. & Dube, K. (2015). Water woes in Harare, Zimbabwe: Rethinking the implications on gender and policy. *International Journal of Innovative Research & Development*, 4(6):390-397.

Gondo, R., Ponchi-Tshekiso, N.D. Mogomotsi, P.K, Mogomotsi,G.E.J.&Chirefu, H. (2020). Analysis of factors influencing domestic water consumption in Karoi Town, Zimbabwe.*Journal of Sustainable Development*, 13(2):82-97.

Gustafsson, J. (2017). Single case studies vs multiple case studies: A comparative study. Halstad: Halstad University.

Hesse-Biber, S. N & Leavey, P. (2011).*The practice of qualitative research*. 2nd ed. Thousand Oaks: SAGE.

Hove, M. & Tirimboi, A. (2011).Assessment of Harare water service delivery. Journal of Sustainable Development in Africa, 13(4): 61-84.

Jéquier, E and Constant, F.(2010).Water as an essential nutrient: the physiological basis of hydration.*European Journal of Clinical Nutrition*, 64(2):115-23.

Kliot, I. (2005). Improved indicators of water use performance and productivity for sustainable water conservation and saving. *Agric. Water Manag. 108*:39–51.

Kunguma, J. (2009). Irrigation water management policies: Allocation and pricing principles and implementation experience. *Nat. Resour. Forum,28*, 112–122.

Makwara. E.C. & Tavuyanago, B.(2012). Water woes in Zimbabwe's urban areas amid plenty: 2000-present. *European Journal of Sustainable*, 1(2): 151-180.

Malik, A., Yaser, A.,Tabinda, A.B & Abubakar, M.(2012). A water-borne disease, cost of illness and willingness for disease interventions in rural communities of developing countries. *Iranian Journal of Public Health*, 41(6):39-49.

Mangizvo,R.V., Mupfuuri, E. & Mashaka, C.(2016). Vulnerability and resilience in the face of water shortage: The case of Mkoba 19 in Gweru city, Zimbabwe. *International Journal of Development and Sustainability*, 5(1):27-43.

Mulwa, F., Zhou, L. & Fangninou, F. (2021).Water scarcity in Kenya: Current status, challenges and future solutions. *Open Access Library Journal*, 8:1-15.

Musemwa, M. (2008). *The politics of water in post-colonial Zimbabwe, 1980-2007*. Johannesburg. University of Witwatersrand.

Musemwa, M. (2021). Urban struggles over water scarcity in Harare. *The Journal of American Academy of Arts & Sciences*, 150(4):27-47.

Nayar, V. (2013). The water crisis – Rethinking water governance. *Journal of Land and Rural Studies,* 1(1), 75-94. doi:10.1177/23210

Nhapi, I. (2009). The water situation in Harare, Zimbabwe: A policy and management problem. *Water Policy*, 11:221-235.

Nhlanhla, M,2020.*Water scarcity in SA: A result of physical or economic factors?*https://www.politicsweb.co.za/opinion/water-scarcity-in-sa-a-result-of-physical-or-econo

Serrat, O. (2017). The Sustainable Livelihoods Approach.*Knowledge Solutions: Springer*: 21–6.

Taherdoost, H. (2016). Sampling methods in research methodology. How to choose a sampling technique for research. *International Journal of Academic Research in Management (IJARM)*, 5(2)18-27.https://seahipaj.org/journals-ci/dec-2020/IJIPSD/full

UNICEF & WHO.(2012). *Progress on drinking water and sanitation*. New York: UNICEF and WHO.

UNICEF. (2021). Water scarcity: Addressing the growing lack of available water to meet children's needs. https://www.unicef.org/wash/water-scarcity

UNICEF.(2016).Collecting water is often a colossal waste of time for women and girls. https://www.unicef.org/press-releases/unicef-collecting-water-often-colossal-waste-time-women-and-girls

United Nations .2018. The 2030 Agenda and the Sustainable Development Goals: An opportunity for Latin America and the Caribbean. Santiago: United Nations

United Nations. (2017). *The world population is projected to reach 9.8 billion in 2050 and 11.2 billion in 2100*.https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html

United Nations. (2020). The United Nations World Water Development Report: Water and climate change. Paris: UNESCO.
UNSECO.(2019). *World Water Assessment Programmeme*. Paris: UNESCO.
WaterAid. 2012. Handbook on climate change and disaster resilient water, sanitation and hygiene practices. Dhaka: WaterAid in Bangladesh.
WHO. 2009. Protecting health from climate change: Global research priorities. Geneva: WHO.
WHO. (2021). *Overview (Water*).https://www.afro.who.int/node/5707
WHO.(2022).*Drinking-water*.https://www.who.int/news-room/fact-sheets/detail/drinking-water
Yin, R. K. 2018. Case study research and applications: Designs and methods. 6th ed. London: SAGE.

COVID-19 and the Work-Life Balance in Zimbabwe Private Sector Companies

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Abstract

The Coronavirus disease of 2019 (COVID-19) has resulted in the creation of a new and complex business environment. Labour markets were interrupted and this ignited an enormous and instant series of trials and testing with flexible work arrangements and new relationships. Research to date has emphasized work-life balance (WLB) in the work and family domains only, whilst overlooking the effects of a pandemic as posed by COVID-19. Henceforth existing knowledge on remote working can be questioned in an extraordinary context. The study aimed to investigate the impact of COVID-19 on the WLB in the post-pandemic period and beyond. It also aimed at exploring the projected abnormalities that are driving a foreseeable future policy revolution in the world of work and employment. The study utilised the qualitative research approach. A survey research design was used to select research participants. Snowballing purposive sampling was also used to get further referrals. The research study included 100 white-collar private-sector employees who completed an online questionnaire. Data were presented and discussed qualitatively. The study revealed that although hybrid and flexible work arrangements would be more central in the post-pandemic for non-manual work, it will not be an "one-sizefits-all solution. The traditional work systems and practices are likely to continue and workplaces will not completely disappear. In addition, those who are engaged in manual labour will continue current work practices with increased

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demands. Employers' focus on employees' WLB in the new normal will target employees' motivation and achieve a better WLBe. The study recommended that new policies for crisis management and Hybrid work culture should be developed and implemented, especially for office workers. Government must also set aside funds or provide aid to private sector companies to prevent future crises.

Keywords: diversity, remote working, working from home, pandemic

INTRODUCTION

The macroeconomic variables, ranging from political, economic, social and technological transformations are strong forces that radically transform many aspects of our lives and this includes the "work" environment where societies are often mandated to take proactive steps to adapt to the new norm to remain competitive. One crisis that reconfigured societies and economies was the Industrial Revolution. This revolution changed the way people lived and worked and it also established a Work-Life Balance (WLB). Similarly, the ongoing Coronavirus has produced and continues to produce notable changes in work, work practices and the relationship of workers to co-workers, companies, customers, communities, localities and WLB. As part of the ongoing efforts to curb the transmission of coronavirus disease and help to protect the health and safety of employees, public and private organisations have generally adopted preventive measures like remote work arrangements, social distancing, staggered working hours and other methods to reduce the presence of employees within work environment while also sustaining organisational activities (ILO, 2020).

Even though the above-named practices are now widespread globally, the application of these has not been uniform and consistently varying between countries, sectors, or industries. The practices also vary in terms of implementation and intensity. For example, in most private sectors, white-collar employees (those whose work involves mental work), have enjoyed the health protection of working from home while those engaged in physical activities had to continue reporting for work, often exposing them to greater health risks (ILO, 2020c).

Both public and private sector business endeavour to continuously improve and standardise their business operations and policies with modern-day requirements which aim to attract, motivate and retain employees. However, a lot still needs to be done in terms of the WLB and workplace flexibility. For most private sector companies, the core objective of setting up a business is for maximum profit. However, in pursuit of profit maximisation, private sector companies must not overlook the WLB for their workers in this 21st century. One notable change that from the COVID-19 pandemic is "remote working" across occupations (Kramer and Kramer, 2020). WLB is considered to be of great importance to private-sector businesses in Zimbabwe.

In times of calamity, strategic swiftness is required to ensure the achievement of organisational goals (Liu, Lee & Lee, 2020). Lee *et al.* (2020) emphasize that organisations must be proactive in resource allocation and coordination and utilise resources efficiently for the achievement of organisational goals. It is against this background that the uniqueness and the intricacy of COVID-19 presented a major challenge that compromised the achievement of organisational goals in private sector companies in Zimbabwe.

COVID-19 is a global public health emergency that resulted in lockdowns and disruptions of many businesses and people's livelihoods across the world (Muhammad, Khan, Kazmi, Bashir, Siddique, 2020). The consequences of the COVID-19 pandemic on the economic landscape, business environment, employment and the way people work have been far-reaching. According to the World Health Organisation (WHO) (2020), COVID-19 is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SAR-COV-2). The coronavirus was discovered in the Wuhan Province of China in 2019. Within a short space of time, the virus had rapidly spread worldwide due to the transit of people. It is transmitted from person to person when people breathe in air contaminated by droplets and small airborne particles containing the virus (Muhammad *et al.*, 2020). Transmission is more intense when people are near. However, the infection can occur over longer distances, particularly indoors (Pierantoni, Pierantozzi and Sargolini, 2020).

COVID-19 was declared a global pandemic by the WHO on 11 March 2020. Following the declaration, a state of disaster was proclaimed in Zimbabwe by President Dr. E.D. Mnangagwa on the 20th of March 2020. Early efforts to contain the pandemic were put in place in the form of lockdowns or travel restrictions and this had a resultantly negative effect on social gatherings and economic welfare (Gumbo, 2020). Gumbo further asserts that a national lockdown and prohibition of gatherings was legislated for 21 days, commencing 30 March 2020. Lockdowns were aimed at containing the rate of transmissions by buying time for public officials to enhance their health capacity systems and improve their preparedness to deal with the anticipated full impact of the pandemic (*ibid*..)

Globally, governments took varying degrees of action to mitigate the impact of COVID-19. It was in the midst of this storm that private sector companies suffered heavily due to the closure of their businesses. According to Mann (2014), the private sector exists to make a profit. Hence, the virus created an unfamiliar environment where their profits significantly dwindled whilst expenses ballooned. Furthermore, the pandemic created an exceptionally complex scenario for private sector employers, as they faced not only a severe economic downturn but also a sharp health and safety crisis requiring extraordinary steps to protect their employees from the virus (Elsafty and Ragheb, 2020).

LITERATURE REVIEW

THEORETICAL FRAMEWORK: SELF-DETERMINATION THEORY

The study utilised the Self -Determination Theory (SDT) of motivation to understand the rapid transformation and adaptation of employees to the COVID-19 crisis. The SDT is a motivational theory of personality, development and social processes that looks at how social contexts and individual differences facilitate different types of motivation, especially self-directed motivation and organised motivation and in turn predict learning, performance, experience and psychological health (Ryan and Deci, 2000). The theory proposes that all human beings have three basic psychological needs, namely the need for competence, autonomy and relatedness. This means workers,

apart from fulfilling their need for achievement, also need to strike a balance between work and social life. The satisfaction of the mentioned needs is essential for the efficient and effective functioning of the body toward achieving personal and organisational goals. This is because the satisfaction of these basic needs promotes maximum motivational characteristics and states of autonomous motivation and intrinsic aspirations, which facilitate psychological health and effective engagement with the world.

The use of the SDT for this study was essential because it enabled the researchers to understand how employees survived mentally during and after the pandemic. The theory attributes survival in a crisis to self-determination and discretion to make individual development choices.

THE EMERGENCE OF THE CONCEPT OF WORK-LIFE BALANCE

The concept of the WLB emerged as early as the 1970s when employees endeavoured to strike a balance between career, family and other areas of their lives. This concept also gave birth to 'telecommuting' where employees performed their work duties in different locations with the aid of technology. Telecommuting replaced work-related travelling and since the early 1970s, the term has gained popularity, especially in developed nations (Niles, 1997). Chung (2018) posits that the concept of telework gave birth to the notion of Working from Home (WFH).

DEFINITION: WORK-LIFE BALANCE

According to Cox (2018), WLB refers to how an employee finds the equilibrium point between different work roles and various aspects of life to achieve wellness. The WLBe, therefore, is a state where an employee enjoys maximum happiness, self-fulfilment and job satisfaction. Jyothi and Jyothi (2012) posit that it is achieving a balance between employees' family or personal life and work lives.

The work-life balance phenomenon is premised on the notion that a balance must be struck between one's work and social life for self-fulfilment. Jyothi and Jyothi (*ibid.*) argue that the WLB has a negative

or positive effect on an employee's performance. This means an imbalance between work and personal life can negatively affect productivity levels and also decrease an individual's performance (Konrad and Mangel, 2000) since employees are often stressed when they fail to meet company goals and family roles.

WORK STRESS

According to Kim *et al.* (2019), work stress refers to a condition that affects the emotions and cognitive processes of employees at the workplace. Workplace stress is, therefore, the gap between various job demands and available resources. If resources are short in supply, workers are likely to be negative and stressed. Consequently, workplace stress may cause role ambiguity, overwork, role conflict and time pressure during working from home, which can reduce job satisfaction (*ibid..*). Work stress is another key predictor that affects and has a significant effect on job satisfaction (Hsu *et al*. 2019).

BENEFITS OF WORKING FROM HOME WFH IN THE POST-PANDEMIC PERIOD

Research studies conducted in the United States unmasked that 37% of private sector jobs could be completed at home during the COVID-19 pandemic (Dingel and Neiman, 2020). Working from home in this country was possible for those offering financial services, professional mastery, business management and scientific services. However, some jobs in other sectors like health care, farming and hospitality suffered immensely since they could not be done at home. Although there has been a significant increase in WFH, academics still weigh the advantages and disadvantages of the concept.

Empirical evidence suggests that WFH has many advantages for companies in the private sector because it results in increased job performance since employees are always on their jobs around the clock regardless of location,(Vega *et al.*, 2015). It also results in improved job satisfaction since WEH can support the WLB positively. Furthermore, the COVID-19 pandemic presented an opportunity for the co-existence of both private and public sectors in Zimbabwe to work harmoniously by adapting flexible work arrangements.

Furthermore, WFH is advantageous because it positively impacts the WLB (Wessels *et al.*, 2019). Working from home has been viewed as a way of improving an employee's WLB because it accords employees an opportunity to take care of their family members (Ammons and Markham, 2004). There are many advantages and drawbacks associated with working from home, as such Human Resources Departments must manage this arrangement properly for tangible benefits.

Moreover, Kazekami (2020) stipulates that WFH is significant to an employee's working life because it enhances the quality and competencies of employees. It also increases employee happiness and openness to creativity will lead to innovation. Research to date has shown that teleworking increases job performance, lessens work-family imbalance, reduces stress levels and lessens turnover intentions (Contreras *et al.*, 2020; Kossek *et al.,* 2006; Fonner and Roloff 2010; Anderson *et al.,* 2015). However, this benefit can be proven if employees can obtain managerial support, peer support and technological support. Working from home support helps to reduce any potential negative impacts arising from social isolation and mitigates work-family and work-life balance conflict (Contreras *et al.*, 2020).

In addition, remote working in the private sector post-pandemic period is essential because it provides better flexible work arrangements in this busy economy. WFH during the post-pandemic period enabled workers to deal with family matters since work can be done from any location. This also helps to strengthen the family bond and allows employees to harmonise the freedom of time management and their personal and job duties (Coenen and Kok, 2014). Furthermore, remote working during the COVID-19 period allowed workers to work without immediate supervision as compared to a formal workplace, thereby decreasing employee stress levels. Moreover, it eliminated the individual and organisational burden of absenteeism.

Remote working also led to the digitalisation of the workplace in private sector companies. Legner *et al.* (2017) defined digitalisation as a

socio-technical, developing process that occurs at the individual, organisational, societal and global levels in all sectors. Digitalisation uses tools to convert analogue information into digital information. In Zimbabwe, since the beginning of the pandemic, the private sector witnessed a quick movement of digitalisation and the adoption of digital technologies. As a result, more employees migrated to work from home. However, the WHO (2020) cites that digitalisation is not evenly spread across the globe, with less developed nations struggling with the lack of broadband, internet connection and available information and communications technology (ICT) tools to enable teleworking. For example, only a quarter of the population in Sub-Saharan Africa has access to the internet (Gómez-Jordana Moya, 2020). The situation is further worsened by regions with regular power cuts and weak internet services.

The post-COVID-19 pandemic period is likely to be characterised by increased productivity in the srivate sector. Indeed, the mentioned benefits lead to greater employee loyalty and commitment to the organisation, job satisfaction, and improved work-life balance and well-being. WFH has benefits for both employers and employees. Delanoeije and Verbruggen (2020) posit that telework can reduce turnover rate and increase employees' productivity, job engagement and job performance.

CHALLENGES OF WORKING FROM HOME

Several challenges are likely to be faced by Zimbabwean private sector employees post-pandemic as far as the WLB is concerned. Purwanto *et al.* (2020), highlighted that the post-pandemic period is likely to be marred by increased social isolation, work and family distractions and employees shouldering the costs associated with WFH. They further point out that employees may bear additional costs like internet and electricity costs. Furthermore, Collins and Moschler (2009) argue that WFH increases employee alienation and isolation from colleagues due to increased social distancing measures, thus straining the relationship between co-workers.

On the other hand, WFH is likely to cause performance management challenges for Human Resources Management Departments. Most

managers cited that it is often difficult to manage the performance of someone who is working from home, hence managers showed great concern for reduced production levels (Purwanto *et al.,* 2020).

Another challenge posed by WFH is employees' lack of concentration due to home disturbances and distractions. Employees might be distracted by the presence of young children or family members and noisy environments without proper office tools while working at home (Kazekami, 2020). It is therefore imperative that Human Resources Departments draw clear demarcation boundaries between work and family if WFH is to yield tangible benefits.

Another challenge that is likely to emerge as a result of WFH is the failure of employees to collaborate and work together for the achievement of organisational objectives (*ibid*.). This is further worsened by the fact that innovation and creativity are stifled due to a lack of teamwork. Furthermore, synchronous communication decreases, making it difficult for workers to exchange and share information.

COVID-19 PANDEMIC AND WORKING FROM HOME IN ZIMBABWE

Many places have been adopting different means to deal with and defend themselves against the COVID-19 pandemic and Zimbabwe is no exception. Research findings indicate that Zimbabwe was among the first African countries to be affected by the pandemic. However, quick measures were put in place to contain the virus. The private sector, however, suffered immensely as a result of the imposed lockdowns. Some companies closed,whilst others struggled to meet their expenditures and failed to pay their employees on time. In trying to alleviate the situation, some companies ended up rationalising their staff and restructuring to a lean organisational structure. Marawanyika (2021) has reported that the Commercial Bank of Zimbabwe (CBZ) instigated voluntary retrenchment due to failure to meet its operational costs. In addition, most private sector employees in Zimbabwe were ill-prepared for the novel coronavirus in terms of resources such as ICT gadgets to enable working from home. Most companies struggled to provide their employees with access to the internet for continued services. Some employees were caught up in

lockdown restrictions and failed to access their various places of residence. As a result, this halted most work procedures in the private sector.

Working from home during the COVID-induced lockdown for most private employees in Zimbabwe was quite challenging. Irrespective of whether they were living on their own or with family, employees had to get involved in some household chores. During the lockdown, coordinating between work and family demands was a difficult task for every employed individual. According to the Boundary Theory, employees create and maintain physical, temporal and psychological boundaries around them to enable them to simplify their functioning in the world around them (Allen *et al.,* 2014). Formation of such boundaries enabled employees to minimise the interference of work and non-work life with each other. Drawing on the Boundary Theory, it is posited that while working from home during the lockdown, employees struggled to create and maintain temporal, physical and psychological boundaries and consequently maintain the WLB.

RESEARCH METHODOLOGY

The research utilised the qualitative research methodology approach. The use of a qualitative research approach was significant because it allowed the researcher to get an in-depth analysis of employees' feelings and perceptions about the post-COVID-19 period and the WLB. Data was collected using primary and secondary data collection tools. Online questionnaires were used to collect primary data. Secondary data obtained from academic articles and journals complemented the primary data. Further, data was collected from the private sector employees in Zimbabwe who were working from home during the COVID-19-induced countrywide lockdown.

RESULTS

The study revealed that COVID-19 gave birth to the rise of online collaborations and virtual meetings. The study participants hinted at the maximum benefits derived from online collaborations. For instance, one participant emphasized that "online virtual meetings are more structured and with clear agendas which allowed participants

from geographically dispersed teams to work together closely, thereby improving employee cohesion."

In addition, some participants emphasized that such collaborations with the outside world were also made easier since online platforms bring users in different locations closer together. The study revealed that the Human Resources Management (HRM) Departments are crucial for the physical and mental health and well-being of employees since a healthy employee is a productive human being who contributes significantly to the achievement of organisational goals. It further revealed that most private sector employees did not provide any psychological or mental health support for their employees. However, this is in contrast with the findings were done by Cheng *et al.* (2022) whose findings revealed that traumatic events such as a pandemic affect an employee's mental health. His findings suggested that interventions are necessary and may be carried out to minimise the pandemic's negative psychological consequences. Other studies also show that COVID-19 prompted various psychological phenomena such as moral harm, extreme anxiety, fear of disease, depression and acute stress (Gibson and Janikova, 2021; Phillips and Kucera, 2021; Lewis and Zauskova, 2021).

The research revealed that the WLB can be enhanced by working from home. Similarly, Grant *et al.* (2013 revealed that e-working would improve the WLB and e-workers found it possible to combine work-life and non-work life. Furthermore, the collapse of work-life boundaries and the fear of being under surveillance from employers, have all led to people working harder for longer (Ajith & Patil, 2003).

The research also unmasked that most employees went through severe stress during the COVID-19 period while balancing their work and personal life and this influenced their performance, not only in their workplaces but on the domestic front as well. The struggle to juggle work and family responsibilities emerged as one of the sources of emotional exhaustion experienced by employees during the COVID-19-induced nationwide lockdown. This is likely to persist in the post-COVID era as employees try to cover their backlogs. Hence there's need for employees to balance their gender roles and working life. This

is affirmed by Bloom *et al.* (2015) who learned that job satisfaction increased by working from home.

Furthermore, the researchers discovered that 75% of employees in the private sector in Zimbabwe did not have access to an internet connection while others did not have funds to purchase data which is expensive in the country. Furthermore, the study revealed that the few that had internet access lacked the basic training and skills required to operate and use virtual platforms like Google classrooms, Zoom and Google Meet to successfully deliver their different work mandate. The study also revealed that demographic factors like age and marital status impact the WLB. Young employees supported the idea of working from home, whereas older employees preferred to be in a familiar work environment. These findings are similar to Sharma & Bajpai's (2013) findings that age, marital status and several dependants have a high impact on the WLB. Further, most respondents highlighted that they are likely to face financial difficulties in the private sector as opposed to their counterparts in the public sector. This was attributed to the fact that the private sector suffered a great downturn due to the recession induced by the pandemic.

CONCLUSION AND OPTIONS FOR THE FUTURE

The post-pandemic recovery period in the Zimbabwean private sector, must address the interruptions in labour markets, interruptions that have given rise to numerous experimentations with remote work, flexible work arrangements and new relationships to centralised working environments. Moreover, achieving a WLB for private sector companies in the post-COVID period is significant for mental and physical health and long-term economic success. Flexible work arrangements are a new work paradigm that governments and businesses should embrace to promote business continuity. In developed continents such as the European Union, member states are being advised to implement policies that support the WLB in the post-pandemic period.

The private sector must develop and review its crisis management policy. More funds must be devoted towards this fund in preparation for future occurrences. The policy must be the blueprint to be used in

future. It is important to note that no situations are the same and do not require the same responses, but it is essential to have guidelines that ensure continuity of work even in the face of catastrophic disasters. Employers need to come up with new ways of monitoring performance and managing productivity when employees work from home. Also, new ways of managing the WLB must be devised.

According to Hamouche (2020), training plays a significant role in a period of crisis, such as a pandemic. Training and education help to develop the needed skills for employees, increase COVID-19 awareness, reduce the risk of the virus spreading and prevent mental health issues. Furthermore, training helps to support employees in the process of transition toward remote working. In reality, not all employees have the proper digital skills to cope with these changes generated by the use of ICT, hence the need to train them on the utilisation of ICTs. Employees need to be trained in ICT because this helps with the facilitation of their work and communication with their manager and peers while they are away from their workplace (Greer & Payne, 2014).

The study further recommends that the private sector must develop, design and implement creative methods of the WLB to ensure their survival. Communication strategies that are correlated to employee participation, involvement and continuous communication with employees virtually must be developed. Improved communication and availability of ICT tools will go a long way in modernising the workplace environment and creating an ideal environment for work to be done at home.

PROMOTING THE PHYSICAL AND MENTAL WELL-BEING OF EMPLOYEES

COVID-19 ushered in the development of new routines like isolation and quarantine. These developments increased the employees' anxiety levels, fears, stress and psychological problems. So the study recommends that HRM must develop strategies that improve the physical and mental health of employees. An employee's mental well-being and physical health are the cornerstone of effective performance, service quality and employee motivation which help to achieve the

organisation's mission and productivity and increased customer satisfaction, sales and profitability.

- The right time to resort to other working alternatives for the continuity of business operations in these uncertain times.
- The study proposes the implementation of effective HRM policies like staff rationalisation and restructuring to reduce staff costs and ensure employees contribute meaningfully to the achievement of organisational goals.

- There is need for government funding for private sectors to help combat calamities that may hinder their operations for continued survival. A fund can be set up to deal with a crisis such as the one posed by COVID-19.

REFERENCES

Ajith, M. &Patil, V. S. (2013). and An Empirical Study on Work-Life Balance for Role Prioritization of IT Employees. RVIM Journal of Management Research, 5(1): 31-40

Albertsen, K., and Rafnsdóttir, and G.L., and Grimsmo, and A., and Tómasson, and K. &Kauppinen, and K. (2008). Workhours and Work-Life Balance. SJWEH Suppl. (5):14–21.

Azzizi, A., Doha, A, Saad. E, Hilali and Chakib, N. (2022) Health-Related Quality of Life of Moroccan COVID-19 Survivors: A Case-Control Study.

Belotto, M.J (2018) Data Analysis Methods for Qualitative Research: Managing the Challenges of Coding, Interrater Reliability and Thematic Analysis, New York: Biomedical Research Alliance.

Dessler, G. (2005). Human Resource Management. New Jersey: Pearson Education.

Dzobo, M, Dzinamarira, T, Chitungo I, Mhango, M and Makanda, P. (2020) Risk Factors for COVID-19 among healthcare workers. A protocol for a systematic review and meta-analysis.PLoSONE16(5):e0250958.DOI:10.1371/JOURNAL.PONE.025095

Elsafty, A. and Ragheb, M (2020). The Role of Human Resources Management Towards Employees Retention During COVID-19 Pandemic in Medical Supplies Sector- Egypt. Business Management Studies, 2020, Vol.6, issue 2, 5059.

Gautam, A. &Khurana, C. (2017). emotional intelligence: The essential ingredients to employees' professional success. Vidya International Journal of Management Research, Vol. 5, No. 1, pp. 78-88.

Gautam, A., &Jain, S. (2016). Performance management system in telecom industry: comparison of Indian public and private sector undertakings. International Journal of Research in Commerce, IT and Management, 6(12), 1-5.

Greet, T.W and Payne, S.C (2014) Overcoming Telework Challenges: Outcomes of successful telework. The Psychologist-Manager Journal, 17(2), 87-111.

Goodman, A.; Wielgoszweska, B. and Green, F. (2020). Finances and Employment during Lockdown Briefing, Centre for Longitudinal Studies, University College London.

Gumbo, O. (2020). COVID-19 Lockdown Measures on Zimbabwean Populace. Advances in Social Sciences Research Journal,7,797-814. https://doi.org/10.14738/assrj.77.8728

Hamouche, S. (2020). COVID-19 and employees mental health: Stressors, Moderators and agenda for organizational actions.

International Labour Organisation. (2020b, May 27). ILO Monitor: COVID-19 and the world of work. Fourth edition. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/publication/wcms_745024.pdf.

Jain, P. (2013). A Comparative Study of Work-Life Balance among CA, Doctors and Teachers. IRC'S International Journal of Multidisciplinary Research in Social & Management Sciences, Volume: 1, Issue: 4, pp 58-65.

Jane, S., Brown, J. & Lee, C. (2004). The Second Work-Life Balance Study: Results from the Employees' Survey, Employment Relations Research Series, Department of Trade and Industry, UK. ISBN:085605 3937.Pp.101.

Kazekami, S.(2020). The Influence of Working from Home on Employee's Productivity. Telecommunications Policy, 44 (2).

Kumari, L. (2012). Employees' Perception On Work-Life Balance And Its Relation With Job Satisfaction In Indian Public Sector Banks. IJEMR, Vol: 2, Issue: 2, pp. 113.

Madhusudhan, V. G. &Nagaraju, K. (2013). and Work-Life Balance of Teaching Faculty regarding Andhra Pradesh Engineering Colleges. Global Journal of Management and Business Studies, Volume 3, Number 8, pp. 891-896.

Liu, Y., Lee, J.M, & Lee, C (2020). The challenges and opportunities of a global health crisis: The management and business implications of COVID-19 from an Asian Perspective. Asian Business & Management, 19,277-297. CrossRef Google Scholar

Madipelli, S., Sarma, V. &Chinnappaiah, Y. (2013). Factors Causing Work-Life Imbalance among WorkingWomen-A Study on School Teachers. The Indian Journal of Industrial Relations, 48(4): 612-633.

Matema, C, Manjengwa, J, Tirivanhu, D and Tizora, R. (2016) Deprivation among children living and working on the streets of Harare. Development Southern Africa 33(1):53-66.

Muhammed, S. A, Khan, S., Kazmi, A., Bashir, N & Siddique, R. (2020). COVID-19 Infection: Origin, Transmission and Characteristics of Human Coronaviruses. Journal of Advanced Research, 24, 91-98.

Murphy, F., & Doherty, L. (2011). The experience of work-life balance for Irish senior Managers. Equality, Diversity and Inclusion: An International Journal, Vol.30 Iss:4, pp.252-277, Emerald Group Publishing Limited.

Pandu, and A., Balu, A. & Poorani, K. (2013).Assessing Work-Life Balance among IT &ITeS Women Professionals. Indian journal of industrial relations 48(4):611-620

Padma, M. S. (2013). Role of Family Support in Balancing Personal and Work-Life of Women Employees. IJCEM International Journal of Computational Engineering & Management, Vol. 16 Issue 3, May 2013, pp 93-97, ISSN: 2230-7893.

Pierantoni, M, Pierantozzi, N and Sardonini, M (2020). A Qualitative Review for the Reorganization of Human Resources Management. University of Camerino.

Saunders, M. Lewis, P and Thornhill, A (2009) Research Methods for Business Student. 5th ed. Edinburgh Gate: Pearson Education Limited.

Sharma, J.P and Bajpai, N. (2010) Organisational Commitment and its impact on Job Satisfaction of Employees: A Comparative Study in Public and Private Sector in India. International Bulletin of Business Administration, 9, 7- 19.

Sileyew, K.J (2019). Research Design and Methodology.

Such, J.&Karthikeyan, P. (2014). Work-life balance of women employee: A literature review. International Journal of Management Research & Review. Volume 4/Issue 8/Article No-3/797-804.

Tariq, A., Siddique, A. &Tanveer. (2012). Work-Life Balance as a Best Practice Model of Human Resource Management: A Win-Win Situational Tool for the Employees and Organizations. Mediterranean Journal of Social Sciences, Vol. 3 (1) January 2012, ISSN 2039-2117.

Thriveni, K.K. *et. al.* (2012). Impact of Demographic Variables on Work-Life Balance of Women Employees (with special reference to Bangalore City), International Journal of Advances in Management and Economics, Vol. 1 (6), 226-229.

Townsend, Keith J. and Bailey, Caroline and Brown, Kerry A. and Bradley, Lisa M. and Lingard, Helen C. (2006) How would employees 'construct' a balance between work and non-work life? Work-life Balance in the Construction Industry. In Proceedings 14th International Employment Relations Association Conference, Hong Kong.

Tworek, H., Beacock, I. & Ojo, E. (2020). Democratic Health Communications during COVID-19: A RAPID Response. Vancouver, BC: UBC Centre for the Study of Democratic Institutions,https://democracy2017.sites.olt.ubc.ca/files/2020/09/Democratic-Health Communication-during-COVID_FINAL.pdf

Varatharaj, V. &Vasantha, S. (2012). Work-Life Balances A Source of Job Satisfaction - An Exploratory Study on the View of Women Employees in the Service Sector. International Journal of Multidisciplinary Research, Vol. 2, Issue 3, pp. 450-458.

Varuhas, J *et al.* (2003). Work and Family Balance- An Economic view. http://www.treasury.govt.nz/publications/research-policy/wp/2003/03-26/twp03-26.pdf.

Voydanoff, P. (2005). Toward a conceptualization of perceived work-family fit and balance: a demands and resources approach. Journal of Marriage and Family, 67(4), 822-836.

Yadav, R. K., &Dabhade, N. (2013). Work-Life Balance And Job Satisfaction Among The Working Women Of Banking and Education Sector – A Comparative Study. International Journal of Advancement in Education and Social Sciences, 1(2), 17-30.

The Housing Provision and Environmental Protection Dilemma: A Cause-Impact Analysis of Urban Housing Development on Harare's Wetlands

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Abstract

This article discusses the causes and impacts of urban housing development on wetlands in Harare. Being a local authority, the City of Harare has the mandate to provide housing for its inhabitants and at the same time protect the natural environment such as wetlands that are inherent in the city. Recent trends show that there has been a trade-off between housing provision and wetlands protection. A qualitative research design, which entailed the use of interviews with town planners and environmentalists was used to gather data for this study. The data was analysed using content analysis. The study results revealed that fragmented legislation, lack of enforcement, deficient wetlands categorisation criteria, political interference, corruption and low wetlands prioritisation were the contributory factors for housing development on wetlands in Harare. Consequently, water retention capacity, flood attenuation strengths, biodiversity supporting services and spatial extent of the wetlands have been greatly affected. However, if these developments continue unabated, the residents of Harare will be affected by a serious water crisis and environmental problems such as flooding.

Keywords: housing development, legislations, environment, urbanity, special economic zones

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INTRODUCTION

Urbanisation has transformed cities and towns in Africa. City life has been a major pull factor in migration and statistics show an immense evolution in the desire to live in cities. In 1950, only 16.8% of Africa's population inhabited cities (Manirakiza, 2011) and it is projected that the urban population will rise to 68% by 2050. Projections by UN-Habitat (2009) suggest that a continuing population increase in urban areas will add approximately 2.5 billion people to the current urban population by 2050 and this may amplify environmental challenges in the cities. There has been a drastic increase in population from a mere 50 000 inhabitants in 1962 when Kampala (Uganda) was declared a city to 1 208 544 in 2002 and 1.5 million in 2014 (Uganda Bureau of Statistics, 2002, 2016). The planning and development of cities have become complex due to the dynamics of urban space utilisation that has resulted from increased population. Housing demand in Harare and other cities in Zimbabwe has always been on the rise post-independence. The housing waiting list for Harare currently stands above a staggering figure of 500 000 home seekers (Chibamu, 2018). The pressing need to provide housing and related support services has led to the liberalisation of the housing market not just in Harare but countrywide (Kachere, 2014). However, rapid urbanisation in Africa had adverse effects on the environment.

Urban development on wetlands has been a prominent phenomenon in the past two decades (Ramsar Convention on Wetlands, 2018). Cui and Shi (2012) suggest that a general increase in the urban population has resulted in increased demand and pressure for urban housing and other related services. With nearly four billion people now living in urban areas, this growth has a direct detrimental effect on wetlands (United Nations, 2014). Housing development has been the most noticeable urban development activity on wetlands and it has degraded wetlands' functionality in the urban ecosystem (Kadziya and Chikosha, 2013). Nonetheless, studies investigating the factors contributing to developments in wetlands are limited in Zimbabwe. This study sought to investigate (1) the nature of developments on wetlands in Harare (2) the factors contributing to developments on wetlands and (3) the effects of developments on wetlands.

REVIEW OF RELATED LITERATURE

Research has shown that rapid urbanisation stretched the demand for housing development beyond what the city could provide, resulting in invasions of wetland areas. The effects are likely to be high in cities of the developing world where the pace of urban development and population increase is rapid. According to Wear and Greis (2002), urban development is a significant factor affecting forest ecosystems and wetlands in the Southern United States. In North Carolina, the forest cover and wetlands have declined by approximately 1.0 million acres (about 5%) since 1990 and urban development is the predominant cause of the net loss (Brown, 2004). Extensive urban development has also been implicated as the lead cause of habitat loss and species endangerment in the mainland United States (Czech *et al.*, 2000).

However, the rapid growth in world population and the need for more space to accommodate urban development activities posed a huge environmental challenge due to the existence of wetlands in urban areas. This is inconsistent with a global call through Agenda 2030 to make cities and human settlements inclusive, safe, resilient and sustainable (Goal 11) and to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reserve land degradation and halt biodiversity loss (Goal 15) (UNEP, 2017). Given that environmental sustainability and decent human life are at the ccentre of the sustainable development goals (SDGs (UNEP, 2017), the need to balance both targets is key to the achievement of Agenda 2030 at a very local level.

WETLANDS

Wetlands are water body systems such as marshes, fens, peat lands, pans, swamps, streams and lakes, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Government of Zimbabwe, 2002; The Ramsar Convention on Wetlands of International Importance (Article 1.1)). These are areas where water is the primary factor controlling climate, environment and associated plants and animal life in an area (Harare Wetlands Trust, 2015) and may be waterlogged

perennially or seasonally (Kecha *et al.*, 2007). Globally, wetlands occupy approximately 12.1 million km² of the land surface which is about 9% of the earth's surface (Ramsar Convention on Wetlands, 2018). The largest wetlands are in Asia, occupying 32% of the global area. North America follows with 27% of the global area. Latin America and the Caribbean occupy 16% of the total global wetlands area. Africa and Oceania have 10% and 3%, respectively (Davidson, 2018). Wetlands include permanently or seasonally inundated freshwater habitats ranging from lakes and rivers to marshes, along with coastal and marine areas such as estuaries, lagoons, mangroves and reefs (Millennium Ecosystem Assessment, 2005). Wetlands exist in many kinds of climates, on every continent except Antarctica. Harare is a wetland city. It sits on land that largely was a wetland but has been disturbed by human activities and urban development. In Kampala, 31 km² out of 172 km² of its space are swamps (Pomeroy, 2004). Wetlands vary in size from isolated prairie potholes to huge salt marshes. They are found along coasts and inland. Some wetlands are flooded woodlands, full of trees. Others are more like flat, watery grasslands. Still, others are choked by thick, spongy mosses (Convention on Biological Diversity, 2014). They are transitional zones that are neither dry nor saturated or underwater. They are characterised by having hydric soils, hydrologic periods of being wet for at least 5% of the growing season and hydrophytes which are wetland plants (Bullock and Acreman, 2013). Wetlands vary widely because of locational variances in soils, topography, climate, hydrology, water chemistry, vegetation and other factors such as human interference (Kecha *et al.*, 2007).

As one of the most productive ecosystems in the world, wetlands are a very important resource to humans, flora and fauna in both urban and rural areas (Millennium Ecosystem Assessment, 2005; Ramsar Convention on Wetlands, 2018; Russi *et al.*, 2013). Wetlands and the varied vegetative components that makeup wetlands provide many ecological and socio-economic goods and services to urban residents (Russi, *et al.*, 2013). They act as carbon sinks, sources of food, water, papyrus for craft making and herbs from vegetation. From an environmental point of view, the Millennium Assessment Report of 2005 states that wetlands are very instrumental in offering ecological

services such as water purification and waste treatment; retention, recovery and removal of excess nutrients and other pollutants. They physically, chemically and biologically remove pollutants and sediments from the wastewater disposed of them (Davidson, *et al.*, 2017).

Urban wetlands contribute to watershed functions, most notably in flood attenuation, groundwater recharge and discharge, shoreline protection and wildlife habitat. In addition, they support soil formation, sediment retention and accumulation of organic matter (Ramsar Convention on Wetlands, 2018). The Convention on Biological Diversity (2014) states that wetlands perform three major functions. First, they provide a habitat for plants and animals that live primarily in wetland areas. Migrating birds are a primary user of wetlands. Second, they contribute to flood control. Wetlands can store large amounts of water when heavy rains occur (Convention on Biological Diversity, 2014). Wetlands will store much of the water accumulation and reduce the flooding in surrounding areas. Third, wetlands purify the water of harmful chemicals from human use such as pesticides, herbicides and cleaning solutions; pathogens and particulates (Russi, *et al.*, 2013). This shows that wetlands ecosystems are a life support system for rural and urban residents and adverse effects are seen when they are disturbed. In Zimbabwe, the Ministry responsible for Environment and Climate spearheads wetlands protection through the Environmental Management Agency (EMA). The main statutory tools used are the Environmental Management Act Chapter 20:27 and Statutory Instrument 7 of 2007. Other legal instruments that impinge on developments on wetlands include the Urban Councils Act, the Rural District Councils Act, the Water Act and the Regional, Town and Country Planning Act .

URBAN DEVELOPMENT AND THE ASSOCIATED IMPACTS ON WETLANDS

Projections by UN-Habitat suggest that 50% of Africa's population will be living in cities by 2030 (UN-Habitat, 2009). Rapid urbanisation is being experienced in Africa and African cities are currently confronted with the formidable challenge of responding to the rapidly growing urban population, whilst ensuring that cities remain socially inclusive, environmentally sustainable and economically viable. This has then

translated to most cities failing to balance the three pillars of sustainability in their growth and hence the prospering of economic and social pillars has taken place at the expense of the environmental pillar (Martines and Alves, 2015). Population increases in most cities lead to the straining of urban infrastructure and services which has resulted in some urban dwellers failing to access the services (Cui and Shi, 2012). Such a situation has resulted in increased urban poverty levels and such a social problem has spatial implications. This has led to increased urban agriculture in environmentally sensitive areas such as wetlands, informal settlements, slums, sand abstraction and other illegal or environment-degrading practices in cities (Jamal and Mortez, 2014).

A concrete jungle has been created in Kampala on land that used to be wetlands and the city is now experiencing constant flooding, increased runoff and siltation of Lake Victoria (Byaruhanga and Ssozi, 2012).

The major impact of rapid urbanisation in Africa as a region is the stunted attainment of development goals. Premature urbanisation and urban developments are challenges affecting all types of urban areas from new towns such as Abuja (Nigeria) and Lilongwe (Malawi) to cities in rapidly growing economies such as Addis Ababa (Ethiopia), Cairo (Egypt), Luanda (Angola) and Beira and Maputo (Mozambique) (UN-Habitat, 2017). Environmental degradation, which compounds environmental injustices and threatens the sustainability of development, has been one major cost that has emerged due to urbanisation. Interestingly, environmental degradation is preventable with the right planning and management. Most African cities have been facing challenges in ensuring quality urban development that is both sustainable and equitable (UN-Habitat, 2008). This has seen the destruction and disturbance of most urban wetlands in cities in the developing world.

This saw the engagement of housing cooperatives and private land developers in the housing market. This policy position did not go well in terms of the preservation of wetlands. Several home-seekers managed to develop residential properties with some on wetlands, which are ecologically sensitive areas. Having achieved success in one

area of housing provision, it was derogatory to the goal of protecting ecologically sensitive areas. This is evidenced by Nyavaya's (2018) assertion that only a fifth of the wetlands in Zimbabwe's urban areas are reported to be in a healthy functioning state. The sustainability of urban wetlands is compromised as urban development activities continue to happen in such sensitive areas.

The protection and management of wetlands in Africa depend highly on the context of individual countries' legal systems, their economies and their political systems. Unfortunately, the proclivity of African governments and local authorities to prioritise economic benefits over ecological benefits has always led to a situation where construction projects are favoured at the expense of nature. Bad corporate governance and corruption have also resulted in land designated and gazetted by law as wetlands to be used for other uses that are detrimental to the wetland.

HOUSING PROVISION, WETLANDS AND ENVIRONMENTAL PROTECTION: THE NEXUS

Housing provision and environmental protection are some of the major mandates of urban local authorities as stated in the Urban Councils Act (Chapter 29:15) Section 96 subsections 2 and 4 (Government of Zimbabwe, 2005). These two are also at the centre of global plans such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals. Millennium Development (SDGs) Goal 7 which was to ensure Environmental Sustainability targeted the provision of proper housing to slum dwellers and the protection of the natural environment where wetlands are included (United Nations, 2014). This was further prospered by SDG 11 whose aim was to ensure access for all to adequate, safe and affordable housing and basic services. SDG 15 (Life on Land) was aimed at protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably managing the forest, combating desertification; halt and reversing land degradation and biodiversity loss (UNEP, 2017). Sustainability in housing provision and environmental protection has become the ccentre for MDGs and SDGs considering that their global goals are

directly focusing on environmental issues and addressing human housing needs (UNEP, 2017). The continuum from the MDG to the SDGs positions environmental sustainability and sustainable housing provision as the centre of the 21st century's goals and targets.

Despite all these efforts to balance housing provision and environmental sustainability, the fulfilment of the former has compromised the protection of the latter, causing devastating effects on wetlands. The control of housing development on wetlands is one of the critical issues challenging urban planners, development practitioners, environmentalists and city fathers in most cities in the developing world. African cities are confronted with the formidable challenge of providing housing to the ever-increasing urban population while at the same time ensuring that cities remain, socially inclusive, environmentally sustainable and economically viable. Martines and Alves (2015) precisely opine that the prospering of economic and social pillars of sustainability has taken place at the expense of the environmental pillar which promotes wetlands protection. An untamed quest to provide adequate housing for all urban dwellers has caused the invasion of ecologically sensitive areas, leading to the disappearance of urban wetlands, meadows, streams and hinterlands (Centre for Watershed Protection, 2006). Wetlands are slowly vanishing and are being replaced by pavements, buildings and sterile landscaping that make the few remaining wetlands unable to perform their natural functions as natural green infrastructure. Brugnmann and Robert (2005) believe that environmental problems such as flooding and reduced underground water recharge are resulting from wetlands invasions.

SOME INTERNATIONAL CASE STUDIES

GRANADA, SPAIN

By the end of the 1980s, the proclivity to develop coastal wetlands was driven by a limited appreciation of the ecological value of such spaces by local authorities. As a result, they were classified as developable

and buildings were erected along the coast. This led to the wetlands shrinking and a substantive loss in biodiversity in all its forms. The realisation of the impact of development that ignored the wetland led to a change towards municipal housing and tourism models that were more sustainable in their approach. However, there was a dilemma between promoting tourism along the coastal wetlands by constructing tourist hotels and luxurious conference centres and protecting the wetland for ecological purposes. The implementation of the Coastal Preservation Model, which protected the coastal wetlands was seen as being counterproductive for tourism development. Even so, being the only one in the province, it was highly important to protect the coastal area for the preservation of biodiversity. The sustainable approach to land use planning and environmental protection made it possible for it to accommodate more than half of the endangered bird species in the region. The Granada experience prompted the idea of public participation in land use planning and the preservation of nature. The UN-Habitat (2008) suggested that the sustainability of environmental preservation initiatives by government or local authorities is highly dependent on the support that the public is giving to such initiatives. It also showed that the idea of protecting wetlands requires an intentional policy shift towards strengthening laws and regulations that encourage the preservation of biodiversity.

NAIROBI, KENYA

The Nairobi case involves the increase in population in the city which has led to pressure for resources from the shelter, infrastructure and food. Human settlements to shelter the city's inhabitants and stream bank cultivation to provide food for city dwellers have led to land fragmentation and wetlands invasion. The Nairobi River Basin and its several tributaries, such as Mathare and Ngong Rivers, have not been spared by the impacts of increasing human settlements and activities in the City of Nairobi. Because they flow through the City of Nairobi, the rivers have been contaminated by waste from settlements. In addition to that, most of the Nairobi River basin and its associated wetlands have been lost to infrastructure and property. Construction

is also rampant around the Nairobi dam along the Motoine River where extensive sewage treatment work is being done (UNEP, 2009).

Wetlands in Nairobi support a wealth of biodiversity both flora and fauna. The Nairobi River Basin hosts both natural and agroforestry trees such as Cyprus, Croton, Eucalyptus and the Bamboo tree. It is also home to floral species native to Nairobi. The wetlands and associated forest harbour many fauna and avifauna species which include the African hare, bushbucks and mongoose. A variety of primates also reside in the wetland and these include, among others, the black and white colobus monkey, sykes monkey and vervet monkey. The wetlands lie within the route of migratory birds moving from Europe to Africa to breed. Having this richness in biodiversity composition, the ecological integrity of the Nairobi River Basin and its associated wetlands has been greatly compromised by the invasion of such spaces by urban agriculture and human settlements (Ye *et al.*, 2009).

Several lessons were also learned in the Nairobi instance. The improvement of the already converted land to become more productive reduces the need for locals to colonise more lands (*ibid*.). This lesson hinged on the understanding that if the colonised land is not used efficiently, more land may be required and more wetlands will be disturbed. The establishment of stricter environment protection rules was also seen as a pivotal measure in the protection of wetlands which are ecologically sensitive areas. Educating residents on the more important roles played by wetlands that do not necessarily benefit them economically was also cited as a measure to convince locals to take part in conservation efforts (UNEP, 2009).

MATERIALS AND METHODS

The study employed a case study research design and the focus was on Harare. Four (4) wetland areas, namely Monavale, Northwood, Budiriro and Dzivarasekwa, were sampled out of 29 gazetted wetlands in Harare. Table 1 provides a brief background of the selected wetlands.

Table 1: Background information on the selected wetlands

Name of Wetland	Location of the Wetland
Monavale	Monavale wetland is one of the seven Ramsar Sites in Zimbabwe. It is located to the north of Harare's city centre. It's surrounded by middle- to upper-income residential suburbs such as Monavale, Meyrick Park and Milton Park. Monavale wetlands are one successful community-led wetland restoration project that has ever happened in Zimbabwe.
Northwood	Northwood is located on the North East side of Harare's city centre.
Budiriro	Budiriro wetland is located in a high-density zone west of the city centre.
Dzivarasekwa	Dzivarasekwa wetland is located to the west of the city centre and is abutted by residential suburbs.

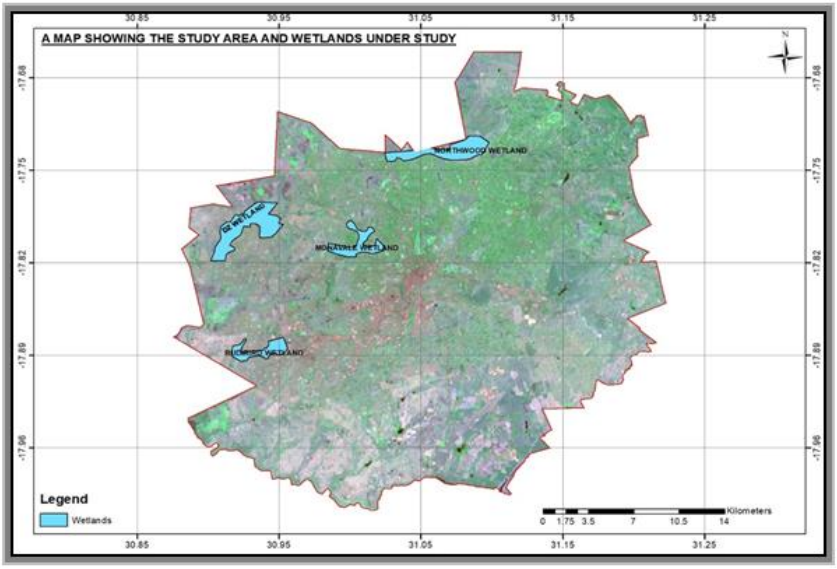

Figure 1.1: Showing the 4 wetlands selected from the 29 wetlands in Harare

Data was collected through conducting key informant interviews with officials from the Environmental Management Agency (EMA), the City of Harare, the Conservations Society of Monavale and the Harare Wetlands Trust. In addition, transect/nature walks were conducted on

the wetlands to observe how humans interact with the wetlands and the visible impacts resulting from such interactions. Documents such as local authority plans, publications and statutory documents were also extensively reviewed.

A quantitative approach was adopted for data analysis and important categories or themes were identified in the data and patterns and relationships (Flick, 2013). To support this, thematic analysis was also used to categorise data meaning through the creation of themes that guided the presentation (Denzin, 2011).

RESULTS AND DISCUSSION

DEMOGRAPHIC PROFILE OF THE RESPONDENTS

Table 1 shows the nature of respondents who participated in the survey. Notably, respondents were selected from town planning, environment and community members to ensure a balanced assessment of the issues under consideration.

Table 1: Profile of respondents

Participant No.	Respondents	Nature of Organisation	No of Interviews
1	Town Planners	Harare City Council/Local authority	1
2	Environmentalist		1
3	Environmentalist	Environmental Management Agency	1
4	Wetland Protection Manager	Wetlands Trust Organisation	1
5	Wetland Superintendent	COSMO	1
6 & 7	Residents / Households	Monavale	2
8		Northwood	1
9 & 10		Budiriro	2
11 & 12		Dzivarasekwa	2
TOTAL			**12**

THE NATURE OF DEVELOPMENTS ON WETLANDS IN HARARE

There is a consensus among the respondents that wetlands have been invaded by various forms of urban development activities. Despite this, there is a lack of consensus among the respondents relative to the

actual hectares of wetlands occupied by urban development activities. Interviewees from the City of Harare suggested that approximately 10% of the total wetlands in Harare have been occupied by urban development and human activities. However, an approximation generated by the EMA suggests that 12 977.7 hectares (55.2%) of wetlands have been built up out of the total of 23 504.9 hectares. The approximation potentially explains the water supply challenges experienced in Harare.

Table 2 presents some of the main urban development activities taking place on the identified wetlands.

Table 2: Urban development activities on selected wetlands in Harare

Name of Wetland	Nature of Activities
Monavale	a. Housing b. Institutional developments
Northwood	a. Landowners (30) were issued with EIA certificates and licenses to operate commercial and industrial uses. b. Industrial/manufacturing use (Halsted, Electrosales, Vakani Panner, Seed Companies, Superfit, Maxitiles) c. Petrol filling station (PFS) (Trek PFS) d. Quarrying e. The Pomona Barrack is also located on the Northwood Wetlands
Budiriro	a. Housing development by cooperatives such as Motherland Housing Cooperative, Teurai Ropa Housing Cooperative and Stars Consortium. b. Institutional (Budiriro School)
Dzivarasekwa	a. A layout to facilitate housing development has been approved to provide 130 housing stands. b. Institutional uses (Pinewood High School).

Table 2 shows the various urban development activities on the selected wetlands. Notably, the main urban development activities on the wetlands include housing development, industrial activities and commercial activities. Interestingly, housing is the main urban development activity or land use invading wetlands. This is confirming the extent of the housing problem in Harare where over 500, 000 people are on the housing waiting list. Industrial and commercial activities dominate the wetlands such as Northwood and Monavale, which are located in proximity to high-income areas.

FACTORS CONTRIBUTING TO DEVELOPMENT ACTIVITIES ON WETLANDS IN HARARE

The study sought to identify the factors contributing to urban development activities on wetlands in Harare. The factors will be discussed under the four themes which emerged from the analysis of the data.

FRAGMENTED LEGISLATIVE FRAMEWORKS

The results suggest that lack of consensus concerning the legality of housing development on wetlands is a contributory factor to housing development activities on wetlands. This is amplified by the fragmentation of legislation relating to wetlands protection and urban development. Two main aspects emerged from discussions with research participants. First, EMA perceives that a wetland can be utilised for any use the Minister of Environment, Water and Climate declare when one gets a certificate or license of use from EMA. Second, officials from the City of Harare perceive that wetlands can be used for the provision of critical infrastructure that serves public interest such as base stations, sewer lines, water reticulation systems and power lines. In the latter instance, issuance of a certificate or license of use from EMA is not required but rather justified from a town planning perspective on the grounds of public interest. Nonetheless, a cost-benefit analysis is conducted before the use of a wetland for any use. Impact mitigation measures are required to ensure harmonious co-existence between wetlands and the infrastructure. Accordingly, the City of Harare has approved layouts and building plans that are being erected on wetlands by housing cooperatives and other land developers.

The results suggest that urban development planning and environmental protection planning are not synchronised and this causes chaos in the planning for the development and protection of wetlands. The problem is amplified by the fact that Harare lacks a gazetted wetland map and the administrative overlaps between the Environmental Management (EM) Act and the Regional Town and Country Planning (RTCP) Act relative to wetlands. The lack of explicit provisions in the Layout Design Manual relative to designing in

wetland areas and the long process to stop developments on wetlands further compounds the problem.

LAND TENURE ISSUES

Housing provision has become a prominent business endeavour in Harare due to the increase in the population of all income levels. This is evidenced by the increase in densification initiatives in the high-income residential areas which are coming in the form of cluster housing, second dwellings and high-rise flats. This is coming at a time when cities have become more environmentally conscious and have put measures in place to protect wetlands. The research established that land tenure influences the use of wetlands for urban development and town planning laws. Respondent 1 described how privately owned land is zoned residential by the City of Harare's planning schemes and a wetland by the Harare Wetlands Map. Such discord is likely to contribute to confusion relative to how the land can be utilised. As a planner with the local authority highlights, the City of Harare is bound to follow the provisions of the operative Master Plans, Local Development Plan and Schemes. This suggests that private the land owner can apply and be granted permission to carry out developments on land as long as the development proposal conforms with the operative plan that covers that area. The problem is compounded in areas such as Monavale Vlei where 16 hectares of the land was zoned residential by the Monavale Town Planning Scheme before the promulgation of the Environmental Management Act. The misalignment between town planning and environmental laws contributed to court challenges between owners of the land as they intend to develop and the environmentalists seeking to protect the wetland.

HOUSING DEMAND IN HARARE

The respondents highlighted that the population increase led to an increase in the demand for housing in Harare and with no corresponding supply of land for housing development, wetlands were invaded. The respondents note that although wetlands protection is a priority even in the face of other pressing needs for urban infrastructure and services in Harare, the increasing demand for housing and other supporting services like schools, hospitals and

commercial shops cannot be ignored. This pressure to supply houses to the city residents is forcing the City of Harare to disregard the protection of wetlands to serve an urgent need for housing. As housing is a basic need, the local authority is compelled to balance the act of environmental protection and the provision of houses. The role of politics in housing is also complicating the problem. For example, co-operatives that are well connected to political power, have targeted wetlands with impunity to provide accommodation to their members. Recognising the role of government and local authorities in housing provision, Respondent 1 indicated: "….. it is government and council's mandate to provide housing to urban residents hence they are usually caught in between protecting the environment and providing a basic need. However, there is a need to balance the two." While the importance of housing could not be over-emphasized, alternative sites could be explored instead of targeting wetlands.

In addition, the results suggest that respondents perceive that housing development is prioritised ahead of wetlands protection. This is confirmed by the fact that the local authority has no gazetted wetlands map. "Council, being in a position to do Local Priority Plans, Local Subject Plans that focus only on the city's wetlands, no efforts have been made to do that," Respondent 4 lamented. Since the enactment of EMA in 2002, 18 years down the line, the city still lacks a gazetted wetlands map which has a strong legal backing that is synchronised with other laws to make it perfect as far as protecting wetlands is concerned.

POLITICAL INTERFERENCE

The respondents highlighted that politics play a major role relative to development activities on wetlands. As noted in Table 3, housing development is the main activity on wetlands. This is consistent with the National Housing Policy, which seeks to ensure an adequate supply of housing for all. The respondents perceive that developments in wetlands conducted by co-operatives are connected to politics as most of the housing co-operatives with activities on wetlands are connected to the ruling party (ZANU-PF). Notably, housing co-operatives in Budiriro exhibit these traits in the names such as Teurai Ropa Housing Cooperative that are highly affiliated to the ZANU PF

party. As highlighted by Respondent 10, "*Vanhu vase vamuri kuona ava, vakaunzwa pano* nemusangano (All these people you see were brought here by the party)" suggests serious political interference in planning and land allocation. In addition to direct political interference, precedence relative to the regularisation of illegal developments on wetlands also made people invade wetlands and speculated that they would be regularised. The results confirm past studies where Machamire (2018) established that corruption and political interference in city planning are major causes of wetlands invasion and ultimate destruction in Harare. In Kampala, despite a very good legislative framework for wetlands protection, their wetlands continue to be disturbed by political interference (Kakuru, 2001; Pomeroy, 2012). However, the study results show that the role of politics in wetlands development is more pronounced in Budiriro and Dzivarasekwa than in Monavale and Northwood where other factors such as tenure and town planning are predominant.

IMPACTS OF HOUSING DEVELOPMENT ON WETLANDS

With regards to the impact of urban development activities on wetlands, three main themes, namely the effect on surface hydrological systems, biotic components of the wetlands and wetland connectivity emerged from the analysis of the data. The development of residential properties in any setting brings the need to provide supporting services such as water and sewer infrastructure, institutional uses like schools and health facilities, commercial shops to support the population and recreational facilities, among others. This means that the provision of housing has far-reaching implications for the sustainability of wetland ecosystems. In Harare, surface hydrological systems have been affected and this has affected biodiversity that thrives in wetland ecosystems. When buildings are constructed on wetland areas, the areas cease to be wetlands which means the majority of wetland space has been made extinct by housing provision.

EFFECT OF HOUSING DEVELOPMENTS ON SURFACE HYDROLOGICAL SYSTEMS

Wetlands in Harare are seasonally inundated. This means that they get flooded only when the water table reaches the surface during the wet seasons. Housing developments have fragmented wetlands to an

extent that the natural hydrological flows have been affected. The water purification strength of wetlands has ceased due to disturbance and this has affected the quality of water. Although underground water proves to be clear, surface water has been greatly affected. The restoration of Monavale Vlei has restored its purification characteristics and hence much of the water that seeps into the Marimba River is clear. Pools of surface water on Monavale also were filled up with clear water showing that the wetland's hydrological services are optimally operational. Dzivarasekwa and Budiriro wetlands painted a heavily disturbed surface hydrological system. Housing developments on the wetlands have also brought with them heavy agricultural activities. The wetlands are now clogged with invasive species as a result of the introduction of foreign characteristics like buildings and crops. Respondent 10 narrates the changes in hydrology by saying

> "When we first came here, wells were only three metres deep because the water was very close to the surface, you didn't need a long rope to lower the tin into the well to fetch water… but now, well are going up to eight metres to 10 metres before you reach water levels."

This is evidence of how housing construction and other human activities that housing provision has brought have affected the wetlands' hydrology. The clearing of wetland vegetation has reduced infiltration and percolation which resulted in more surface runoff. Precisely, underground water recharge has been greatly compromised.

EFFECT OF HOUSING DEVELOPMENT ON BIOTIC COMPONENTS OF WETLAND ECOSYSTEMS

The biotic components of wetland ecosystems are animals, birds and vegetation species. Wetlands are home to multitudes of animals, birds and vegetation species. When best performing, they are one of the most productive ecosystems on earth. They act as breeding sites for migratory birds and also places of hibernation. In terms of the animal and bird species, the most common wetland species are the black-headed heron, the grey dove and the black-winged kite which were observed in three of the four wetlands studied in Harare. Because of its restored state, Monavale wetlands have managed to attract and retain

animal species such as bush pigs and rabbits. Several snake species have also been recorded on the wetland.

Harare's wetlands are treeless and have short grass. Wetland vegetation has been affected on two levels which are vegetation survival and vegetation cover. Grass species and wetland shrubs are slowly being replaced by buildings, roads and other human activities that result from housing construction. Invasive species such as the *phragmites australis* have colonised wetlands due to foreign bodies in the wetlands. The eucalyptus, acacias and syringa trees are invasive species that were also observed at Monavale, Budiriro and the Dzivarasekwa wetlands.

Evidence in Harare is the lowering of the water table from 18 to 30 metres below the earth's surface, flooding and pollution of wetland streams (Kadirire, 2014). Chakanyuka (2019) also states that 13 of the 29 wetlands in Harare have already been taken up for construction projects.

EFFECTS OF HOUSING DEVELOPMENT ON WETLANDS ON PUBLIC HEALTH

Evidence shows that the creation of human settlements on wetlands hurts both humans and the wetland ecosystems. While wetlands are water purifiers, they also provide a conducive environment for water-borne diseases because of their nature. When left undisturbed, they are disease-free ecosystems. They only breed human-harming pathogens which cause diseases such as cholera, typhoid and dysentery when human excreta has been introduced to them due to human occupation.

Wetlands become dysfunctional in terms of providing wetland services when humans construct settlements on them. In their natural state, they act as flood attenuators. However, human settlements create impervious surfaces which increase runoff by reducing the capacity of wetlands to absorb the water. Removal of vegetation during construction also affects the existing hydrological systems of wetlands.

DISCUSSION

Protection of ecologically sensitive ecosystems and provision of decent housing are some of the goals of the Agenda 2030 which sets Sustainable Development Goals for 15 years from 2015. There are conflicting interests in the implementation of these in Harare

A common grass type in the studied wetlands is the *parrhesia* although Budiriro and Dzivarasekwa are only left with a few portions where this grass exists. There is still a very heavy presence of the native wetland grass on Monavale and Northwood Vlei because they have not been affected by the invasions.

An official from one of the companies stated that their use is environmentally friendly because the structures they have built on their site and the material used have been approved by EMA not to affect the wetland's normal and natural operations. A further comment was also added that they have developed an Environmental Management Plan which guides how they operate so that their operations do not affect the natural systems and operations of the Northwood Wetland that they are sitting on. The Pomona Barrack is also located on the Northwood Wetlands.

CONCLUSION AND RECOMMENDATIONS

The pattern of urban housing development on wetlands is well-defined and its impacts are being felt and realised. It is, therefore, crucially important for the City of Harare to fulfil its housing provision mandate with great sensitivity to natural green infrastructure. This is the only way the city can balance housing provision and environmental protection, thereby guaranteeing a complete and healthy urban ecosystem that supports humans and nature with positive coexistence.

REFERENCES

Baloi O (2014). Urban Wetlands in the Core of Africa: Protection and Creation of Urban Wetland Landscape in Kigali, Rwanda, Rwanda One Stop Centre for Urban Planning and Construction Rwanda Environmental Management Authority and Rwanda Environmental Management Authority.

Brown, M.J. (2004). Forest statistics for North Carolina, Resource Bull. SRS-88. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Bruegmann and Robert (2005) Sprawl: A Compact History. University of Chicago Press, Chicago.

Bullock, A. & Acreman, M. (2013). The role of wetlands in the hydrologic cycle. Hydrology and Earth System Science, Vol 7, pp. 358-389

Byaruhanga A and Ssozi, L (2012). The Impact of population growth on the Ecosystems and Biodiversity of Kampala: Lessons for Sustainable Urban Development. Sustainable Futures: Architecture and Urbanism in the Global South Kampala, Uganda, pp. 191 - 195

Centre for Watershed Protection (2005). Direct and Indirect Impacts of Urbanization on Wetland Quality, Office of Wetlands, Oceans and Watersheds and U.S. Environmental Protection Agency

Chakanyuka M (25 March 2019). Government ponders taking over Wetlands: News Day, https://www.newsday.co.zw/2019/03/govt-ponders-taking-over-wetlands [Accessed 25/03/2019]

Chibamu A (2018). Half a million homeless people on Harare's land waiting list – Mayor: The News Day. https://www.newzimbabwe.com/half-a-million-homeless-people-on-harares-land-waiting-list-mayor/ [Accessed 12/8/2019]

Convention on Biological Diversity (CBD). (2014). Global Biodiversity Outlook 4. Montreal

Cui, L.L and Shi, J. (2012). Urbanization and its environmental effects in Shanghai, China. Urban Clim, Vol 2, pp. 1–15.

Czech, B.; Krausman, P.R.; Devers, P.K. (2000). Economic associations among causes of species endangerment in the United States. BioScience. Vol50; pp. 593-601

Davidson, N.C. & Finlayson, C.M. (2018). Extent, regional distribution and changes in the area of different classes of wetland. Marine & Freshwater Research (in press)

Davidson, N.C. (2017). Wetland losses and the status of wetland-dependent species. In C.M. Finlayson, N. Davidson, G.R. Milton & C. Crawford (eds). The wetland book: distribution, description and conservation. Dordrecht: Springer.

Denzin, Norman K. and Lincoln, Yvonna S. (2011). The SAGE Handbook of Qualitative Research, 4th edition. London: Sage.

Flick U (2013). The SAGE Handbook of Qualitative Data Analysis, SAGE, London.

Government of Zimbabwe (2002). The Environmental Management Act Chapter 20:27. Ministry of Environment and Climate.

Government of Zimbabwe (2005). Urban Councils Act Chapter 29:15, Ministry of Local Government, Public Works and National Housing.

Jamal M and Mortez S.S (2014). The Effect of Urban Agriculture in Urban Sustainable Development and Its Techniques: A Case Study in Iran; International Journal of Agriculture and Forestry 2014, Vol 4(4); pp. 275-285

Kachere D (2014). The Herald - 2 600 housing co-operatives registered. https://www.herald.co.zw/2-600-housing-co-operatives-registered/ [Accessed 12/8/2019]

Kadirire, H. (2014). Harare's Wetlands under threat. Available at: https://www.dailynews.co.zw/articles/2014/07/20/harare-s-wetlands-under-threat/ [Accessed on 10/08/19]

Kadziya L and Chikosha F (2013). Wetlands and Urban Growth in Bindura, Zimbabwe: Greener Journal of Environment Management and Public Safety, Vol. 2 (6), 195-199,

Kakuru, K. (2001). A Guide to the Environment Impact Assessment Process in Uganda.

Kecha A, Ochieng G, Lekapana P and Macharia G (2007) Status of Wetlands in Kenya and Implications for Sustainable Development: Environment and Sustainable Development, Vol 2 pg. 193 – 208

Martine G and Alves J E D (2015). Economy, society and environment in the 21st century: three pillars or trilemma of sustainability? Economy, Society and Environment in the 21st Century, Vol 3 (7), 23 – 48

Millennium Ecosystem Assessment. (2005). Ecosystems and human wellbeing: wetlands and water: a synthesis. Washington, DC: World Resources Institute

Murungweni F (2013). Effect of Land Use Change on Quality of Urban Wetlands: A Case of Monavale Wetland in Harare. Geoinformatics & Geostatistics: An Overview, pp. 2 – 5

Nyavaya (2018). Zimbabwe's wetlands under threat https://www.thestandard.co.zw/2018/02/05/zimbabwes-wetlands-threat/ [Accessed 10/08/19]

Pomeroy, D. (2012). The Birds of Makerere Hill, Kampala-A Story of Biodiversity Loss

Ramsar Convention on Wetlands. (2018). Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat

Ramsar Convention on Wetlands. (2018). Global Wetland Outlook: State of the World's Wetlands and their Services to People. Gland, Switzerland: Ramsar Convention Secretariat

Russi, D., ten Brink, P., Farmer, A., Badura, T., Coates, D., *et al.* (2013). The Economics of Ecosystems and Biodiversity for Water and Wetlands. London and Brussels: IEEP; Gland: Ramsar Secretariat.

Uganda Bureau of Statistics (2016). The National Population and Housing Census 2014 – Main Report, Kampala, Uganda

UN-Habitat (2009). Promoting Sustainable Urban Development Networking in African Cities, SUD Net Workshop; Cape Town.

UN-Habitat (2017). Africa: Transformational Housing and Sustainable Urban Development in Africa, Habitat III Regional Report on Africa, Abuja.

UN-Habitat (2008). The State of African Cities: A Framework for Addressing Urban Challenges in Africa, United Nations Human Settlements Programmeme

UNEP (2009). Kenya: Atlas of our changing environment. UNEP, Nairobi, Kenya

UNEP (2017). The United Nations Environment Programmeme and the 2030 Agenda: Global Action for People and the Planet.

United Nations (2014) The Millennium Development Goals Report 2014: We Can end Poverty, New York.

United Nations (2014). World Urbanization Prospects: The 2014 Revision. Department of Economic and Social Affairs, Population Division, New York.

Wear, D.N. and Greis, J.G. (2002) Southern Forest Resource Assessment. Gen. Tech. Rep. SRS-53. US Department of Agriculture, Forest Service, Southern Research Station, Ashville.

Wear, D.N.; Greis, J.G. (2002). Southern Forest Resource Assessment: summary of findings. Journal of Forestry, Vol 100(7): pp. 6-14.

A Spatial Statistical Approach Towards Independence of Informal Manufacturers' Psychographics from Town Planning Principles in Harare

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Abstract

This study tested for statistical significance of the association between informal manufacturers' psychographics and town planning principles. Health, safety and order amenity constructs were extracted from existing town planning principles and three vignettes encapsulated in psychographics (knowledge, perception and attitude) were captured in the digital questionnaire for each construct. With these constructs and vignettes, the collected data were analysed using the R language in Spatstat and tested for the independence of association using a chi-square test at a 0.05 level of significance. Study findings revealed that all three psychological vignettes studied have a very weak relationship with town planning principles. All studied relationships gave an r^2 value of at most 1.17%, implying that less than 2% of manufacturers' psychographics are explained by variations in their understanding of town planning principles. Therefore, planning education must be scaled up so that manufacturers gain a full understanding of the importance of town planning goals.

Keywords: spatiality, human behaviour, policy, planning, management

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INTRODUCTION

Understanding the psychographics of informal manufacturers because of town planning is fundamental in predicting their behavioural response to authorities' initiatives such as taxing the informal sector (Government of Zimbabwe (GoZ), 2014). Psychographics define psychological vignettes such as opinions, attitudes, values, knowledge and perception of individuals or groups of participants about a specified phenomenon (Azjen, 1991; Armitage and Conner, 2001). It is argued that "the relative importance of attitude, subjective norm and perceived behavioural control in the prediction of intention is expected to vary across behaviours and situations" (Ajzen, 1991, p 188). Accurate prediction of intentions and behaviour is, therefore, a function of understanding hard data on the importance of attitude, perception and knowledge. The questionable behaviour of informal operators has received considerable attention in the literature (Chirisa, 2007; Shabaneh, 2008; Yiftachel, 2009; Kanbur, 2009; Shah, 2012; Varley, 2013). Outside legally constituted markets, informal operators enjoy free riding, evade taxes and operate in violation of land use zoning laws (Kanbur, 2009; Dube and Chirisa, 2012; Keen and Kanbur, 2015). To this effect, dominating patterns of behaviour, noted over time, are that the informal sector is shy, resilient, resistant, messy and tax evasive. When the heavy hand of planning is visible and more active, the informal sector kind of hibernates and resurfaces at a later stage. This type of behaviour is something that has been described as resilience and resistance by Chirisa (2007) and Varley (2008), respectively.

Sookram, Watson and Schneider (2006) used the case study of Trinidad and Tobago to explain the perception and attitudinal characteristics of households that participate in the informal sector. The findings of this study are important in giving a general insight into how psychographics influence the behaviour of informal operators. However, discussions of issues surrounding these findings were limited only to socio-economic characteristics, mainly informal operators' perception of risk detection by the tax authorities. A somewhat similar study narrated how street vendors in Harare used their knowledge of town planning to escape development control (Chirisa, 2007). Chirisa's (2007) study revealed that the resilience of informal operators to the role of planning to restore order, capture

value and promote good citizenship is driven largely by poverty which pushes people into the streets. No doubt, this study played an important role in bringing to the fore the relationship between town planning principles and the psychographics of informal operators. Limited only to operators in tertiary production, the study did not capture the psychographics of operators in the primary and secondary levels of production. This study failed to report reliability statistics because it was limited in sampling.

As far as it can be ascertained, few studies analysed the psychographics of informal operators, e.g. Sookram, Watson and Schneider (2006) and Chirisa (2007). None of the accessible studies used hard data to explain the relationship between informal operators' psychographics and town planning principles. Drawing up solid conclusions and making inferences from a few published papers on the psychographics of informal operators is thus suspect on three counts of reliability, replicability and empirical backing. What appears open and straightforward to an ordinary eye might have hidden connotations. This, therefore, urges further research to provide hard data on the relationship between the psychographics of informal operators and town planning principles. Unless such kind of studies are carried out, issues inclined toward psychographics will continue to be discussed using facts devoid of empirical backing. The main objective of the present study is to use a spatial statistical approach to test if informal operators' psychographics depends on their understanding of town principles since psychographics "vary across behaviours and situations" (Azjen, 1991, p 188). Essentially, it seeks to find solutions to unanswered questions and challenge unquestioned answers. The hypothesis of this study is as follows: "Informal manufacturers' psychographics does not depend on their understanding of town planning principles".

CONCEPTUALISATION: TRACING THE TOWN PLANNING IDEOLOGY

Tracing competition for space through a historical lens perhaps explains the planning thought and practice. Space is political and people can do anything within their means to control land and land-embedded resources (Elden, 2007). All activities happen in space regardless of the type of activity (social, economic, recreational or industrial). However, activities in space should not be allowed to take

course haphazardly but should be systemised. Thus, our key question is: what informs the orientation of activities in space? What is the rationale behind systematically arranging activities in space? How best can activities that mushroom in space be controlled? These and like questions are best answered by the planning ideology.

Planning principles can be traced back to the ancient Greek and Roman cities where the structure of settlements was designed to promote order, health, security and safety. Being agro-based cities, agricultural activities were separated from cultural and recreational land uses (Mumford, 1938). Another notable milestone in the history of town planning is the industrial revolution in Britain in the late 19th century. During this period, there was growth in manufacturing activities, leading to the over-concentration of industries and settlements adjacent to industrial sites. Serious health problems presented themselves and awakened planning authorities to consider separating industrial and residential land uses (McAuslan, 1980; Heap, 1996). Zoning laws were enacted to promote order and public health.

The promotion of planning principles is backed by planning law, regulations, statutory plans and planning standards in deciding settlement structures (Wekwete, 1989; Chaeruka, 2002). In Zimbabwe, layout plans, development plans and master plans are designed with the view of fulfilling the main object of the Regional, Town and Country Planning Act (RTCPA) of 1996. The Act stresses that standards contribute towards promoting health, safety, order, aesthetics, amenity, welfare, convenience, efficiency and public interests. Through part IV, the act provides for development control and how it should be exercised in the country. Despite the clarity of the planning framework in dealing with activities that violate the provisions of the planning ideology, the informal sector seems to be 'free riding' than anything, a mess and resilient to planning control (Chirisa, 2007; Dube and Chirisa, 2012). The next section gives a theoretical inquiry into the knowledge, attitude and perception of informal operators given town principles.

THEORETICAL FRAMEWORK

The meta-analytic review of the Theory of Planned Behavior (TPB) by Armitage and Conner (2001, p 471) revealed that "27% and 39% of the

variance in behaviour and intention, respectively" are accounted for by the TPB. This partly explains why the TPB has received mass support in literature as a useful tool for foretelling different behaviours and behavioural intentions (Van den Putte, 1991; Godin, 1993; Blue, 1995; Conner and Sparks, 1996; Godin and Kok, 1996; Hausenblas, Carron and Mack, 1997). Inspired by Armitage and Conner's (2001) meta-analytic review, the present study used the TPB to explain the interplay between informal operators' cognitive human factors (attitude, perception and knowledge) and town planning principles (order, safety, health and amenity). The TPB is premised on three primary building blocks; behavioural, normative and control beliefs (Azjen, 1991).

These primary building blocks feed into secondary building blocks: attitude, subjective norm and perceived behavioral control (PBC). All three secondary building blocks inform intention which then influences behaviour. However, PBC can directly influence behaviour in selected cases (Armitage and Conner, 2001). This summative descriptor of the TPB is best illustrated diagrammatically in Figure 1. It must be noted that this paper adapts only the secondary building blocks (highlighted in a dark shade) of the TPB to explain whether informal operators' psychographics depends on their understanding of town planning principles. Where other parts of the TPB are referred to, it will be to clarify certain issues or explain circumstances

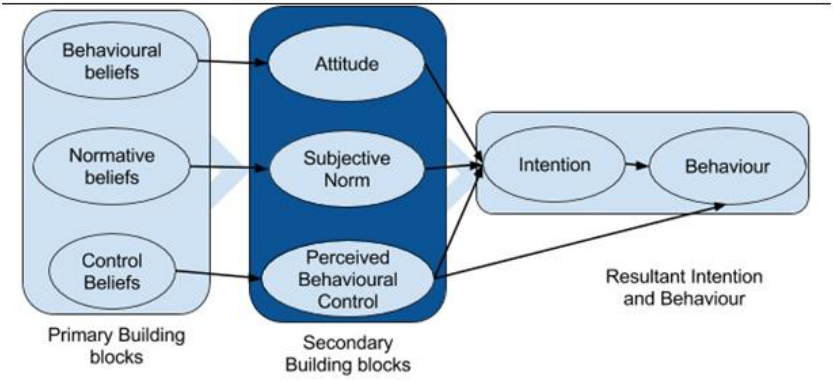

Figure 1: Theory of Planned Behavior (Adapted from Armitage and Conner, 2001)

Attitude refers to a person's evaluation of a given phenomenon. Attitude can either be positive or negative (Azjen, 1991). Where the attitude towards a specific behaviour is more positive, "the stronger the individual's intention to perform it" (Armitage and Conner, 2001, p 474). Whether positive or negative, attitude depends on behavioural beliefs, that is, the assumed cost or benefit of acting in a certain way. In cases where the assumed benefits outweigh the costs, individuals are more likely to develop a positive attitude toward something and vice versa. Subjective norm is defined as 'an individual's perceptions of general social pressure to perform (or not perform) the behaviour" (*ibid*.). The intention to act in a particular way depends on one's perception or knowledge that some significant others will approve or disapprove of the intended act. In the context of informal operators, general social pressure is likely to come from other operators who are likely to motivate the approval or disapproval of certain behaviour. The fundamental feature of the TPB, which differentiates it from the Theory of Reasoned Action (TRA) is the inclusion of PBC (Azjen, 1991; Conner and Sparks, 1996; Godin and Kok, 1996). PBC defines a set of potential constraints on the action as perceived by the actor. It is argued that PBC feeds from control beliefs which explain the perceived power of inherent factors to facilitate or inhibit the performance of the behaviour (Ajzen, 1991).

The underlying infrastructure of TPB's secondary building blocks (that is, attitude, subjective norm and PBC) are corresponding beliefs explained in the foregoing. These basic factors are widely known in psychological circles as the underlying cognitive structure or human factors (Azjen, 1991; Van den Putte, 1991; Godin, 1993; Blue, 1995; Armitage and Conner, 2001; Adjibolosso, 2013). Arguably, the quality of human factors is paramount (Adjibolosso, 2013; Chirisa, Mavhima, Matamanda, 2018). In this case, human factors are concerned with understanding the interaction of informal manufacturers and town principles. Dabengwa (1998: p 198) quoted in Chirisa, Mavhima, Matamanda (2018, p 52) has noted that "human factors must be directed towards developing the character content of the human beings who carry out the economic development of their society".

Realising optimum human factor quality is envisioned to promote livable working environments devoid of accidents, noise and pollution. It has been noted that "the relative importance of attitude,

subjective norm and perceived behavioural control in the prediction of intention is expected to vary across behaviours and situations" (Ajzen, 1991: 188). Armitage and Conner (2001: 471) concluded that the subjective norm construct is generally "a weak predictor of intentions" as compared to PBC and attitude. Ajzen's (1991) meta-analysis of the TPB found a multiple correlation coefficient of attitude, subjective norm and PBC, with an intention of $r = 0.71$, signifying a very strong positive relationship. In the present study, we wish to determine how human factors (specifically, attitude, knowledge and PBC) of informal operators vary in the context of town planning principles.

RESEARCH METHODOLOGY

The study was carried out in the Harare Metropolitan Province of Zimbabwe as shown in Figure 2.

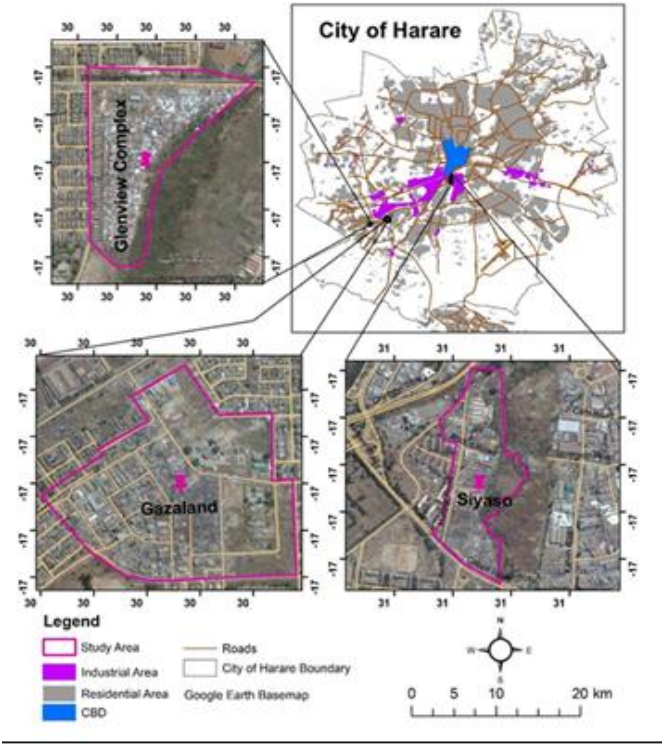

Figure 2: Location of Study Areas (Google Maps, 2016)

The study was designed using the multiple case study of three sampling windows (study sites), that is, Siyaso, Gazaland and Complex Home Industries in Harare, Zimbabwe.

Within the multiple case study of three home industries, only the embedded case of informal manufacturing was studied. Informal manufacturing, in the secondary level of production, was purposively selected because it accounts for a larger proportion of activities in terms of both the level and value of trade. Informality in Zimbabwe and elsewhere is cross-sector visible, found in the primary, secondary and tertiary levels of production (Chirisa, 2009; Miraftab, 2009; Varley, 2009; Dube and Chirisa, 2012; Majumdar and Borbora, 2012; Shah, 2012). In comparison to other levels of production, the secondary level of production generates large volumes of activity and employs a substantial number of people (Hart, 1973; Despres, 1988; Sparks and Barnett, 2010; Majumdar and Borbora, 2012). The diagrammatic illustration of the multiple-embedded case study design adopted for this study is shown in Figure 3.

Drawing up experiences from three different cases, arguably, guaranteed conclusive power (Johnson and Onwuegbuzie, 2004; Creswell, 2005; Yin, 2006; Saunders, Lewis and Thornhill, 2009). This strategy helped in tracing similarities, congruencies and variations in patterns of behaviour and assumed a positive correlation between operators working in neighbouring areas. Within the multiple-embedded case study, a sample survey was used to gather data from the informal manufacturers. That survey helped in mapping the spatial distribution of informal manufacturing activities in home industries.

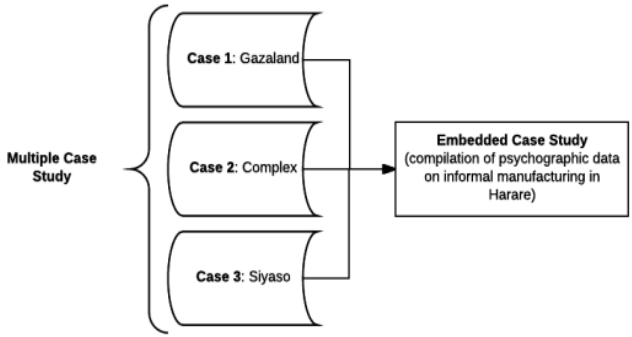

Figure 3: Multiple-Embedded Case Study Strategy (Adapted from Johnson and Onwuegbuzie, 2004; Yin, 2006)

A customised android mobile geo-application, based on Geographic Position System (GPS), was developed by a data scientist specifically for use in data collection for the survey of informal manufacturing in Harare.

Snowball sampling made it easy to utilise the spatial setting and assumed a positive correlation between manufacturers in establishing the trade flow network connecting informal operators.

With the help of a data scientist, Python scripts were used for data cleaning through the removal of null responses and erroneous (illegal values) due to typing mistakes by enumerators, e.g. an age value of more than 360 or less than five years. The cleaned and normalised data were analysed first in R language's Spatstat package to find measures of average and spread. Further analyses were done in R language using chi-square tests to determine whether the psychographics of individual operators depend on their understanding of town planning principles. Where there was dependence, the relationship was quantified using regression analysis and the strength of association was calculated using Pearson Product Moment Correlation Coefficient (PMCC). Complementary to the statistical analysis is a force field analysis which was used to systematically analyse the restraining and driving forces surrounding this complex town planning and urban informality impasse.

ANALYSIS OF STUDY RESULTS

The results are classified according to the psychographic-town planning principle nexus per study site. Results for all statistical tests were carried out at a 5% level of significance. On one end, collective results were determined using a chi-square threshold value of 15.507 corresponding to 8° of freedom and 0.05 level of significance, While n the other, site-specific results were determined using a chi-square threshold value of 9.488 corresponding to 4° degrees of freedom and a 0.05 level of significance. Any chi-square value above the threshold value led to the rejection of the null hypothesis in favour of the alternative hypothesis and vice versa. Semi-processed data, which led to the synthesised results in this section. Such data was captured using scenario-based questions crafted with hidden meaning as explained in the materials and methods section.

KNOWLEDGE-TOWN PLANNING RELATIONSHIP

A detailed quantitative investigation of the relationship between knowledge of informal manufacturers and each of safety, order, amenity and health is discussed in this sub-section. Table 1 shows a detailed summary of this relationship.

Table 1: Knowledge-Town Planning Relationship (Study Findings, 2017)

Relationship	Collective (N=642)		Gazaland (N=189)		Siyaso (N=242)		Complex (N=211)	
	χ^2	r^2	χ^2	r^2	χ^2	r^2	χ^2	r^2
Knowledge-Safety	32.38	0.001 6134176	31.613	0.0011 041917	6.294	0.0013 187531	9.164	$2.7291\ 837e^{-5}$
Knowledge-Order	23.155	0.000 4811912	21.128	0.000 8671894	7.54	$8.4711\ 278e^{-5}$	5.286	0.000 3639453
Knowledge-Amenity	23.941	0.0012 0932983617 6	19.154	$8.6725\ 3382700007e^{-7}$	11.784	0.003 5249975734 56	4.593	0.003 8636145
Knowledge-Health	26.65	0.003 7363499779 76	17.337	0.003 9613277912 46	5.732	0.001 9033849328 4	16.155	0.000 2578189145 44

Overall, informal manufacturers' knowledge depends on their understanding of all town principles (safety, health, order and amenity). This is supported by collective chi-square values which are above the cut-off value of 15.507 for all four relationships (see first column of Table 1). Despite the existence of positive relationships, collective results suggest that all relationships are very weak, with less than 1% of their knowledge explained by the variation in understanding of the town planning ideology (all collective r^2 values are below 0.001). The greater percentage, more than 99%, of the variation in this dependence is explained by other factors, other than human factors under study, sampling error included.

This overall interpretation is influenced largely by Gazaland whose contribution outweighs other sampling windows. This is probably because, informal as it is and disorderly as it appears, the degree of orderliness in Gazaland is far much better when one compares it with Siyaso and Complex. Such higher quality of orderliness promotes safety and health practices for both the manufacturers and the environment. Just like the collective results on the knowledge-town planning principle relationship, all chi-square values for Gazaland are above the threshold value of 15.507. This signifies that informal manufacturers' knowledge depends on their understanding of town planning principles. They have some knowledge of town planning principles, but their knowledge is, to a larger extent, clouded by the profit motive and probably a general lack of training on such issues.

For Siyaso, manufacturers' knowledge does not depend on their understanding of the safety, order and health principles given their chi-square values which are all below the 9.448 threshold value. Only, the knowledge-amenity relationship for Siyaso explains some form of dependence given the chi-square value of 11.784 which is above the threshold value. Even for a knowledge-amenity relationship where there is dependence, the degree of dependence is very weak ($r^2 = 0.00352$) with only 0.352% of the variation in their knowledge

explained by the relationship between knowledge and amenity principle. Knowledge of manufacturers working in the Complex does not depend on their understanding of safety, order and amenity ideology, giving their chi-square values of 9.164, 5.286 and 4.593 respectively which are all below the 9.448 threshold value. For the manufacturers in the Complex, the relationship between knowledge and health principle generated a chi-square value above the threshold value (16.155) implying that manufacturers' knowledge is, to some extent, explained by their understanding of health practices.

Whether knowledge of manufacturers working in the Complex depends on their understanding of town planning principles, the coefficient of determination for the four relationships studied is all less than 0.01, implying that more than 99% of manufacturers' knowledge is explained by other variables other than their understanding of safety, order, health and amenity principles. Thus, informal manufacturers' knowledge of town planning principles differs from site to site, though there is an insignificant difference across the three sites studied. Because of this insignificant difference, all relationships proved to be weak. So, the variation in informal manufacturers' knowledge is, to a lesser extent, explained by their understanding of town planning principles. This implies that the quality of the interaction of manufacturers' knowledge and town planning principles is very low.

ATTITUDE-TOWN PLANNING RELATIONSHIP

Informal manufacturers' attitudes toward town planning principles, which can either be positive or negative (Armitage and Conner, 2001), produced the results as summarised in Table 2.

Table 2: Attitude-Town Planning Relationship (Study Findings, 2017)

Relationship	Collective (N=642)		Gazaland (N=189)		Siyaso (N=242)		Complex (N=211)	
	χ^2	r^2	χ^2	r^2	χ^2	r^2	χ^2	r^2
Attitude-Safety	35.668	$5.0372704e^{-5}$	17.019	0.00057267 07	2.9894	0.0001116678	32.47	0.001164302
Attitude-Amenity	36.548	0.00189774 98	12.558	0.00051854 99	8.649	0.00896690 25	33.21	0.01435002 74
Attitude-Health	2.4244	0.00201453 49	1.0036	0.00110966 99	1.8554	0.00218074 43	0.8346	0.00034097 88
Attitude-Order	11.731	0.00411814		0.00112682		0.00583323		0.00213692

Attitude-safety and attitude-amenity relationships for Gazaland and the Complex resulted in chi-square values above the threshold value implying, that the attitude of informal manufacturers depends on their understanding of safety and amenity principles. This positive attitude towards safety and amenity shown by manufacturers working in Gazaland and the Complex partly explains why the collective chi-square values for these two relationships attitude-safety and attitude-amenity) is also above the cut-off value of 15.507. These results cloud the chi-square values for the same relationships for manufacturers working in Siyaso. Generally, manufacturers in Siyaso have a negative attitude (signifying poor human factor quality) towards safety, amenity and health. This is explained by chi-square values of 2.984, 8.469 and 1.8554, respectively, which are all below the threshold value of 9.448. The fact is that there are poor-quality human factors as far as health and safety are concerned. Thus, their negative attitude partly explains why they are dotted haphazardly in space without concern for the health and safety implications associated with over-concentration. In the long run, the existence of low-quality human factors will expose manufacturers and people residing in neighbourhoods surrounding sampling windows to health risks. Negative externalities such as health risks have more geographically concentrated impacts.

Shockingly, for all three sampling windows, manufacturers' attitude towards health is negative because of chi-square values which are all below the cut-off value. They seem not to care about health implications associated with land compartmentalisation practices within home industries, leading to a complex mixture of land uses. For example, an observed reality in all the home industries is that grinding dust circulates freely in the air finding its way to food being prepared adjacent to manufacturing activities. Such poor-quality human factors concerning public health could be a potential health hazard because some of the grinding dust may contain toxic substances with long-term negative effects.

PERCEPTION-TOWN PLANNING RELATIONSHIP

Findings relating to the perception of informal manufacturers towards town planning principles are presented in Table 3. Gazaland and Complex have comparable levels of dependence on manufacturers' perception of safety, order and amenity principles (all chi-square values are above the 9.448 threshold value). These perceptive results suggest that individual controlling beliefs in these two sites are shaped by their concern for safety, order and amenity practices. Such a positive concern is explained by good quality human factors towards town planning principles.

Table 3: Perception-Town Planning Relationship (Study Findings, 2017)

Relationship	Collective (N=642)		Gazaland (N=189)		Siyaso (N=242)		Complex (N=211)	
	χ^2	r^2	χ^2	r^2	χ^2	r^2	χ^2	r^2
Perception-safety	20.265	8.6991791e-5	10.497	2.9882393e-5	1.2381	0.0001112571	18.004	3.1117163e-5
Perception-order	22.023	0.00248675 96	18.031	0.00876782 97	2.8781	1.7470728e-5	11.182	0.00905671 98
Perception-amenity	43.45	0.00161862 91	37.07	0.00845387 02	5.196	0.0003532971	20.928	0.01179508 95

Siyaso generated results that are contrary to other sites. For each of the three relationships perception-safety, perception-order and perception-amenity, the controlling beliefs of individual manufacturers are not shaped or influenced by their understanding of town planning principles (χ^2 is less than the threshold value of 9.448). The perception-amenity relationship for the Complex is peculiar because the controlling beliefs of individual manufacturers contribute 1.17% to the variation in their amenity practices. Contrary to this, in all other relationships, regardless of sites, individual manufacturers' controlling beliefs contribute less than 1% variation in their practice of town planning principles.

DISCUSSION

Collective results of the three study sites revealed that informal manufacturers' knowledge, that is, human factor quality, depends on their understanding of each of safety, health, order and amenity (see first column of Table 1). Despite the existence of positive relationships, collective results suggest that all relationships are very weak, with less than 1% of their knowledge explained by the variation in understanding of the town planning ideology (all collective r^2 values are below 0.001). This finding is supported by Armitage and Conner's (2001) meta-analytic review of the TPB which concluded that the subjective norm construct is generally "a weak predictor of intentions" as compared to PBC and attitude. On the same note, Chirisa (2007)'s post-2005 Harare study of informality revealed that street vendors used their knowledge of town planning principles to escape development control. However, Chirisa's (2007) conclusion did not indicate whether this relationship is weak or strong because it was devoid of quantitative backing. It must be noted that the revealed weak relationship cannot be generalised across different sites since it differs between sites. It is also critical to note that collective and site-specific results of the perception-town planning principle and attitude-town planning relationships were found to be generally weak. All three vignettes encapsulated in cognitive human factors (knowledge, perception and attitude) revealed a very weak relationship with town planning principles. This is explained by coefficients of determination of at most 1.17% for all studied relationships. This is contrary to the conclusion by Armitage and Conner (2001) that the knowledge

vignette is generally a weak predictor of behaviour as compared to PBC and attitude.

CONCLUSION AND RECOMMENDATIONS

The foregoing paragraphs have revealed the relationship between three cognitive human factors (knowledge, attitude and perception) of informal manufacturers and each of the four constructs (health, order, safety and health) embedded in town planning principles. Of the 12 expected relationships per study site, one relationship was dropped at the data cleaning and reduction stage. Results of the final 11 relationships revealed that there is a generally weak relationship between informal manufacturers' cognitive human factors and town planning principles with varying degrees of weakness. Therefore, it is recommended that planning education must be scaled up with the view of improving informal manufacturers' knowledge, attitude and perception toward planning principles. It is envisioned that this will go a long way in changing their psychographics toward town planning principles. It is also important for future researchers to consider a deep dive into other factors that can predict the intentions and behaviours of informal manufacturers. Human factors are significant in understanding how the moral, aesthetic and human capital components must be improved, articularly, in changing the attitudes of manufacturers to be more positive, power-packed with faith, hope and love based on principles regarding what is wrong and right and having a deep sense of and love for order and the knowledge and acquired skills. This will go a long way in promoting order, health, safety and amenity, thereby sustaining livable environs.

REFERENCES

Adjibolosso, S. 2013. "Pursuing Sustained Socioeconomic Change in Africa: The Human Factor Way." *The African Business Review,* July-August: 043-048.

Armitage, C. J. and M. Conner. 2001. "Efficacy of the Theory of Planned Behavior: A Meta-Analytic Review." *Journal of Social Psychology,* 40: 471–499.

Ajzen, I. 1991. "The Theory of Planned Behavior." *Organizational Behavior and Human Decision Processes,* 50: 179–211.

Baddeley, A. 2010. "Modeling Strategies." In A. E. Gelfand *et al.* eds. *Handbook of Spatial Statistics.* Hershey.: Tailor and Francis.

Blue, C. L. 1995. "The Predictive Capacity of the Theory of Reasoned Action and the Theory of Planned Behavior in Exercise Research: An Integrated Literature Review." *Research in Nursing and Health,* 18: 105-121.

Chaeruka, J. 2002. Parameter and Practice of Development Control in Zimbabwe: An Evaluation of the System of Development Control with Emphasis on the Determination of Planning Permission and Appeals. Unpublished Mphil Thesis. Harare.: University of Zimbabwe.

Chirisa, I. 2007. "Post-2005 Harare: A Case of the Informal Sector and Street Vending Resilience. What Options Do Key Actors Have?" *Local Governance and Development Journal,* 1(1): 053-064.

Chirisa, I., B. Mavhima and A. R. Matamanda. 2018. "Youth, the Big Man Syndrome and Human Factor Decay in Urban Land Delivery in Zimbabwe." *Review of Human Factor Studies,* 24(1): 046-065.

Conner, M. and P. Sparks. 1996. "The Theory of Planned Behavior and Health Behaviors." In M. Conner and P. Norman, eds. *Predicting Health Behavior*. Buckingham.: Open University Press.

Creswell, J. W. 2005. Research Design: Qualitative, Quantitative and Mixed Methods Approaches. California.: Sage Publications.

Despres, L. A. 1988. Macro Theories, Micro Contexts and the Informal Sector: Case Studies of Self-Employment in Three Brazilian Cities. Working Paper Number 110. Michigan.: Kellogg Institute.

Dube, D. and I. Chirisa. 2012. "The Informal City: Assessing its Scope, Variants and Direction in Harare, Zimbabwe." *Global Advanced Research Journal of Geography and Regional Planning,* 1(1): 016-025.

Elden, S. 2007. "There is Politics of Space Because Space is Political." *Radical Philosophy Review,* 10(2): 101-116.

Godin, G. 1993. "The Theories of Reasoned Action and Planned Behavior: Overview of Findings, Emerging Research Problems and Usefulness for Exercise Promotion." *Journal of Applied Sport Psychology,* 5: 141–157

Godin, G. and G. Kok. 1996. "The Theory of Planned Behavior: A Review of its Applications to Health-Related Behaviors." *American Journal of Health Promotion,* 11: 87-98.

GOZ (Government of Zimbabwe). 2014. *The 2014 Mid-Year Fiscal Policy Review Statement: Towards an Empowered Society and a Growing Economy*. Presented to the Parliament of Zimbabwe on Thursday, 11 September 2014. Harare.: Government of Zimbabwe.

Hart, K. 1973. "Informal Income Opportunities and Urban Employment in Ghana." *Modern African Studies,* 11(1): 61-89.

Hausenblas, H. A., A. V. Carron and D. E. Mack. 1997. "Application of the Theories of Reasoned Action and Planned Behavior to Exercise Behavior: A Meta-Analysis." *Journal of Sport and Exercise Psychology,* 19: 36–51.

Heap, D. 1996. *An Outline of Planning Law*. England.: Sweet and Maxwell.

Johnson R. B. and A. J. Onwuegbuzie. 2004. "Mixed Methods Research: A Research Paradigm Whose Time Has Come." *Educational Researcher,* 33(7): 14–26.

Kanbur, R. 2009. "Conceptualising Informality: Regulation and Enforcement." *Indian Journal of Labour Economics*, 52(1): 33-42.

Keen, M. and R. Kanbur. 2015. "Reducing Informality." *Finance and Development,* 52(1): 52-54.

McAuslan, P. 1980. *The Ideologies of Planning Law*. Pergamon Press.: Oxford.

Majumdar, A. and S. Borbora. 2012. "Growth and Dynamics of the Informal Manufacturing Sector in Assam: A Comparison to the National Level." *Journal of Business Management and Social Sciences Research*, 1(1): 104-120.

Mazongonda, S. S. and F. Muromo. 2011. "Enforcement Orders in Harare: Tools for Promoting Development Control." *Zambezia,* 33(i/ii): 51-56.

Miraftab, F. 2009. "Insurgent Planning: Situating Radical Planning in the Global South." *Planning Theory,* 8(1): 32-50.

Mumford, L. 1938. *The Culture of Cities.* San Diego.: Harcourt Brace Jovanovich Publishers.

Muponda, G. 2012. Nurturing Latent Entrepreneurship and the Growth of Small Firms in Zimbabwe: A Case Study of Harare Metropolitan Province. Unpublished PhD. Thesis. Harare.: University of Zimbabwe.

Saunders, M. N., P. Lewis and A. Thornhill. 2011. *Research Methods for Business*. New Delhi.: Pearson Education.

Schneider, F. 2005. "Shadow Economies around the World: What do we Really Know?" *European Journal of Political Economy,* 21(3): 598-642.

Shabaneh, l. 2008. Measurement of Informal Sector in Adverse Conditions: Relevance of Methods. Bamako.: Palestinian Central Bureau of Statistics.

Shah, M. K. 2012. *The Informal Sector in Zambia: Can it Disappear? Should it Disappear?* Working Paper 12/0425. London.: International Growth Centre.

Sookram, S., P. K. Watson and F. Schneider. 2006. Characteristics of Households in the Informal Sector of an Emerging Economy. Available at: https://pdfs.semanticsscholar.org/c3aa/597e1440cf691a5ee7dd5d00470b8913b0cc.pd
[Accessed 28 June 2018].

Sparks, D. L. and S. T. Barnett. 2010. "The Informal Sector in Sub-Saharan Africa: Out of the Shadows to Foster Sustainable Employment and Equity." *International Business and Economics Research Journal,* 9(5): 001-012.

Uzhenyu, D. 2015. "Formalisation of the Informal Sector in Zimbabwe: A Key Success Factor to Sustainable Development." *Journal of Business and Management,* 17(10.Ver. II): 64-75.

Van den Putte, B. 1991. 20 Years of the Theory of Reasoned Action of Fishbein and Ajzen: A Meta-Analysis. The Netherlands.: University of Amsterdam.

Varley, A. 2013. "Postcolonialising Informality?" *Environment and Planning D: Society and Space,* 31(1): 4-22.

We were K. H. 1989. *Planning Laws for Urban and Regional Planning in Zimbabwe: A Review*. RUP Occasional Paper No. 20. Harare.: University of Zimbabwe.

Yiftachel, O. 2009. "Theoretical Notes on 'Gray Cities': The Coming of Urban Apartheid." *Planning Theory,* 8(1): 87-99.

Yin, R. K. 2006. "Mixed Methods Research: Are the Methods Genuinely Integrated or Merely Parallel?" *Research in the Schools,* 13: 41–47.

ZIMSTATS. 2012. *Labour Force Survey*. Harare.: Government of Zimbabwe.

Environmental Impacts of Unutilised Fly Ash and its Potential Utilisation for Soil Productivity and Food Security

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Abstract

The combustion of coal during thermal electricity generation produces huge volumes of fly ash solid waste. The disposal and storage of dry fly ash in the environment have resulted in high nutrient concentration levels becoming toxic to humans, air, soil and water environments. Soil nutrient deficiency is limiting sustainable food productivity with soil nutrient deficiencies and limited access to fertilizers or biological options aggravating the predicament of hunger. This study focused on assessing the environmental impacts of fly ash and its potential utilisation in crop production. The study was conducted at Harare Power Station (17^0 50′ S and 31^0 1′ E) and Harare Experimental Station (17^0 49′S and 31^o2′ E). Mixed research methods were used. To unearth the environmental impacts of fly ash qualitative research approach guided by the interpretivism paradigm was applied. Purposive sampling of six key informants was implemented and data was gathered using in-depth and semi-structured interviews. Thematic content analysis was used to analyse the data. To evaluate the potential utilisation of fly ash for sustainable crop production, laboratory analysis of the physical and nutrient composition of fly ash was undertaken. To evaluate the effects of fly ash on tomato, cucumber and rape crops, a field experiment was set up. A Randomised Complete Block Design (RCBD) with five treatments, replicated three times, was implemented on each of the crops. The analysis of variance was used for analysing the results. Results showed that dumped and stored fly ash caused air pollution, groundwater contamination, human health

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effects and soil pollution. Fly ash can potentially be used in crop production to control soil-borne pests and diseases and improve the physical and nutrient characteristics of soil for improved crop yields. The application of fly ash had a significant effect ($P<0.05$) on the growth and yield of tomatoes, cucumbers and rape. The highest yields were realised at 25% fly ash soil concentration, while 100% fly ash was toxic.

Keywords: Waste; Sustainable; Nutrients, management; Soil

INTRODUCTION

Sub-Saharan Africa continues to face multiple environmental management challenges that include pollution, poor waste management, deforestation and land degradation (ZINDC, 2016). Coal combustion during thermal electricity generation produces huge volumes of fly ash solid waste that is finally disposed into the environment becoming a major concern to African communities (Kishor *et al*., 2010). Where fly ash is generated, piles accumulate as waste, resulting in high nutrient concentration levels becoming toxic to air, soil and water ecosystems. Exhaustion of allocated fly ash landfills and increased demand for more space to dispose of the fly ash have resulted. Environmentally sound production systems aimed at ending poverty and hunger, climate action and building sustainable cities and communities are crucial for Sub-Saharan Africa to achieve sustainable development. The exhaustion of soils over many years of cultivation and limited access to fertilisers or biological options aggravates the predicament of attaining sustainable development. Farmers have resorted to the application of agricultural lime to amend soil acidity status and increase crop yields. However, the method contributes to global warming as the carbon in lime is finally released into the atmosphere as carbon dioxide (Basu *et al., 2009*). Due to the nutrient composition of fly ash, its controlled utilisation in crop production can improve soil texture, amend water holding capacity, increase soil pH and enhance soil fertility (Carlson and Adriano, 1993). Thus fly ash can be utilised as a by-product in crop production to enhance the low nutrient and depleted status of Sub-Saharan African soils, rather than stored as unutilised waste at power stations. Therefore, exploring the

controlled utilisation of fly ash in crop production creates a platform for sustainable waste recycling and increased food production. Currently, farmers' practice of applying fly ash in cropping fields is negligible because there is limited lab-to-land research to unearth optimum rates of fly ash application for crop production. Given developmental problems like a burgeoning population, growing food demand and shrinking natural resources, it is necessary to sustain the production of crop yields and soil health in an eco-friendly way. Thus there lies a challenge to convert the environmental threat of fly ash into an opportunity for ensuring food security.

Industrialisation, urbanisation and population growth are traits of present-day African society that are becoming inevitable, contributing to growing electricity demand (Lockeshappa and Dikshit, 2011; UN, 2019). Industrialisation's negative impacts on the environment and social life are the production of large quantities of industrial waste and the problems associated with waste's safe management and disposal, scarcity of land, materials and resources for developmental activities (Senapati, 2011). Urbanisation and population growth require more electricity from coal-based thermal power plants, resulting in large amounts of waste being generated causing environmental health degradation The disposal of fly ash into the environment is a major concern throughout the world (Kishor *et al*., 2010) and may become costly (Basu *et al*., 2009). Fly ash can be considered either as a waste or as a resource yet to be fully utilised (Lokeshappa and Dikshit, 2011). According to Wang and Wu (2006), sustainable methods for the utilisation of fly ash to avert its increasing toxic threat to the environment and to streamline affordable waste disposal techniques are being sought.

In Sub-Saharan Africa, soil nutrient deficiency has increasingly become a stumbling block to sustainable food production and exhaustion of soils over many years. Also, high costs of fertilizers or biological options aggravate the problem of land, food shortages and poverty. Sustainable fly ash waste management in agriculture production systems complements the green economy concept that results in

improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). Agriculture can logically offer economically and environmentally sustainable fly ash waste management in crop production rather than disposal in landfills (Singh *et al*., 2010). Utilising fly ash in amending dilapidated soil status provides opportunities for economic growth, poverty alleviation and food security without liquidating or eroding natural assets.

THEORETICAL FRAMEWORK

Solid waste management and food security can be best comprehended from the Integrated Sustainable Waste Management (ISWM) and Sustainable Livelihoods Approach (SLA) frameworks. The ISWM examines the physical and governance aspect of waste management (Wilson *et al*., 2013). The physical aspects involve collection, disposal and recycling, while governance aspects include users and service providers, financial sustainability and coherent and sound institutions underpinned by proactive policies. It is an approach to reaching better and more sustainable solutions to fly ash solid waste problems (Solomon, 2011). The important principle of ISWM is that a waste management system should be appropriate for local conditions and be feasible from a 'technical, environmental, social, economic, financial, institutional and political perspective' (Anschutz *et al*, 2004 cited in Solomon, 2011). The ISWM offers the greatest opportunity to develop a sustainable fly ash waste management system by considering the environmental, economic and social aspects of waste management. In the case of fly ash, ISWM will aim at combining waste streams, waste collection, treatment and disposal methods into a practical waste management system that aims to provide environmental sustainability and social benefits for the Sub-Saharan African populace. It considers the total system and looks for the best mix of treatment methods in crop production to minimise the economic costs of crop production and maximise environmental protection and food security social benefits. The level of integration within the ISWM system will be dependent upon the current prevailing dilapidated soil conditions and

its potential to improve soil productivity for increased food security. Within the context of sustainable development, there is a need to curb the growth of unutilised fly ash in the environment. Therefore, where fly ash is produced, there is a need to recognise it as a resource and recover more value from it. Thus the fundamental aim of any waste management strategy should be the maximisation of resource efficiency by promoting sustainable waste management.

The SLA is a way how marginalised communities utilise available resource portfolios on both short and long-term basis to be able to cope with and recover from shocks and stresses through adaptive coping strategies that should be economically sound, ensuring that livelihood activities do not irreversibly degrade natural resources within a given ecosystem. The SLA refocuses development efforts on the elimination of poverty and encouragement of economic growth that benefits the poor through sustainable development, whose aims are to create sustainable livelihoods for marginalised people by promoting development and conserving the environment (Solesbury, 2003). Due to population growth, rapid urbanisation, poverty, growing food demand and shrinking natural resource base, the SLA is best suited as it stresses utilising and building on the best existing tools for the circumstances which may include reducing, recycling, re-using waste and also an analysis of how they will affect the environment by incorporating the sustainability context. Thus, environmental impacts of unutilised fly ash utilisation come as waste material generated and managed by institutions which can be utilised as a resource input for use in degraded soils by farmers for sustainable crop production so that they achieve short-term and long-term household food security and increasing output per unit land area hence poverty reduction.

METHODOLOGY

A case study to identify the impacts of unutilised fly ash was carried out at the Harare Power Station. The station is a thermal-based electricity production plant located in the Workington area of the Harare Central Business District (17^0 50′ S and 31^0 1′ E). To evaluate the

potential use of fly ash in sustainable crop production and evaluate the effects of fly ash on tomato, cucumber and rape production, a glasshouse experiment and laboratory analysis, were conducted at the Harare Experimental Station, Zimbabwe. The site lies on 17^0 49'S and $31^o2'$ E at an altitude of 1513m above sea level.

The guiding paradigm of this research was triangulation using qualitative and quantitative research methods. A case study to understand the environmental impacts of fly ash and its potential use in crop production was explored using interpretivism grounded in phenomenology. Key informants from the Environmental Management Agency (EMA), National Social Security Authority (NSSA) and the Zimbabwe Power Company (ZPC), explained in detail the potential environmental impacts resulting from fly ash piles. The Department of Research and Specialist Services key informants and a farmer using fly ash as cropping media were also interviewed to unearth the potential use of fly ash in cropping systems. Data samples from the total population were drawn based on the quality of information they could provide. In data generation, the selection of the units was based on the characteristics of the sample relative to the understanding of the environmental impacts of unutilised fly ash and from which one can learn the most and gain understanding and insight. Qualitative data were generated through key informant interviews and semi-structured interviews using interview guides. Thematic content analysis was used to analyse the qualitative data obtained from the key informant interviews.

To evaluate the potential utilisation of fly ash in sustainable crop production, laboratory analysis for the chemical and nutrient composition of fly ash was undertaken. Fly ash samples collected from different parts of the Harare Power Station landfill were mixed to form a composite sample, while the Domboshava soils were also independently analysed to determine the initial nutrient composition.

Table 1

Property	Method of analysis	Reference
Texture (g Kg^{-1}):	hydrometer	Bouyoucos
Nitrogen(%)	Kjeldahl	(Barker and Pilbeam, 2010)
Phosphorus%	Spectrophotometer	(Faithfull, 2002)
Calcium%	AAS	(Fertasa, 2016)
Potassium %	1.0M Extraction	(Fertasa, 2016)
Sulphur%	Gravimetric	(Fertasa, 2016)
Magnesium%	AAS	(Tan, 2015)
Iron p.p.m	EDTA	(Fertasa, 2016)
Manganese p.p.m	EDTA	(Fertasa, 2016)
Zinc p.p.m	EDTA	(Fertasa, 2016)
Boron p.p.m	Hot water	(Fertasa, 2016)
Copper p.p.m	EDTA	(Fertasa, 2016)
Soil organic Carbon(g Kg^{-1})	Walkely-Black	(Okalebo *et al.*, 2002)
EC (s m^{-1})	Electrode	(Fertasa, 2016)
pH	$CaCl_2$	(Fertasa 2016)

To evaluate the effects of fly ash on tomato, cucumber and rape crops, a pot experiment in a glasshouse was done. A Randomised Complete Block Design (RCBD) with five treatments, replicated three times, was implemented on each of the crops. To reduce experimental errors, blocking was done against light intensity gradient and light direction. The treatment levels applied were zero (control), 25%, 50%, 75% and 100% concentration levels of fly ash. A total population of 30 plants in the gross plot areas for each of the crops was planted for evaluation. The cucumber shoots percentage was determined by a score count. Plant height was measured from the ground surface to the apical meristem using a graduated metal tape measure. Plant girth was measured at the plant crown using a vernier calliper. A physical stem count was done weekly and fully developed leaves were considered. The crop biomass yield was weighed using the electric sensitive scale (Salter- AND Ep 12Ka) to ensure yield accuracy. Collected data were subjected to Analysis of Variance (ANOVA) using GenStat 14th edition. Separation of means was done using the Least Significant Difference (LSD) test at a 0.05 probability level.

RESULTS AND DISCUSSION

ENVIRONMENTAL IMPACTS OF UNUTILISED FLY ASH

From the interviews, respondents indicated that there were environmental impacts resulting from the failure to utilise fly ash. The impacts revealed from interviews include air pollution, groundwater contamination and human health effects.

ATMOSPHERIC AIR POLLUTION

On atmospheric air challenges being faced by the Harare Power Company on their current handling and disposal system, the respondent highlighted that:

> "In the early summer season when it is dry, neighbouring industries complain a lot about dust emanating from our coal heaps and mists of grey dust are most common during the August and September period. This is one of the most difficult periods because environmental inspectors are always at our throats as they try to attend to complaints about dust brought before them by our surrounding community that operates within our vicinity."

The findings indicate that particulate matter of unutilised fly ash is easily blown by the wind into the atmosphere in large quantities and causes a lot of dust. Thus fly ash causes visual distortions to motorists which may result in accidents as the power station is situated near the Central Business District where there is high traffic movement. The transfer of fine grains of fly ash dust from heaped piles settles on the leaves of nearby vegetation around the power station, thereby reducing the photosynthetic area of plants and subsequent limitation of carbon sequestration. The movement of fly ash dust particles contaminates any food that is in proximity to the fly ash heaps. TheHarare Power Company is near a pig meat industrial company, hence it is be possible that the meat is exposed to potential contamination from fly ash. The dust particles also distort breathing air for those closer which may easily cause choking and long-term health after-effects. In this regard, the findings concur with Basu *et al*. (2009) that fly ash particles are ionospheric in nature, thus they are less dense (1- 8g cm^{-3}) such as non-magnetic and magnetic particles of 2.7g cm^{-3} and 3.4g cm^{-3} respectively and can easily be blown by the wind for long distances (Kishor *et al*., 2010; Basu *et al*., 2009; Natusch and Wallace., 1974). Furthermore, in responding to the question of possible

environmental hazards caused by fly ash, the occupational health practitioner indicated that dust is a major environmental hazard:

> "Most of the employees' internal health risks working with fly ash are related to the dust they breathe in the work environment. They inhale mineral dust through the nose and straight to the brain. This is why we advocate for the maximum mouth, eyes and ear protection gear for workers in the thermal electricity generation industry and enforce the frequent measuring of air dust particulate matter to check on the low threshold levels."

These are the reasons occupational health practitioners seeking to eliminate dust pollution, advocate for dust control measures at the Harare Power Station. It is these air pollution factors that contribute to global warming as greenhouse effects become evident through the mist and it further contributes to climate change and human health defects, creating unsustainable livelihoods. Based on ISWM, when air is being polluted, it is an environmental cost (Solomon, 2011) that has been created causing shocks and stress factors that are not sustainable for development based on the tenets of the SLA (Chambers and Conway, 1992). Thus it potentially creates the hazard of food contamination and related health effects that could reduce the human, financial, social and environmental capital of a nation.

HUMAN HEALTH IMPACTS

Accumulation of fly ash at the Harare Power Station landfill and its accumulation at the regulated dumpsite is directly associated with negative human health impacts because of direct exposure to fly ash as unearthed by this research study. When examined for potential conditions emanating from unprotected exposure to fly ash, the occupational health agent interviewed said:

> "Exposure to fly ash without efficient protection may cause three major internal health diseases, namely *Pneumoconiosis* also known as black lung disease, *Emphysema* (airway obstruction in the respiratory system) and industrial *bronchitis*. Generally, it also causes occupational cancers and asthma. Secondly, due to the nature of fly ash, it may initiate a spontaneous ignition which may result in a fire that may cause dermal burns on those exposed".

In addition, from an environmentalist point of view, he posited that:

> "Fly ash is a solid waste hazardous material which is injurious to human health because it contains sulphur, nitrous oxide and sulphur dioxide which in my understanding causes skin irritations, bronchi inflammation and skin sensitising phenomena to those exposed"

It is crystal clear that fly ash exposure to humans is hazardous and poisonous through direct conduct, inhalation and ingestion. The finding concurs with Sajwan *et al*. (1999) who noted that fly ash contains toxic trace elements described as poisonous that lead to detrimental health effects. This could be due to continued exposure that may eventually lead to lifetime injuries or death. Based on the response of the occupational therapist above, the causal agents of internal diseases pneumoconiosis, emphysema and industrial bronchitis could be attributed to the finer fractions of fly ash that are deposited into the lungs, respiratory tract and alveolar respectively as also identified by Senapati (2011), Singh *et al.* (2017) and Sajwan *et al*. (1999). Furthermore, Arsenic and Lead could be blamed for cancers and asthma (Benhard *et al*.,1986). The evidence provided by the environmentalist about inert concentrations of sulphur, nitrous oxide and sulphur dioxide in fly ash could be true that it may cause dermal disorders as also shown by Basu *et al.* (2009) that fly ash contains sulphur, which may be toxic with heavy concentrations. However, Hodgson and Holliday (1966) indicate that these toxic elements are drastically reduced through oxidation, and Page *et al. (*1979) support this view as they indicate that the toxic elements from Aluminium are bound in insoluble alumina-silicate, hence confining its biological toxicity. The handling, storage and disposal of fly ash should be done with extreme caution to avoid injuries or death. To avoid such hazards, the best alternative is to dispose of the fly ash. However, the researchers observed that the Harare Power Station offers workers protective clothing in the form of mouth muffs, helmets, rubber gloves, gumboots, work suits and transparent goggles. To reduce occupational hazards from an occupational health agent perspective, the company recommended that:

> "Regular watering fly ash, regular worker rotations, medical surveillance and withdrawing those detected, environmental surveillance by measuring dust particles and dust masking are the probable solutions to health risks associated with fly ash."

These procedures are expensive. For example, watering fly ash is wasting water which is a scarce resource while regular worker rotations require a larger labour force which is costly to replace and train more and environmental surveillance kits are deemed expensive given resource limitations. Thus, the only solution would be the

implementation of the ISWM, the fly ash management system being appropriate to local conditions and being feasible from technical, environmental, socioeconomic, financial, institutional, political and technological perspectives (Anschutz *et al*.,2004; cited in Solomon 2011). The health issues presented by un-utilising fly ash should be tackled in their entirety by considering the interconnectedness of components, operations and functions and therefore should recognise the full complexity of waste management practices (McDougall *et al*., 2001) by considering recycling and reusing fly ash as a major input in crop production. Thus total disposal of fly ash from landfill sites for agricultural purposes enhances increased production by deriving the nutrients in fly ash. It then provides coping mechanisms that are feasible to eliminate occupational shock and stress of sickness and injury at work, while increasing the worker's longevity to reduce household poverty as they remain in employment. This is how the SLA could achieve sustainable development when health impacts caused by fly ash are eliminated through fly ash utilisation.

GROUNDWATER CONTAMINATION

The interviews did not reveal much about the level of groundwater contamination. However, an analysis of how unutilised fly ash can contaminate groundwater can be made based on the 1993 chemical analysis done by Wankie Colliery in respect of fly ash waste used at the Harare Power Station. Table 1 indicates the inherent chemistry of the fly ash.

Table 1: Chemical analysis of fly ash from Harare Power Station

Element Analysed	Ultimate Analysis (%)
Carbon	88.29
Hydrogen	3.63
Nitrogen	1.99
Sulfur	2.87
Phosphorus	0.025
Chlorine	0.08
Silica	41.3
Alumina	33
Iron Oxide	14.8
Magnesium oxide	0.8
Titanium oxide	1.2
Alkalis	4.1

Results in Table 1 indicate that fly ash produced at the Harare Power Station contains an appreciable base, and essential and trace elements. Leaching of these elements from fly ash landfills into the ground causes water pollution. The fly ash contains Carbon, Nitrogen, Hydrogen, Sulphur, Phosphorus and Chlorine as bases. When in an aqueous environment, Nitrogen and Phosphorus are highly associated with algae formations. Furthermore, the addition of nitrogenous material into the water system results in increased acidification of the groundwater, hence the alteration of the groundwater to saline conditions. Heavy metal elements, Iron, Sulphur, Calcium, Magnesium and alkalis, have heavy leaching characteristics as propounded by Sadasivan *et al*. (1994). These elements percolate from unutilised fly ash in landfills, resulting in groundwater contamination (Basu *et al*., 2009). However, Rohriman (1979) noted that the solubility of trace and heavy metals in fly ash is less than 10%. According to Natusch (1975), 5-30% of toxic elements such as Copper are leachable and the concentration of this element is considered low. Its chances of leaching are also considered negligible to cause groundwater pollution. These findings simulate that the alkalis components of the fly ash analysis are 4.1% and are considered negligible to cause groundwater contamination. However, it is not clear on the safety level of the groundwater for consumption as no analysis has been done (Basu *et al*., 2009).

Failure to utilise fly ash and recover value from it (ISWM) results in contamination of groundwater which depletes the water resource for use by future generations. This entails a livelihood becoming unsustainable without the capacity to cope with and recover from stress and shock situations, undermining its capacities and assets, leading to failed contribution on net benefits to other livelihoods at all levels in the short and long term (Chambers and Conway, 1992).

POTENTIAL UTILISATION OF FLY ASH IN CROP PRODUCTION PEST AND DISEASE CONTROL

It has been established that soil-borne pests and diseases can be controlled by using fly ash in crop production. Responding to how the farmer got to know about the use of fly ash in crop production, the farmer:

> "Our first ever tomato crop under greenhouse production and using the conventional production system suffered over 25% crop loss from nematode destruction. We then inquired how we would be able to tackle the problem from a seasoned farmer from the Goromonzi District who recommended we use coal rubble as a hydroponic production system. In trying to source coal rubble, we could not find it on the market and we settled for fly ash which we only got after failing to acquire coal rubble. On our first crop under fly ash production, we have not lost a single plant due to nematodes".

From the response given, it is evident that fly ash has the potential to control nematodes. This may have been possible through the creation of unfavourable conditions for the survival of the pest. This is achieved through disturbing microbial-mediated processes in the soil ecosystem (Babich, 1983). The application of fly ash was reported to inhibit microbial respiration and enzymatic activity of soil habitat micro-organisms (Garau *et al*., 1991; Karpagavalli and Ramabadran, 1997). Pitchel (1990) reported that the addition of 20% fly ash in soil reduces the growth of soil-borne pathogenic bacteria. Similar outcomes were noted by Khan *et al*. (1997) when 30% fly ash and soil mixture reduced the penetration and reproduction of nematodes in tomatoes. Furthermore, Ahmad and Alam (1997) reported a reduction in root galling signs, resulting from root-not nematode infestation when fly ash was applied to the tomato crop.

The availability of excessive soluble salts and trace elements in fly ash is thought to be an inhibitor for the survival of the nematode pest as it cannot survive in extremely alkaline conditions (Sim *et al*., 1995; Basu *et al*., 2009). This notion is evident from the laboratory analysis of the fly ash which recorded a pH value of 7.9, contained high exchangeable cations (Potassium 0.29mg/100g; Calcium 70.28; Magnesium 0.88mg/100g) and heavy metals, Zinc 123.6ppm and Copper 17.4ppm), creating alkaline conditions which inhibited nematode infestation in the tomato crop. However, Gaind and Gaur (1991) identified fly ash's ability to enable the proliferation of micro-organisms that enhance the availability of Phosphorus. The micro-organism is known as *Arbuscular mycorrhiza.* These bacteria are beneficial in tomato and cucumber production and are available and effective at alkaline pH for Phosphorus fixation (Hayman and Mosse, 1971). However, high alkaline properties of fly ash have inhibitory effects (Basu *et al*., 2009) on microbial respiration and enzyme activities of Rhizo-bacteria that

are responsible for nitrogen fixation (Pitchel 1990; Garau *et al*., 1991 and Karpagavalli and Rambadran 1997) in legumes. The detrimental effects are, however, reduced during natural leaching (Sims *et al*., 1995).

In light of the ISWM, fly ash has been used to detoxify the soil in a manner that is ecologically friendly, reducing economic loss and maximising social benefits in a socially acceptable manner (Wilson, 2013). Thus fly ash has been utilised as a replacement for ozone-depleting Methyl-bromide in preventing root-not nematode infestation. Thus sustainable fly ash waste management complemented the green economy by significantly reducing environmental risks and ecological scarcity according to UNEP (2011). Relating to SLA, unutilised fly ash material that poses danger to the environment as a green solid waste was used in livelihood crop production activities to avoid shocks of economic loss from nematode infestation and cost of fumigants and poverty by safeguarding production. This was also done in an eco-friendly manner by observing the Montreal Protocol policy as the farmer avoided using chemicals such as Methyl-bromide that depletes the ozone layer.

IMPROVED SOIL PHYSICAL CHARACTERISTICS FOR SUSTAINABLE CROP PRODUCTION

One of the benefits of using fly ash in crop production, as stated by the farmer, was that fly ash has abilities that can be used as an effective soil medium for crop growth. The farmer used coal rubble in a hydroponic system which is a crop-growing media. A follow-up question was how the farmer was using the available fly ash as a hydroponic system to their advantage and the farmer said that:

> "We fill 5-kg black poly-sleeves with fly ash and we grow our plants in there, we practice all agronomic practices such as fertilization and irrigation while the plants are in these plastic sleeves."

Fly ash waste can certainly be used as a soil medium in which crops can be grown. It has properties that enable it to be classified as a good soil medium. It showed that fly ash has an excellent draining and water-holding capacities and minimises leaching. The view is also supported by the finding of the laboratory analysis which unearthed that fly ash possesses fine-grained clay loam, showing that it is capable

of retaining sufficient water and nutrients without leaching them to enable efficient and effective crop growth.

Plate 1: Cucumber crop grown on fly ash by the farmer.

Photos by Tinashe Magada M in Harare (31/01/2017; 24/02/2017 and 03/03/2017)

Fly ash exhibited properties such as availability, ability to reproduce crops, good moisture and nutrient retention, optimum infiltration, aeration and drainage, good cation exchange capacity and alkaline pH as similarly highlighted by Arteca (2015). Concurrently, Ghodrati *et al*. (1995) identified microporosity and water-holding capacity to be advantages derived from fly ash use in the soils. The application of fly ash in crop production was shown to improve the structure, reduce soil crusting and promote good seed emergence in fine-textured soils.

The fine-grained silt clay textural characteristic extracted from the laboratory soil analysis results shows that fly ash has a low-bulk density compared to some soils which are crucial for effective crop growth. The results were further supported by the experience of the farmer who indicated that:

> "We are now able to produce throughout the season. Previously, during the summer rainy season, our land was mostly clay and highly water logging to the extent that no cropping took place and fly ash emerged to solve this problem".

The response showed that fly ash has abilities to drain excess water from the soil. Water-logging restricts root respiration, resulting in total crop failure which is a characteristic of clay soils. The bulk density characteristics of fly ash could be attributed to circumventing waterlogging conditions. Plate 2 shows evidence of water-logging that inhibits all year-round crop production.

Plate 2: Water-logging conditions precluding conventional crop production leading to fly ash utilisation by the farmer.
Photos by Tinashe Magada M in Harare (31/01/2017)

Chang *et al*. (1977) and Basu *et al*. (2010) identified bulk density as the physical properties that enable fly ash to be considered a cropping medium. Jones and Amos (1976) reported a low-bulk density when 50% fly ash was added to soils. Fly ash application rates of 5%, 10% and 15% weight to clay soils were observed to lower the bulk density of the soil (Kene *et al*., 1991; Garg *et al*., 2005). Prabakar *et al*. (2004) claimed that the reduction of dry density of soil in the order of 15-20% when fly ash was added at 46%, resulted in low specific gravity of the soil. Fly ash has a high surface area and it is light textured, resulting from porous carbonaceous cenosphere particles with a range of 4µm-

70µm in size, comprising 8-85% silt, 0-10% clay, 7-90% sand (Kishor *et al*., 2010) which reduces its density to less than 1% (Hodgson and Holliday, 1966).

The outcome of the ability of fly ash to work as an effective soil medium identified through this study emanates from the characteristics of fly ash. The characteristics, as propounded by Kishor *et al*. (2010) and Natusch and Wallace (1974), are that fly ash bulk density ranges between 1-8gcm^{-3}, water-holding capacity is generally between 49-66% on a weight basis, while moisture retention from 6.1% at 15 bar and 13.4% at 1/3 bar. Additionally, the specific gravity of fly ash ranges between 2.1 to 2.6 g/cm^{-3} with average particle densities for non-magnetic and magnetic particles of 2.7 and 3.4 g cm^{-3}, respectively (Basu *et al*., 2010).

Rather than dumping fly ash in landfills or dumping sites as the current norm, agricultural crop production can offer economic and sustainable fly ash waste management solutions as a cropping medium, proving the view held by Singh *et al*. (2010). Thus, it has properties to be involved in the ISWM as a waste resource with benefits. It has abilities to create physical and biological characteristics of soil that improve the soil structure for efficient crop production.

SOIL AMELIORATE

From the laboratory analysis, fly ash from the Harare Power Station has potentially proven good characteristics as a soil amendment input. Based on the calcium chloride scale, pH of 7.9, Calcium-70.28, and medium-free carbonates have shown that it is highly alkaline and can be mixed in the soil as a liming agent to amend soil acidity which inhibits efficient and effective crop growth. From the results, fly ash has demonstrated capabilities to be a potential liming material without a doubt. The analysis of Domboshava soil shows that it could have limited crop growth as it had pH 5.0 resulting in limited crop growth in the control treatment compared to 25% fly ash.

Similar pH and carbonates are the major chemical characteristics in fly ash said to be principal benefits of its ability to neutralise acidic soils (Matsi and Keramidas, 1999; Pathan *et al*., 2003; Cetin and Pehlivan,

2007). Its liming capabilities and alkaline nature were recorded to be able to neutralise soil acidity and provide plant nutrients (Phung *et al*., 1978; Taylor and Schumann, 1988). According to Mittra *et al*. (2004), soil Phosphorus is made available mainly for plant uptake when soil pH is increased, while the acidity is reduced. The application of fly ash to soil was identified to reduce soluble metal toxicity, affect micronutrient availability and enhance soil organism nitrification and soil conditioning (Hayman and Mosse., 1971). It was further unearthed that a decrease in pH below 5.5 results in an increase in aluminium and manganese availability to the plant and reaches a point of toxicity to those plants (Mittra *et al*., 2004). Through continuous cultivation, Zimbabwean soils have been identified to have highly acidic with multiple nutrient deficiencies (Nyamangara and Mpofu, 1996), leading to pH values of less than 5.0 which are prone to Aluminium toxicity, resulting in impediment of maximum crop yields for sustainable livelihoods. To avert this, farmers have resorted to using agricultural lime (Sanchez, 2004), a practice that has been identified to contribute to climate change (Basu *et al*, 2009), due to global warming as the carbon in agricultural lime is finally released in the atmosphere as carbon dioxide (IPCC, 2007; Basu *et al*, 2009). Integrating fly ash, regarded as waste by local police authorities, in crop production as a soil amending resource, assists in sequestering carbon dioxide in the atmosphere, ensuring sustainable livelihood through increased crop output and contributing to minimising global warming as noted Ferreira (2003) and Montes *et al*. (2008). It thus leads to the amalgamation of the ISWM and SLA approaches to development by eliminating the effects of global warming and ensuring food security and increased income at household levels. It also contributes to reducing land degradation caused by lime mining as fly ash would be readily available.

SOURCE OF CROP NUTRIENTS

Fly ash derived from the Harare Power Station is a source of essential plant nutrients. The laboratory soil analysis report from the Ministry of Agriculture unearthed that fly ash is a source of Potassium (0.29mg/100g), Magnesium (0.82mg/100g) Calcium (70.28mg/100g). It also contains heavy metals (Zinc,123.6 and Copper, 17.4) that are essential for maximising crop growth. However, it has low readily available Nitrogen (5 ppm) and Phosphorus (9 ppm) that are not

sufficient for crop growth. Mixing the fly ash with soils from Domoshava which are medium-grained sandy with an acidic pH(5.0) containing Potassium (1.04mg/100g), Magnesium (0.88mg/100), Zinc (2.4) and Copper (16.8) will improve te potential capabilities of the soil to efficient crop production that maximise yields. The fly ash has also proved to be able to withhold plant nutrients and avoid leaching due to its high conductivity of 1320 micromhos.

Fly ash has both soil-amending and nutrient-enriching properties, it helps improve crop growth and yield in low-fertile soils (Basu *et al*., 2004). Correspondingly to the findings of this study, fly ash was also identified to contain essential plant nutrients Calcium, Iron, Magnesium and Potassium (Koreak, 1995; Kachroo *et al*., 2006; Lee *et al*., 2006; Inam, 2007; Basu *et al*., 2009). In legumes, fly ash was identified to hasten the uptake of Calcium and Magnesium (Page *et al*., 1979). Furthermore, increased fly ash concentration from 0, 10, 20 and 100% in a normal field, increased the soil pH, hence increasing the availability of Sulphate, Carbonate Bicarbonate, Chloride, Phosphorus, Potassium, Calcium, Copper Zinc and Boron (Khan and Khan 1996). On the contrary, fly ash is not acknowledged as an optimum source of Phosphorus (Martens, 1971). Due to the inherent Nitrogen and Phosphorus deficiency of fly ash, it is necessary to supplement to ensure desirable crop growth. According to Inam(2007), fly ash dose at 10t ha^{-1} supplemented with 20kg ha^{-1} proved effective while a mixture with 40kg ha^{-1} was toxic to the mentioned crop.

SUSTAINABLE YIELDS

Application of fly ash from the farmer's point and pictorial findings is a testimony that flies ash waste from the Harare Power Company has agronomic benefits that result in high yields. Responding to the inquiry on the yields the farmer is getting from utilising fly ash in cucumber and tomato crops, she said:

> "Since it is our first crop with fly ash, we haven't read much into it but currently we have managed 3.5kg per plant of cucumber which when converted to a 1ha with 33 333 plants will yield 116t/ha. Given the scenario that over the years we never got a yield on this part of the land area due to logging, this year is a great achievement. However, we are in our initial stages of harvesting our tomatoes but they are promising a good harvest as well"

From the farmers' perceptions, it could be suggested that fly ash has been able to provide a meaningful yield that would be economically beneficial. This outcome could be attributed to the fact that the farmer can use the land all year round even if water logging occurs. Furthermore, the said yield of 116t/ha adds income during the climatic stress season. Sustainable value is also attained as the farmer will biologically control soil-borne diseases using fly ash as earlier discussed, thereby cost-cutting on soil fumigants. Plate 3 presents the potential utilisation of fly ash to produce a good tomato harvest.

Plate 3: Tomato crop grown on fly ash at early, vegetative and ripening stages by the farmer.
Photos by Tinashe Magada M in Harare (25/01/2017; 01/03/2017 and 16/05/2017).

With this evidence, the research is also convinced that a bumper yield will be attained on this crop. It has been proven by Basu *et al*. (2009) that fly ash is capable of increasing crop growth and yield. Tomato yield was found to increase when 5% fly ash was added to the soil(Ahmad and Alam, 1997). Similar results were further found to increase tomato yield when 40-50% fly ash compared to un-amended soil (Khan *et al*., 1997). Fly ash has also been found to increase the yield of Sabai grass (Grewal *et al*., 2001; Hill and Lamp, 1980, Sridhar *et al*., 2006).

Thus fly ash use on agricultural soil is suggested by Schoeman and van Deventer (2004) to be a promising endeavour from an environmental viewpoint. Thus it provides a reuse principle of fly ash waste and provides high yield aimed at ending poverty, addressing hunger, clean water and sanitation and sustainable cities as enshrined in the sustainable development goals (FAO, 2016).

EFFECTS OF FLY ASH ON CROP PRODUCTION

EFFECTS OF FLY ASH ON CUCUMBER GROWTH

A significant effect ($p<0.001$) between fly ash treatments was recorded on cucumber girth and shoot count growth and a significant effect ($p<0.05$) was obtained on plant height (Figure 1).

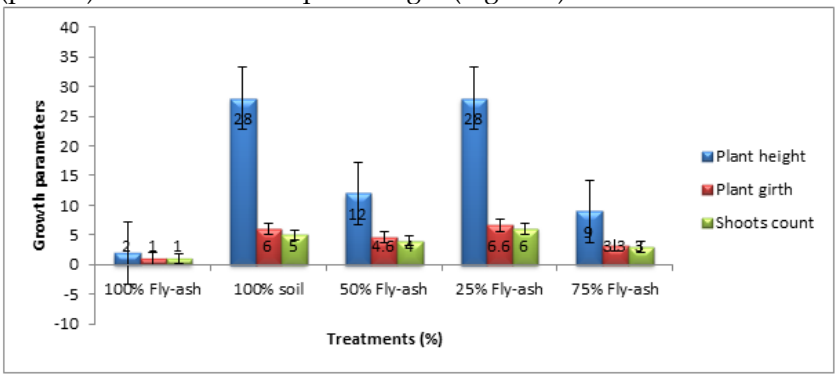

Figure 1: Effects of fly ash application rate on growth parameters of Cucumber

VERTICAL BARS REPRESENT STANDARD ERROR BARS OF MEANS

Figure 1 reveals that both control treatment and 25% fly ash showed the highest and almost similar levels of growth while treatment of 100% fly ash produced the least cucumber growth patterns. The results of poor growth of cucumber on 100% fly ash can be attributed to excessive application rates of fly ash. Because of these outcomes, Singh and Siddiqui (2003) identified a gradual decline in rice growth parameters at high rates (60%-100%) of fly ash amendments of soil against improved growth rates when a lower (40%) application rate

was used. The poor performance of cucumber growth can be attributed to higher toxicity resulting from higher pH (7.9) and concentration level of nutrients (Magnesium- 0.82mg/100g and Zinc-123.6ppm) evident from the laboratory analysis and free bases (Sulphur- 2.87%, Chlorine- 0.08%, Aluminium- 33% and Titanium- 1.2%) chemical analysis. These negative effects on the growth of cucumber are in agreement with the findings of Singh and Siddiqui (2003) who related the negative effects of crop growth resulting from high salinity from sulfate, carbonate and bicarbonate in fly ash. A higher application rate of fly ash causes toxicity to plants (Kalra *et al.*, 2000).

Plate 4: Effects of fly ash on cucumber crop in the experiment

Photo by Tinashe Magada M in Harare (23/04/2017)

EFFECTS OF FLY ASH ON FRESH YIELD OF RAPE

The application of fly ash had a significant ($p<0.001$) effect on the fresh yield of Rape (Figure 2).

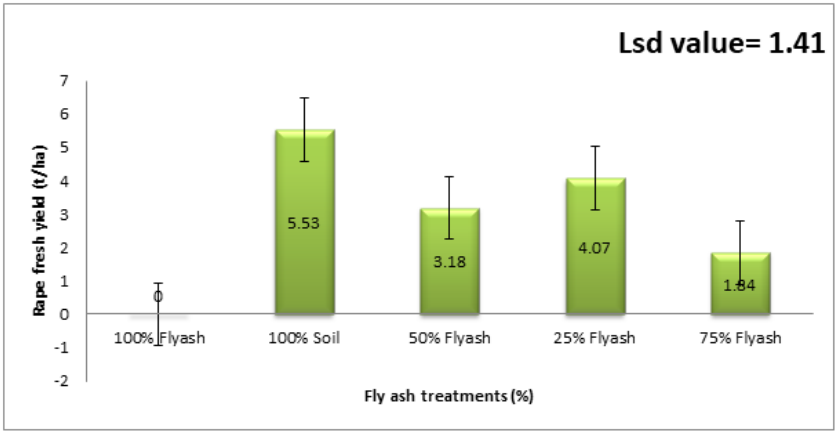

Figure 2. Effects of fly ash application rate on fresh leaf yield of Rape

VERTICAL BARS REPRESENT STANDARD ERROR BARS OF MEANS

The control treatment produced the highest (5.3 t/ha) yield while plants treated with 100% fly ash resulted in (0t/ha) total Rape failure. No significant effects ($p>0.05$) on fresh yield of Rape were noted between 100% soil (control) treatment and 25% fly ash treatment which produced the highest yield (4.07t/ha) among the fly ash treatments (Figure 2).

Based on results from the laboratory soil and fly ash analysis, the highest (5.53t/ha) fresh leaf yield of Rape in the 100% soil (control) treatment can be attributed to the residual high (71ppm) and (360ppm) Nitrogen and Phosphorus nutrient of the Domboshava soil, respectively. The Rape plants in the 100% fly ash did not survive from the onset. The result may be due to the high pH (7.9) of the fly ash sample, considered strongly alkaline. This is a probable indication that at full concentration level, fly ash is detrimental to the Rape crop. However, 25% fly ash treatment produced the highest (4.7t/ha) fresh leaf yield amongst the fly ash treatments but was significantly the same with 100% soil treatment. This outcome shows that the addition of 25% fly ash to soil enhanced the yield of Rape, resulting from an

improvement of the physical properties of the composite medium as also reported by Buck *et al.* (1990). To this effect, fly ash was able to improve the Domboshava soil water-holding capacity by regulating the infiltration rate of water. This is similar to the the outcome that Chang *et al*. (1977) unearthed that soil-amended fly ash increases water-holding capacity by 8% and reduces encrustation. This amount of water available for plants would be enhanced (Taylor and Schumann, 1988) which would be beneficial for the growth of plants under rain-fed agriculture (Basu *et al*., 2010). The Domboshava soil, due to its texture, is prone to high leaching of nutrients, hence high (1320) conductivity of nutrients in the 25% fly ash medium was greatly increased leading to the insignificant difference between the 100% soil (control) and 25% fly ash treatments.

Plate 5: Effects of fly ash on rape crop under experiment
Photo by Tinashe Magada M in Harare (23/04/2017)

EFFECTS OF FLY ASH ON TOMATO GROWTH

A significant effect ($p<0.001$) between treatments was recorded on plant height, girth and the number of shoots of Tomato while a significant effect ($p < 0.05$) was recorded on flower count at six weeks after transplanting (Figure 3).

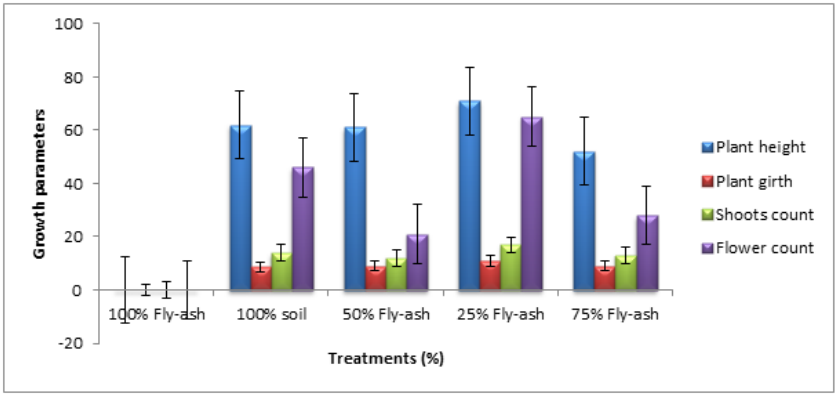

Figure 3. Effects of fly ash application rate on growth parameters of Tomato

VERTICAL BARS REPRESENT STANDARD ERROR BARS OF MEANS

Tomato plants treated with 25% fly ash performed highest (71cm, 11mm, 17 and 65) on all growth parameters (height, girth, shot count and flower count), respectively, while 100% fly ash treatment scored zero (0) on all growth parameters. The 25% was superior against the control treatment (100% soil) which recorded 62cm height, 8.6cm girth, 14 shoots and 46 flowers.

In explaining this result, it can be stated that the effect of 25% fly ash on Tomato is superior against all other treatments, though not significantly to the control treatment. The superiority may have resulted from the ability of the fly ash to alter the pH of the medium. Mixing of fly ash with soil in the ratios 25%, and 75% respectively managed to adjust the pH of the soil from acidic conditions pH (5.0) to an average pH (6.4). In addition, fly ash and soil managed to combine their residual nutrients (Phosphorus, Calcium, Potassium, Nitrogen, Magnesium, Zinc and Copper) into a composite growing media, hence gaining superior Tomato growth against other treatments. Furthermore, due to the fine-grained sandy clay characteristics of fly ash, the 25% fly ash treatment managed to retain moisture and avoid the leaching of nutrients for the benefit of the crop, a situation that the control treatment (100% soil) could not withhold. On the contrary,

fatality on Tomatoes in 100% fly ash could be a result of strongly alkaline pH 7.9 and Calcium 70.28mg/100g exhibited through analysis of fly ash. This could have resulted in toxicity. From the result, it can also be noted that the more the fly ash concentration, the lesser the Tomato crop growth response.

Plate 6: Effects of fly ash on tomato crop under experiment
Photo by Tinashe Magada M in Harare (23/04/2017)

Similar to the findings, Furr *et al.* (1978) recorded an increase in Tomato growth when 125mt ha^{-1} of fly ash was added on slightly acidic soils, while Ahmad and Alam (1997) obtain increased growth of Tomatoes when 5% fly ash was added to the soil. One of the ways of enhancing crop productivity in acidic soils is using alkaline fly ash as a soil ameliorant (Senapati, 2009). According to Matsi and Keramidis (1999) the use of fly ash, as a liming substitute in acidic soils, improves soil properties, resulting in an increase in crop performance. Application of fly ash to amend soil pH improves crop growth by making available some Calcium and Magnesium (Mittra *et al*., 2004) and reduces soluble metal toxicity, affects phosphorus availability and micronutrient availability, enhances soil organism nitrification and soil conditioning (Hayman and Mosse, 1971). Yet, crop response varies from being beneficial to toxic, hence it depends on the concentration

level (Kalra *et al* 2000; Grewal *et al*. 2001). Higher concentrations of fly ash proved to be deleterious on Soybean and Maize (Shukla and Mishra, 1986). Hence, it unearths the negative impacts on vegetation surrounding its dumpsites.

Based on the technical application of the ISWM concept, fly ash as a waste resource provides a cheaper source of liming material to increase crop yields. On the other hand, crop productivity relies on soil amendments inputs to address low crop output, hence providing a sustainable disposal site for fly ash. The process application of fly ash into the field would entail a livelihood activity that aims at increasing crop yield at a minimum cost of inputs and deriving maximum yields for a sustainable livelihood.

CONCLUSION AND RECOMMENDATIONS

A huge quantity of fly ash on landfills and dumpsites and the type of coal that generates fly ash at the Harare Power Station creates environmentally degrading scenarios. Due to the chemical characteristics of the fly ash, as noted in the study, extreme concentrations of base elements (Zinc, Copper, Sulphur, Chlorine, Nitrogen, Phosphorous, Silica, Aluminium, Iron, Magnesium, Titanium, Calcium and Potassium) and strongly alkalines contribute to groundwater contamination, air pollution, human health hazards and vegetation loss. Algae formations and high water pH preclude safe water for drinking while the less dense particle (Cenospheric) of fly ash results in rising dust that, if inhaled, causes pneumoconiosis, emphysema, occupational cancers and asthma and further distorts visibility within the Central Business District of Harare. Settling of fly ash dust on leaves distorts the photosynthesis processes of vegetation. Death of Tomato, Cucumber and Rape crops in the field experience from 100% fly ash concentration is a testimony of the negative effects that fly ash has on vegetation that may lead to loss of plant biodiversity. Thus, it can be concluded that unutilised fly ash results in negative impacts on the environment.

The pH of 7.9 and nutrient composition (Potassium, 0.29mg/100g; Calcium, 70.28mg/100g; Magnesium, 0.82mg/100g; Zinc, 123.6ppm and 17.4ppm) based on soil analysis, proves the fact that fly ash is rich

in crop nutrients, sufficient for crop growth. In addition, the fine-grained sandy clay texture and 1320 micromhos conductivity level of fly ash is sufficient to enhance water-holding capacity and avoid leaching of nutrients which are prerequisite characteristics of a growing medium that ensures efficient and effective crop production. Conclusively, fly ash can potentially be utilised to attain sustainable crop production as it can neutralise acidic soils that hinder efficient and effective crop production.

It is the conclusion of the present study that the application of fly ash to soils at a 25% concentration rate had significant growth and yield effect on Tomatoes, Cucumber and Rape. At higher concentrations (50%, 75% and 100%) growth is retarded and total crop failure is at a 100% rate. Mixing fly ash and soil at 25% to 75%, respectively reduces the negative toxicity of fly ash on the environment and provides a sustainable optional use as a beneficial input of the so-called solid waste commodity.

Considering Integrated Sustainable Waste Management (ISWM), the generation of fly ash is an inevitable consequence in the Zimbabwean context due to increasing electricity demand. The landfill and dumpsite disposal methods currently in place compromise the future generation to achieve their environmental benefits. Utilising fly ash in crop production provides environmental sustainability and social acceptance that ensure safe human health while considering economic growth technology. Crop production provides a platform to ensure maximum fly ash resource utilisation efficiency on amending the soil's physical and nutrient deficiencies that had become stumbling blocks to sustainable food production, aggravated by high fertilizer costs and exhaustion of soils through continuous cultivation. Considering the environment, the application of fly ash at a 25% rate to amend acidic soils, reduces the amount of fly ash waste on landfills and dumpsites that cause air pollution, contaminate groundwater and cause human health hazards. Furthermore, open-cast mining of lime for crop production enhances land degradation and the lime contributes to global warming through its carbon dioxide release. Thus fly ash provides an eco-friendly means to increase crop production without

deteriorating the ecosystem sustainability potential for the future generation.

In the process, the Sustainable Development Goals (SDG) that include ending poverty, zero hunger, clean water and sanitation, sustainable cities and communities, responsible consumption and production and climate action can be attained through utilising fly ash to increase crop growth and yield per unit area. Thus, fly ash utilisation in crop production qualifies for integration into the sustainable livelihoods approach to eliminate poverty and encourage economic growth that benefits marginalised people by promoting agriculture development and environmental conservation.

From the findings of the study, it could be recommended that:

- Fly ash can be applied at a 25% content mixture to acidic soils to amend deficient pH and improve the physical and chemical properties of such soils for increased crop growth, hence it should not be handled at power stations and disposed of at dumpsites where it causes environmental degradation.
- When using fly ash as an organic soil ameliorant in sustainable crop production, Phyto-toxicity concerns are likely to occur due to its substantial amounts of heavy metals, especially Zinc. Thus a comprehensive compositional analysis of the food crops produced under fly ash needs to be determined before consumption is recommended.
- Effects of fly ash utilisation in Tomato, Cucumber and Rape production were undertaken under greenhouse conditions, hence trials under natural field conditions in which most farmers operate need to be further tested.
- Fly ash should be considered as a soil ameliorant for sustainable crop production to improve national and household food security due to its nutrient composition.
- Considering the short period in which the study was undertaken, long-term trials on crop production using fly ash to determine long-term impacts need to be considered.
- The Harare Power Station should formulate a policy framework with the Ministry of Environment, Water and Climate and Ministry of Agriculture as an Integrated Sustainable Waste Management (ISWM) strategy on

considering fly ash as a standardised input for use in crop production to curb the negative impacts it poses on the environment and encourage the Sustainable Livelihood Approach (SLA) of combating hunger and poverty.

REFERENCES

Adriano, D. C; Page, A. L and Elseewi, A. A. (1980). Utilization of fly ash and other coal residues in terrestrial ecosystems: a review. J Environ Qual; 9:333–44.

Ahmad, A and Alam, M. M. (1997). Utilization of fly ash and Paecilomyces lilacinus for the control of Meloidogyne incognita. Int J Nematol; 7:162–4.

Akkucuk, U. (2016). The handbook of research on Waste management techniques for sustainability.IGI Global. Hershey.

Arthur, M. F; Zwick, T. C; Tolle, D.A and Vanvoris, P. (1984).Effect of fly ash n microbial CO2 evolution from an agricultural soil", Water Air & Soil Pollution.

Arteca R.N. (2015). Introduction to Horticultural Science 2nd edition. Cengage Learning. Stamford

Asokan, P; Saxena, M and Bose, S. K.Z. 1995). Proceedings of the workshop on Fly ash Management in the State of Orissa.RRL.Bhubhaneshwar.

Babich, H; Bewley, R. J and Stotzky, F. (1983). "Application of the „Ecological Dose" concept to the impact of heavy metals on some microbe mediated ecological process in soil".ArchEnvironment Contamination and Toxicology,

Barker, A.V and Pilbeam, D.J. (2010). *Handbook of plant nutrition*.CRC press. New York.

Basu M; Pande, M; Bhadoria, P. B. S and Mahapatra, S.C. (2009). *Potential fly ash utilization in agriculture: A Global Review*. Progress in Natural Science 19: 1173-1186

Bernhard, M, Brinckman, F.E and Sadler, P. J. (1986). *The importance of chemical speciation in environmental processes*.Springer-Verlag. Heidelberg.

Best, J. W and Khan, J.V. (2009). *Research in Education*. PHI Learning Private Limited. New Delhi

Buck, J.K; Honston, R. J and Beimborn, W.A. (1990). Direct seeding of anthracite refuge using coal fly ash as a major soil amendment. In: Proceedings of the mining and reclamation conference and exhibition. West Virginia Univ. Pub. Service No. 2.

Butterly C, Baldock J and Tang C. (2010). *Chemical mechanisms of soil pH change y agricultural residues*. 19th World congress of soil SCIENCE, soil solutions for a changing world. Brisbane

Capp, J. P. (1978). *Power plant flies ash utilization for land reclamation in the eastern United States.* In: Schaller FW, Sutton P, editors. Reclamation of drastically disturbed lands. ASA. Madison. WI.

Carlson, C.L and Adriano, D.C. (1993). *Environmental impacts of coal combustion residues*. J. Environ. Qual. 22:222-247.

Carney D (1998). Sustainable rural livelihoods: What contribution can we make? Department for international development.

Cetin, S and Pehlivan, E. (2007). The use of fly ash as a low-cost, environmentally friendly alternative to activated carbon for the removal of heavy metals from aqueous solutions. Colloids Surf; 298:83–7.

Chambers R and Conway G.R (1992). *Sustainable rural livelihoods: Practical Concepts for the 21st century*. Institute of development studies. Sussex.

Chang, A.C; Lund, L. J and Page, A. L. (1977). *Physical properties of fly ash amended soils*. J Environ Qual;6:267–70.

Chen, J and Li, Y. (2006). Coal fly ash as an amendment to container substrate for Spathiphyllum production. Bioresour Technol; 97:1920–6.

Cohen, M. L. (1994). *Research Methods in Education.*Routledge. London.

Cone, J. D. and Foster, S. F. (2006). *Dissertations and theses from start to finish: Psychology and related fields.*American Psychological Association.Washington, DC

Cozby, P. C. (2004). *Methods in Behavioral Research (8th ed.).* McGrawhill. New York.

Crockett, B (2007). *Issues in Social Science Research*.Admission publishers, Addis Ababa.

Denzin, N. K. and Lincoln, Y.S. (1994). *Handbook of Qualitative Research*.Sage Publication. London.

Desmukh, A; Matti, D. B and Bharti B. (2000). *Soil properties as influenced by fly ash application.* J Soils Crops; 10:69–71.

Dwivedi, A and Jain, M. K. (2014). *Fly ash waste management: a review*. Recent research in science and technology vol 6 No 1.

EMA.(2016). *Safety precautions in handling hazardous substances*.Htpps://www.ema.co.zw. Accessed on 27/03/2017.

Elseewi, A.A; Bingham, F. T and Page, A. L. (1978). *Availability of sulfur in fly ash to plants.* J Environ Qual; 7:69–73.

Elseewi, A.A; Bingham, F. T and Page, A. L. (1978). *Growth and mineral composition of lettuce and Swiss chard grew on fly ash-amended soils.* In: Adriano DC, Brisbin IL, editors. Environmental chemistry and cycling processes, Conf-760429. Springfield, VA.

El-Mogazi, D; Lisk, D. J and Weinstein, L. H. (1988). A review of physical, chemical, and biological properties of fly ash and effects on agricultural ecosystems. Sci Total Environ; 74:1–37.

Faithfull, N. T. (2002). *Methods in agricultural chemical analysis*: A practical handbook. CABI. Wallingford.

FAO.(2011). A policymaker's guide to the sustainable intensification of smallholder crop production.FAO. Rome

FAO.(2016). Overview of the SDGs Process and FAO's contribution to the monitoring framework.APCAS 26TH session. Bhutan.

Ferreira, C; Ribeiro, A and Ottosen, L. (2003). *Possible applications for municipal solid waste fly ash.* J Hazard Mater; 96(2–3): 201–16.

Flick, U. (2006). An Introduction to Qualitative Research 3rd Edition. Thousand Oaks: SAGE. London.

Furr, A. K, Parkinson, T. F, Hinrichs, R. A. (1977). *A national survey of elements and radioactivity in fly ashes.*Absorption of elements by cabbage grown in fly ash soil mixtures. Environ Sci Technol; 11:1194–201.

Garau, M. A, Dalmau, J. L, Felipo, M. T. (1991). Nitrogen mineralization in soil amended with sewage sludge and fly ash. Biol Fertil Soil.

Garg, R. N, Pathak, H and Das D. K. (2005). Use of fly ash and biogas slurry for improving wheat yield and physical properties of soil. Environ Monit Assess;107:19.

Garg, R.N; Kalra, N; Harit. R. C. (2003). Fly ash incorporation effect on soil environment of texturally variant soils. Asia Pac J Environ Dev; 10:59–63.

Ghodrati, M; Sims, J. T; Vasilas, B.S. (1995). *Evaluation of fly ash as a soil amendment for the Atlantic coastal plain. I*. Soil hydraulic properties and elemental leaching. J Water Soil Air Pollut; 81:349–61.

Goetz, L. (1983). Radiochemical techniques applied to laboratory studies of water leaching of heavy metals from coal fly ash. Water Sci Technol; 15:25–47.

GoZ.(2013). *Zimbabwe National Climate Change Strategy*.www. climatechange.org.zw. Accessed on 07/05/2017

Grant, P.M. 1981. *The fertilization of sandy soils in peasant agriculture*. Zimbabwe Agricultural Journal, 78, 169-175.

Grant, P.M., Tanner, P.D. and Madziva, T.J.T. 1973.*Soil acidity factors affecting maize yield in Rhodesia*. Fertilizer Society of South Africa Journal, 1, 39-43.

Grewal, K.S; Yadav, P. S and Mehta, S. C. (2001). The direct and residual effect of fly ash application to soil on crop yield and soil properties. Crop Res; 21:60–5.

Hayman S.D and Mosse B (1971). Plant growth responses to Vascular arbuscular mycorrhiza.In the growth of endogenous inoculated plants in phosphate deficient soils. New phytology. 70:19-21.

Heidrich, C. (2003). *Ash utilization- an Australian perspective*.International ash utilization symposium. Centre for applied energy research. Paper No 3.

Heidrich, C; Feuerorn H. J and Weir, A. (2013). *Coal combustion products: a global perspective.*World of coal ash (WOCA) conference. Lexington

Hodgson, D. R and Holliday, R. (1966). *The agronomic properties of pulverized fuel ash*. Chem Ind; 20:785–90.

Hoy, W. K. (2010). *Quantitative education research*: A primer. Sage. Los Angeles.

Huysamen, G. (2001). Methodology for the Sociological and Behavioral Sciences.Oxford University Press. Oxford

Inam, A. (2007). Use of fly ash in turnip (Brassica rapa L.) cultivation. Pollut Res; 26(1):39 42.

Inam, A. (2007). Response of methi to nitrogen and fly ash supplemented as a source of nutrients. Pollut Res; 26(1):43–7.

IPCC. (2007). Climate change- the physical science basis: contribution of a working group to the fourth assessment report of the IPCC. Cambridge university press. Cambridge

Jamwal, N. (2003) *Is it all grey?* Down Earth.6:38–41.

Jansen, A. J (1996). Management of urban biodegradable wastes: collection, occupational health, biological treatment, product quality criteria and end-user demand. James and James ltd. London

Jala, S and Goyal, D. (2006). Fly ash as a soil ameliorant for improving crop production a review. Bioresour Technol; 97:1136–47.

Jones, C. C, Amos, D. F. (1976*). Physical changes in Virginia soils resulting from additions of high rates of fly ash.*Proceedings of the 4th international ash utilization symposium US Energy Research Development Administration MERC/SP-76-4, Morgantown. WV.

Karpagavalli, S and Ramabadran, R. (1997). *Effect of lignite fly ash on the growth and dry matter production (DMP) of soil-borne pathogens*. National Sem on Bio-Utilization of Khallikote. Berhampur.

Kene, D.R; Lanjewar, S. A and Ingole, B. M. (1991) *Effect of application of fly ash on Physico-chemical properties of soils*. J Soils Crops; 1(1):11–8.

Khan, R.K and Khan, M. W. (1996). *The effect of fly ash on plant growth and yield of tomato*. Environ Pollut; 92(2):105–11.

Khan, N.R; Khan, M. W and Singh, K (1997). Management of root-knot disease of tomato by the application of fly ash in the soil. Plant Pathol; 46:33–43.

Kishor, P; Gosh, A.K and Kumar, D. (2010). *Use of fly ash in Agriculture: A way to improve fertility and productivity.* Asian Journal of Agriculture 4(1): 1-14

Kumar, R (2005). Research Methodology A Step-by-step Guide for Beginners, 2nd edition: Pearson Education. Perth

Kumar, V; Kiran; A. Z and Goswami, G. (2000). *Fly ash use in agriculture: a perspective*. In: Proceedings of the 2nd international conference on fly ash disposal and utilization, vol. I. CBIP. New Delhi.

Kuchanwar, O.D, Matte, D.B, Kene, D.R. (1997). Evaluation of graded doses of fly ash and fertilizers on nutrient content and uptake of groundnut grown on a vertisol. J Soils Crops ;7(1):1–3.

Kumar, V; Mathur, M and Kharia S. P. (2000). *Fly ash management: a vision for the new millennium.* In: Proceedings of 2nd international conference on fly ash disposal and utilization, Vol. I. CBIP. New Delhi.

Lee, S. B; Lee, Y. B and Lee, C. H. (2008). *Characteristics of boron accumulation by fly ash application in paddy soil*. Bioresour Technol; 99(13):5928–32.

Lokeshappa, B and Dikshit A. K. (2011). Disposal and management of fly ash.International conference on life science and technology IPCBEE.Vol 3. Latest press. Singapore.

Lyer, R.S and JA Scott, J.A. (2001). Power station flies ash- a review of value-added utilization outside of the construction industry. Resource.Conservation Recycling 31. 217-228

Matani, A. G. (1998). *Fly ash from thermal power stations: Utilization and Disposal techniques*.Research Journal of Chemistry and Environment, 1: 71-73.

McCauley A, Jones C and Rutz KO (2017). *Soil pH and organic matter*.Nutrient module 8. Montana State University.

McDougall *et al.* (2001). Integrated solid waste management: a Lifecycle inventory. Blackwell Science. Oxford)

Mhazo, M.L, Ngwerume, F.C and Masarirami M.T. (2013). Garlic propagation alternatives using bulblets and cloves of different sizes in a semi-arid subtropical environment. Annual research and review in biology 4(1): 238-245

Mittra, B. N; Karmakar, S and Swaine, D. K. (2003). *Fly ash potential source of soil amendment and a component of an integrated plant nutrient supply system*. In: International ash utilization symposium Center for Applied Energy Research. The University of Kentucky.

Matsi, T and Keramidas, V.Z. (1999). Fly ash application on two acid soils and its effect on soil salinity, pH, B, P and on ryegrass growth and composition. Environ Pollut; 104:107–12.

Mattigod, S. V; Dhanpat, R and Eary, L. E. (1990). Geochemical factors controlling the mobilization of inorganic constituents from fossil fuel combustion residues: A review of the major elements. J Environ Qual; 19:188–201.

Montes, H. G, Perez L. R and Renard F. (2008). *Mineral sequestration of CO2 by aqueous carbonation of coal combustion fly ash.* J Hazard Mater; 181(2–3):1347–54.

Morse S and McNamara N (2013). Sustainable livelihoods approach A critique of theory and practice. Springer. Dordrecht

Mupambwa, H.A; Dube, E and Mnekeni, P.N.S (2015). *Fly ash composting to improve fertilizer value- a review.* South African Journal science 111:1-8.

Murugan, S and Vijayarangam, M. (2013). *Effects of fly ash in an agricultural field on soil properties and crop productivity.* International journal of Engineering research and technology Vol 2 issue 12.

Nachmias, D. and Nachmias, C. (1976). *Research Methods in the Social Sciences*.Edward Arnold, London.

Narayanasamy, P. (2002). *Lignite fly ash as an eco-friendly insecticide*. Available from: http://www.hinduonnet.com (accessed 02.04.17).

Narayanasamy, P. (2003). *Fly ash in the plant protection scenario of agriculture.*In: Mathur GN, editor. Third international conference on fly ash utilization and disposal, Proceedings of the II Central Board of irrigation and power. New Delhi.

Narayanasamy, P. (2005). *Prospect of use of fly ash as a dust insecticide and a carrier in the pesticide formulation.* In: Proceedings of the national business meeting on the use of fly ash in agriculture, FAUP. New Delhi.

Natusch, D.F.S. (1975). Characteristics of pollutants from coal combustion and conversion process. Fort Collins. Colorado.

Natusch, D. F. S, Wallace J. R. (1974). *Urban aerosol toxicity: the influence of particle size*. Science journal; 186:695.

Nawaz, I. (2013). *Disposal and utilization of fly ash to protect the environment*.International journal of innovative research in science, engineering and technology. Vol 2 issue 10.

Neelima, M. R; Khandual, S and Tripathy, A. (1995). Proceedings of the workshop on Fly ash Management in the State of Orissa.RRL.Bhubhaneshwar.

Nyamangara, J. and Mpofu, S.E. 1996. *Soil pH and lime requirement for high potential communal areas of Zimbabwe*.Journal of Applied Science in Southern Africa, 2, 77 81.

Okalebo RJ, Gathua KW, Woomer PL. 2002. *Laboratory methods of soil and plant analysis: A Working Manual*.TSBF-CIAT and SACRED Africa, Nairobi, Kenya.

Page, A. L; Elseewi, A. A and Straughan, I. R. (1979). Physical and chemical properties of fly ash from coal-fired power plants with special reference to environmental impacts. Residue Rev; 71:83–120.

Pathan, S.M; Aylmore, L. A. G and Colmer, T.D. (2003). *Properties of several fly ash materials to use as soil amendments.* J Environ Qual; 32:687–93.

Perrings, C (1994) *Environmental and resource economics*.Edward Elgar publishers. Chaltenham.

Petruzzelli, G; Lubrano, L and Cervelli, S. (1986). *Heavy metal uptake by wheat seedlings grown on fly ash-amended soils.* J Environ Qual; 8:171–5.

Phung, H. T; Lund, I. J and Page, A. L. (1978). *Potential use of fly ash as a liming material*. In: Adriano DC, Brisbin IL, editors. Environmental chemistry and cycling processes, Conf-760429. Springfield, VA.

Pitchel, J. R. (1990). *Microbial respiration in fly ash/sewage sludge amended soils*. Environmental Pollution, 63, pp.225–237.

Plank, C.O, Martens, D.C. (1974). Boron availability is influenced by the application of fly ash to soil. Soil Sci Soc Am Proc; 38:974–7.

Polit, D and Hungler, B. (1991). *Nursing research: Principles and methods*. 3rd edition.J B Lippincott. New York.

Prabakar, J; Dendorkar, N and Morchhale, R. K. (2004). *Influence of fly ash on strength behaviour of typical soils.* Constr Building Mater; 18:263–7.

Prasad, B and Mandal, K. (2008). *Heavy metals leaching in Indian Fly ash.*Journal of Environmental Science Engineering. 50(2):127-132

Proctor, R. W and Capaldi, E.J. (2008). Why science matters: understanding the methods of psychological research. Wiley Blackwell. Malden.

Raj, S and Mohan, S. (2008). *Approach for improved plant growth using fly ash amended soil.* International journal of emerging technology and advanced engineering. Vol 4:6

Randolf, J. (2004). Environmental land use planning and management.Island Press. London

Rautaray, S.K; Ghosh, B. C and Mittra, B.N. (2003). Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in a rice-mustard cropping sequence under acid lateritic soils. Bioresour Technol; 90: 275–83.

Ritchie, J and Lewis, J (2003). *A guide for social science students and researchers*.Sage publications. London.

Rohriman, F.A. (1971). Analysing the effect of fly ash on water pollution. Power; 115:76.

Rose CW (2004). An introduction to the environmental physics of soil, water, and watersheds.Cambridge university press. Cambridge.

Sachs, J. (2004). *Economics and nutrition: how do they intersect?*In SCN News Nutrition and the Millenium Development Goals.Lavenham. UK

Sadasivan, S, Meenaksy, Negi B. S, Krishnamoorthy, T.M and Nambi, K.S.V.(1994). Composition and leachability of trace elements in coal ash and their migration in groundwater at the thermal power plant site at Manuguru.Bhabha research centre. Bombay.

Sajwan, K.S. (1995). The effect of fly ash/sewage sludge mixtures and application rates on biomass production. J Environ Sci Health A Environ Sci Eng; 30(6):1327–37.

Sanchez, P. (2002). *Millenium Project Hunger Task Force.*In SCN News Nutrition and the Millenium Development Goals.Lavenham press. The UK.

Sankari, S, Narayanasamy P. (2006). *Fly ash: a new potential termiticide*. Pestology; 30(8):39–42.

Sao, S; Gothalwal, R and Thetwar, L. K. (2007). Effects of fly ash and plant hormone treated soil on the increased protein and amino acid contents in the seeds of ground nut (Arachis hypogaea). Asian J Chem; 19(2):1023–6.

Sarangi, P. K; Mishra, T. K and Mishra, P.C. (1997). *Soil metabolism, growth and yield of Oryza sativa L. in fly ash amended soil*. Indian J Environ Sci; 1(1):17–24.

Sarangi, P. K; Mahakur, D and Mishra, P.C. (2001). Soil biochemical activity and growth response of rice Oryza sativa in fly ash amended soil. Bioresour.Technol 76.

Sarkar, A and Rano, R. (2007). Water holding capacities of fly ashes: effect of size fractionation. Energy Sources Part A; 29(5):471–82.

Schensul, J., Singer, M., Marshall, P., Trotter, R., Weeks, M., Simmons, J.E. and Radda, K. E (1999). *Ethics, Ethnography, Drug Use and AIDS: Dilemmas and Standards in Federally Funded Research*.National Institute on Drug Abuse.Bethesda

Schnappinger, M.F, Martens, D. C and Plank, C. D. (1975). *Zinc availability is influenced by the application of fly ash to soil.* Environ Sci Technol; 9:258–61.

Sekaran, U. (1984). Research methods for managers: A skill-building approach: John Wiley & Sons Inc. New York

Senapati, M.R. (2011). Fly ash from thermal power plants: Waste management and overview.Current science, Vol 100: 12.

Sharma, S.K and Kalra, N. (2006). Effect of fly ash incorporation on soil properties and productivity of crops: a review. J Sci Ind Res; 65(5):383–90.

Shumba, E.M. 1984. *Yields of maize in the semi-arid regions of Zimbabwe*. Zimbabwe Agricultural Journal, 81, 91-94

Singh, L. P and Siddiqui, Z.A. (2003). Effects of fly ash and Helminthosporium oryzae on growth and yield of three cultivars of rice. Bioresour Technol; 86:73–8.

Solomon, A.O. (2011). The role of households in solid waste management in East Africa capital cities.Wageningen University.Wageningen.

Solesbury, W. (2003). *Sustainable livelihoods: A case study of the evolution of DFID policy*. Overseas Development Institute working paper 217. London.

Steven, B. Alemu, G, Ross, P and Chandler, D. (2012). The use of the constructivist grounded theory method to explore the role of socially constructed metadata (web 2.0) approaches.The University of Portsmouth. Portsmouth

Straughan, I; Elseewi, A.A and Page, A. L. (1978). *Mobilization of selected trace elements in residues from coal combustion with special reference to fly ash*. In: Hemphill DD, editor. Trace substances in environmental health-XII. A symposium. Columbia: University of Missouri.

Strauss, A. and Corbin.J. (1998). Basics of qualitative research: techniques and procedures for developing grounded theory (2nd Edition). Thousand Oaks, London.

UNEP. (2011). *Implementation strategy to reduce the environmental impact of energy-related activities in Zimbabwe.*UNEP collaborating centre on energy and environment working paper No. 5. Riso National Laboratory. Denmark.

Tan, K.H. (2005). Soil sampling, preparation and analysis 2nd edition.CRC press. London

Tan, Y. (2008). *Resettlement in the Three gorges project*. Hong Kong University Press. Aberdeen.

Taylor, E. M and Schumann, G. E. (1988). *Fly ash and lime amendment of acidic coal soil to aid revegetation.* J Environ Qual; 17:120–4.

This, T.L.; Ripp, J.A and Villaume, J.F. (1989). *Physical and chemical characteristics of unsaturated pore water and leachate at a fly ash disposal site.* In: 43rd Purdue industrial waste conference proceedings. Lewis Publishers. MI.

Thetwar, L. K; Sahu, D. P and Vaishnava, M.M (2006). Analysis of Sesamum indicum seed oil from plants grown in fly ash amended acidic soil. Asian J Chem; 18(1):481–4.

Tiwari, K. N; Sharma, D. N and Sharma V. K. (1982). *Evaluation of fly ash and pyrite for sodic soil rehabilitation in UP, India*. Arid Soil Res Rehabil; 6(2):117–26.

Tolle, D.A; Arthur, M. F, Pomeroy, S. E. (1982). Fly ash used for agriculture and land reclamation: a critical literature review and identification of additional research needs. Battelle Columbus Laboratories. Ohio.

Tuckman, B. W (1972*). Conducting Educational Research*.Holt, Rinehart & Winston. New York

Van Hook R. I. (1979). Potential health and environmental effects of trace elements and radionuclides from increased coal utilization. Environ Health Perspect; 33:227–47.

Wang, E. (1997). Development of a Generic process-Oriented model for simulation of crop growth.Heret Utz Verlag Wissenschaft.Munchen.

Wilson, D.C; Velis, C.A and Rodic, L. (2013). Integrated Waste Management in developing countries.Proceedings of the institution of civil engineers.Waste and resources management, 166 (2). 52-68

Wong, M. H and Wong, J. W. C. (1986). *Effects of fly ash on soil microbial activity*. Environ Pollut Ser.

ZINDC. (2015). *Intended Nationally Determined Contributions. Climate policy database*. http://www4.unfccc.int. Accessed on 07/03/2017