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SCHOOL OF ARCHITECTURE AND BUILT ENVIRONMENT

**Need for Integrating Mining Operations into Detailed Physical Planning in
Peri-urban areas.**

Case Study of Gasabo District

*A Thesis submitted to the University of Rwanda in partial fulfilment of the
requirements for the degree of Master of Science/Geo-Information Science for
Environment and Sustainable Development*

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Declaration

I, Alexis Byiringiro, hereby declare that, unless specifically indicated to the contrary in the text, this research work entitled: “Need for Integrating Mining Operations into Detailed Physical Planning in Peri-urban areas” is a product of my work under the supervision of Dr. Jean Pierre Bizimana. To the best of my knowledge, it has never partially or totally been previously submitted in any other University or academic institution for a degree award. I hereby certify that the above declaration statement is correct.

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Abstract

Mining as land use type often competes with other types of land use such as residential and agriculture use even though it usually occupies a small fraction of the land surface. However, mining operations as land use is not considered in the proposed zoning regulations by the Detailed Physical Plan for Gasabo District where about 17 mines perimeters with the area of 5177 ha exist including the one of Buhiza-Nkusi with the area of 400 ha.

This research includes the background information about mineral resources extraction and land use planning, mine life cycle, socio-economic and environmental impacts of mining, mineral safeguarding in urban areas, and an overview of mining industry and land use planning in Rwanda. The research examines both the opportunities and the conflict between mining operations and other land uses in Buhiza and Nkusi Cells. Nine Villages within the study area were covered for the data needed for this research. A total number of 117 respondents were contacted for relevant information through questionnaire administration and interviews. In addition, community representatives, mine representatives, and the authorities from different relevant institutions and organizations that deal with mineral resources extraction and land use planning were contacted for relevant data.

The analysis of relevant literature review and data collected during field observation and household survey has indicated that with the increase of mining operations more land will be required and this will have always direct and indirect conflict with agricultural, conservation and residential land uses.

The research suggests the integration of the concept of mineral safeguarding area which will play an important role in reducing the conflict between mining operations and adjacent land uses. It then proposes the framework for integrating mining operations into detailed physical planning through the involvement of key stakeholders with the purpose of addressing the conflict between mining operations and other land uses in peri-urban areas.

Key words: *Mining, Mineral Safeguarding Area, land use planning, zoning,*

List of acronyms

CBD: Central Business District

CoK: City of Kigali

EDPRS II: Economic Development and Poverty Reduction Strategies

EIA: Environmental Impact Assessment

GIS: Geographic Information Systems

GMD: Geology and Mines Department

LMD: Land and Mapping Department

MINALOC: Ministry of Local Government

MINIRENA: Ministry of Natural Resources

MSA: Mineral Safeguarding Area

PTA: Mineral Potential Targeted Area

RDB: Rwanda Development Board

REDEMI: Régie d'Exploitation et de Développement des Mines

RHA: Rwanda Housing Authority

SOMIRWA: Société Minière du Rwanda

UPC: Urban Planning Codes

USD: United States Dollars

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1. Chapter one: Introduction

1.1. Background information

According to the practice guide of the Department for Communities and Local Government (DCLG) in United Kingdom; minerals make an essential contribution to the nation's prosperity and to quality of life for, sustainable community development. They are a pre-requisite for the buildings and infrastructure that society needs. In addition, some industries are wholly dependent on minerals as basic raw materials (DCLG 2006). The United State Bureau of Mines defined in 1989 a mineral resource as *"a concentration of naturally occurring solid, liquid or gaseous material in or on the Earth's crust in form and amount that economic extraction of a commodity from the concentration is potentially feasible"*. The choice of extraction method is based on the characteristics of the mineral, safety and environmental concerns, and technology and economics. The most traditional methods for mineral resources extraction are surface mining and underground mining (Jenny & Johan 2008).

Discovering metal-rich deposits commonly requires extensive searching, and exploration is the first step in the mining cycle. Once exploration geologists find an area with metals, they determine whether it is sufficient to be mined profitably. If the deposit is rich enough, activities to extract the metals from the earth begin. Mine closure is the final step in the mining cycle. Closure involves many activities specifically conducted to prevent or mitigate undesired environmental and social impacts (Travis *et al.* 1999). Each stage of mineral development is characterized by a number of activities that vary in their potential to impact the land use. Although minerals exploration requires access to large tracts of land. While the area of land under exploration is sometimes vast, there

are few land-based activities that generally have a low negative impact on environment. In the mineral resources extraction phase, the focus is on a smaller land area, with higher impacts (Euromines 2011). Each mining phase in the operation system has the potential to cause negative consequences on the environment; furthermore, mining can generate large impacts, long after the closure of its operations (Hildebrando 2006). Pre-determined outcomes can be achieved or progressed satisfactorily and there should be ample opportunity to overcome any major issue that may create problems after closure (Australia 2006).

Information on spatial location of mineral resources is becoming increasingly important due to a widening gap between supply and demand for resources, competition for land-use, a complex planning system and increased data requirements from planning departments to deal with minerals issues. Effective mineral conservation requires the location of mineral resources to be known, as well as the spatial extent of the mining areas where other proposed development might hinder or prevent exploitation of these mineral resources in the future. These areas should be shown in planning documents and suitable policies adopted to manage the development (Wrighton & Bide 2012).

Effective environmental policies and regulation for protecting mineral resources for the long term requires that their definitions be based upon the availability of the geological information. Mineral protection should not be curtailed by other land use planning designations such as urban areas and environmental designations without sound justification. Mineral conservation in urban areas may not be appropriate when resources occur extensively within the plan and where extraction methods are unacceptable in an urban environment such as mineral extraction by blasting of hard rock (McEvoy *et al.* 2007). In urban and peri-urban settings, mineral resources can be overlooked in land use planning processes mainly because of assumptions about mineral resources extraction; its incompatibility with other land uses, or a lack of appreciation of the potential benefits from mineral resources extraction. These challenges mean that the development opportunities from mineral resources extraction are naively disregarded. In other cases, land use decisions are reversed to allow for mineral resources extraction which can be both wasteful and disruptive. Decision-makers may decide to prioritize other land uses than mineral resources extraction in a given area. However,

it is important that decision-making guided by adequate geological information and mineral potential data in order to avoid unnecessary opportunity loss for national, regional and local economies (Euromines 2011). Mining activities therefore require the highest attention in land use planning, regulation and management from various departments working together (Brumfitt 2013).

1.2. Mining and land use planning in Rwanda

The geology of Rwanda is dominated by the Kibaran Belt, which also underlies in parts of Tanzania, Uganda, Burundi, DRC and Angola. The belt is known to be widely mineralized, hosting deposits of tin, tungsten, coltan (niobo-tantalite), gold and semi-precious stones (Byamukama *et al.* 2011). Rwanda was not a globally significant consumer of minerals. In 2008, however, Rwanda's share of the world's tantalum mine production amounted to about 5%, and tungsten, 4%. In 2007 (the latest year for which data were available), the mining and quarrying sector accounted for less than 0.8% of the gross domestic product. In 2008, tin mine production increased by an estimated 22%. In 2007, niobium (columbium) and tantalum mine production increased by about 160% each, and tungsten, by an estimated 107% compared with that of 2006 (Yager 2010). The EDPRSII targets to earn 400M USD in 2017-2018 from the mining sector according to the Government of Rwanda (GoR 2013).

The current mining policy sets out a framework of five strategic pillars that stem from an analysis of the major constraints facing the industry. These pillars are effectively the desired outcomes of the Mining Policy and should have a range of social, economic and environmental impacts (MINIRENA 2010). Mineral resources extraction is already taking place at more than 800 mine sites in the Rwanda and among them more than 30 mine perimeters are located in City of Kigali boundary.¹

¹ City of Kigali refers to administrative entity not to urban context

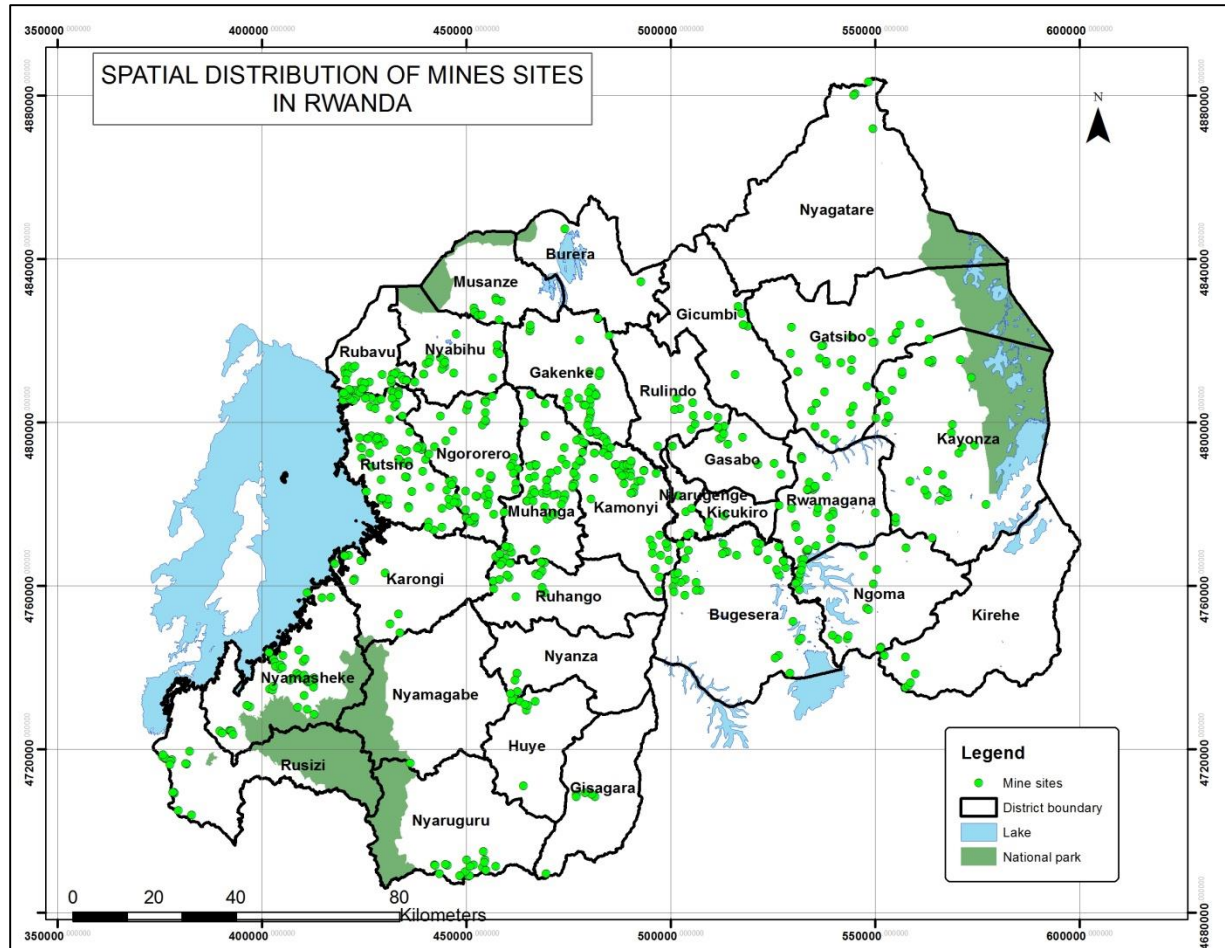


Figure 1: Spatial distribution of mine sites in Rwanda

Source: RNRA, 2015

Mining sector is governed by the Ministry of Natural Resources (MINIRENA) under the implementation of Rwanda Natural Resources Authority (RNRA), particularly the Geology and Mines Department to enforce and regulate the sector. Rwanda Geology and Mines Department identified the potential areas of significant mineral deposits. The Rwanda Government Cadastre portal which is accessed on (<http://portals.flexicadastre.com/rwanda/>) is playing an important role in terms of sharing information about spatial location of mineral resources extraction (MINIRENA 2015).

Apart from mining sector, Land and Mapping Department of the RNRA regulates the land and mapping sector. In this framework, RNRA has initiated the National Land Use and Development Master Plan with an objective of guiding the use and management of land in Rwanda for efficient,

effective and equitable use of country's natural resources (Swedesurvey 2010).. This land use planning document was approved by Cabinet on 19th January 2011. Mineral resources extraction is one of the areas which have been addressed by the National Land Use and Development Master Plan where mineral deposits have been shown. This land use planning document proposes the following regulations about mining:

- i. Area and hub of national interest for sustainable mining exploitation is defined as natural resource reserved for the exploitation of Rwanda's mineral wealth within acceptable environmental parameters and encouragement of safe and healthy mining practices.
- ii. Regarding mineral deposit, no land use change is allowed that obstructs exploitation. Social and environmental impact assessments must be conducted prior to mining activities. Exploitation shall comply with relevant environmental standards.
- iii. Mining land should be used for quarrying of minerals and complementary activities demanding large land areas and great distance off residential areas. Attention should be given to protect surrounding areas from negative environmental impact. (Swedesurvey 2010).

The proposed land use guidelines at national level as highlighted above are supposed to be implemented at local level through the physical plans according to the National Land Use and Development Master Plan. These physical plans should determine the total urban land supply, consider monitoring of land use changes and project compliance to land use policies and guidelines and consider monitoring the deviation of the existing land use to the proposed structure plan or zoning (Swedesurvey 2010). Having completed the Kigali Conceptual Master Plan and Detailed Master Plans for Nyarugenge District as well as various other sub-areas of Kigali, the City developed Detailed Physical Plan for Gasabo District and Detailed Physical Plan for Kicukiro District in order to have an integrated detailed plan for the entire City. However, mining operations is a land use that is not well integrated into the proposed zoning regulations by these detailed physical plans.

1.3.Problem statement

Mining as land use type often competes with other types of land use such as residential and agriculture use even though it usually occupies a small fraction of the land surface (Ololade 2012). Uncertainty over the ability to obtain access to land for mineral exploration and extraction imposes serious constraints on industry. At the same time, many other actors – including local communities– have vital interests in how land is used and who makes decisions regarding land use (IIED & WBCSD 2002). The closure of a mine site may leave nearby mining communities with potentially damaged surrounding habitats as well as with a loss of employment, which can result in individuals needing to decide whether to leave their communities to find employment opportunities farther from home (Ferguson 2015).

Under the District Development Plan of Gasabo District, improved minerals extraction and land use management through the implementation of Land Use Master Plan are among the strategies to be undertaken in order to ensure the rehabilitation of ecosystem (Gasabo 2013). Detailed District Physical Plan for Gasabo presents the updated Zoning Plan and regulations which is one of the key tools to implement the Master Plan proposed for Gasabo District. It is intended as a clear mechanism for directing the development in the public-private sector to follow a clear set of development objectives, definitions and regulations that reflect the planning concepts proposed in the Master Plan (Surbana 2013a). However, mineral resources extraction as land use is not considered in the proposed zoning regulations by the Detailed Physical Plan for Gasabo District. Despite this lack of integration of mining in land use planning and zoning, the district Gasabo account about 17 mines perimeters with the area of 5,177 ha exist including the one of the mining company called King Mines Company Ltd. with the area of 400 ha. This issue could lead to land use conflicts during different mining phases and during the implementation of the proposed Gasabo land use zoning plan.

1.4.Research objectives

Agenda 21 on Sustainable Development, 1992 recommended that by examining all uses of land in an integrated manner, it makes it possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development (IIED & WBCSD

2002). Rwanda Vision 2020 states that: Currently, Rwanda's scarce land resources still face a challenge of ineffective translation of the developed land use master plan into sector strategic plans and District Development Plans. In the coming years, Rwanda will ensure that every development plan is guided by the land use master plan (GoR 2013). Based on these statements, the main objective of this study is **to investigate the role of integrating mining operations into detailed physical plans in peri-urban areas of City of Kigali**. To achieve this main objective, specific objectives and related research questions have been formulated as illustrated in the table n°1.

Table 1: Specific objectives and related research questions

Specific Objectives	Questions
1. To assess the current status of the integration of mining operations into land use planning in Rwanda.	• What is the current status of the integration of mining operations into land use planning in Rwanda?
2. To identify the positive and negative impacts of the mine life cycle in operational and adjacent area of Buhiza-Nkusi concession.	• What are the economic impacts of mining on adjacent community? • What are the social impacts of mining on adjacent community? • What are environmental impacts of mining on operational area?
3. To propose a guiding framework on how mining operations can be integrated into detailed physical plans processes in Rwanda	• What is the existing framework related to the integration of mining operations into land use planning? • Why post mining land use should be focused on? • How mine concession should be safeguarded in peri-urban areas? • How mine life cycle can be integrated into detailed physical planning process?

1.5.Hypothesis

Despite the fact that mining operations have a small share of City of Kigali's total land use, conflict can arise at the local level where mineral resources extraction is perceived as competing with other land uses.

1.6.Scope and limitation of research

This research is not about detailed physical planning or mineral resource extraction per se. Rather, the study is about developing the framework related to the integration of mineral resources extraction into land use planning processes. Using the case study of District Detailed Physical Plan for Gasabo District, the research focused on the Buhiza-Nkusi mine concession which is owned by the company called King Mines Company Ltd, existing and proposed land use plan and regulations in both operational and adjacent areas of the mine perimeter will be assessed.

1.7.Study design

The multi-disciplinary nature of this research requires that various techniques be applied to achieve to the expected result. It is in that framework that this research requires documentation from different sources, field survey and contact with relevant group through interviews.

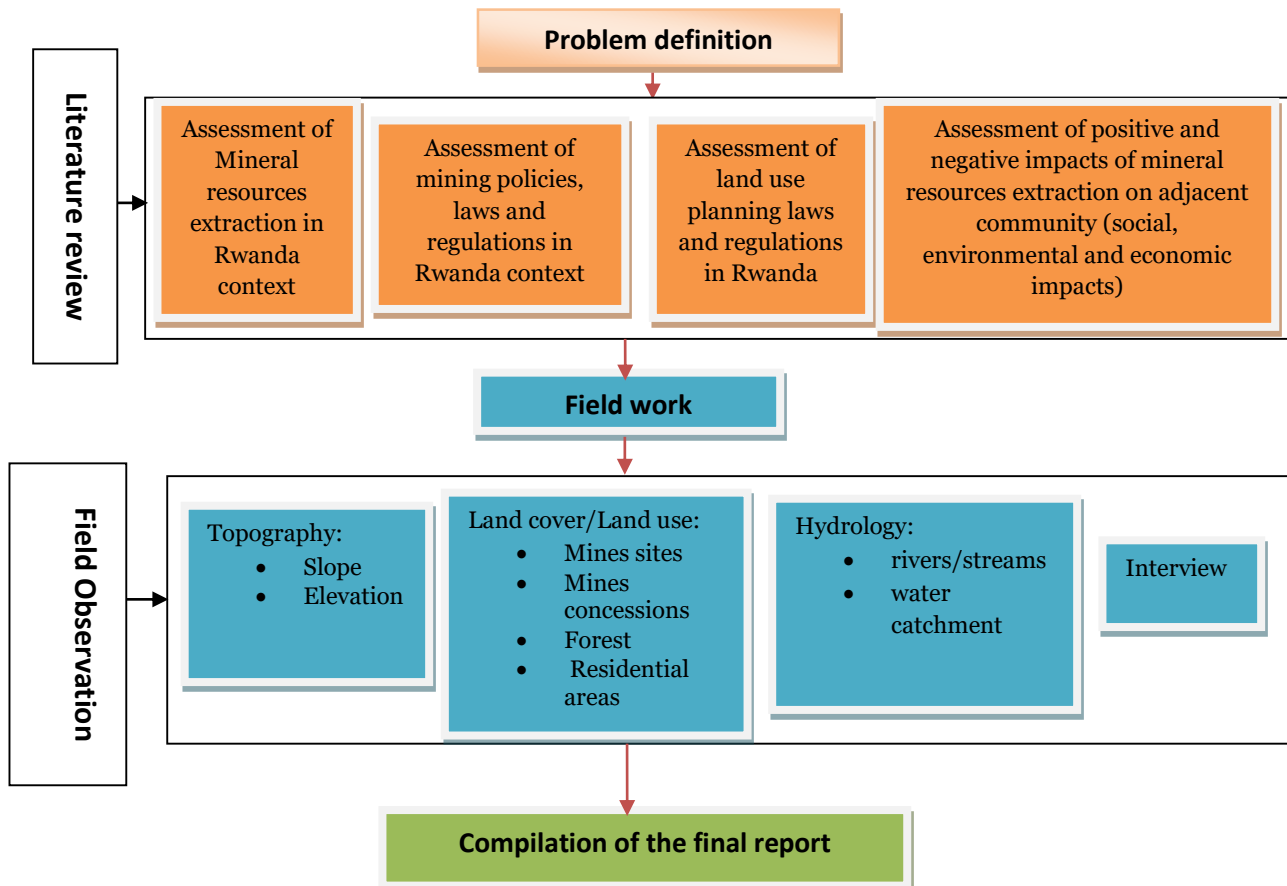


Figure 2: Flow chart of the study design

The collected data will be visualized (charts and maps), interpreted, and finally compiled with the purpose of providing responses to the research questions. All data collection methods and techniques will be more explained in the chapter on research methodology.

2. Chapter two: Mining implications on urban land use planning

2.1.Introduction

The aim of the literature review was to obtain background knowledge about the mineral resources extraction and land use planning. This chapter provides details of the theories, concepts and techniques of mineral resources extraction and land use planning as are relevant to the study. Thereafter, an extensive literature review was conducted to orientate the researcher on concepts such mine life cycle, environmental and socio-economic impacts of mining, and land use planning procedures; and to put the current study into the context of what is known about the topic.

2.2.Mine life cycle

Minerals are naturally-formed chemical elements or combinations of elements that have specific chemical compositions and physical properties. Metallic and non-metallic minerals occur in ordinary rocks throughout the Earth's crust, but only a few minerals contain high enough concentrations of metals to be mined profitably. The economically important part of a mineral deposit is known as the “ore” or “ore body” (Travis *et al.* 1999). Mining is the process of extracting metallic or non-metallic mineral deposits from the Earth. This process is performed by two operation systems which are surface or open-pit, and sub-surface or underground mining (Hildebrando 2006). The knowledge of the mineral deposit at the beginning of a mining project is estimated from the scattered information that has been obtained during exploration (Arteaga 2014).

A mining project involves several stages, starting with initial exploration and settling with Reclamation and Rehabilitation (post-closure scenario), phases of mine life cycle are Exploration, Mine planning, Construction of access roads, Mineral resources extraction/processing, and mine closure (Kumar 2014). The mining industry and its regulators are starting to recognize that closure

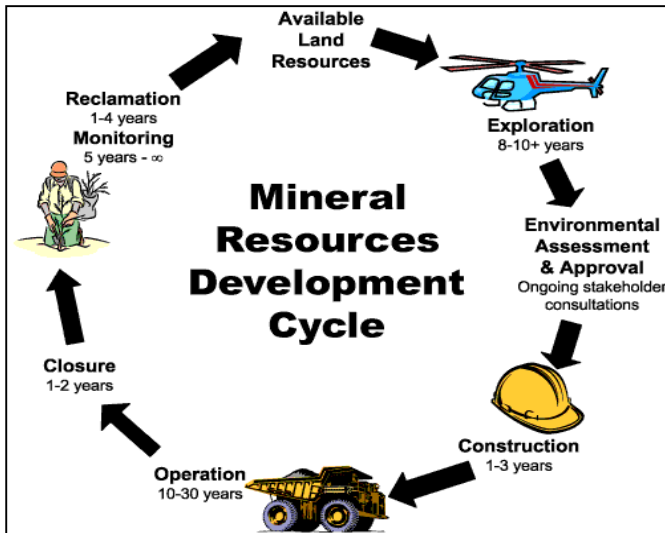
need to be planned and integrated throughout a mine's life (McKenna 2002). The key activities carried out during different stages of mining are highlighted in the table n°2.

Table 2: Key activities carried out during different stages of mining

Phase	Key activities
Exploration and feasibility	• Mapping, geology, petrology and petrography, geochemistry, geophysics, subsurface sampling (trenches, pits...) • Mineral anomalies identification • Qualitative and quantitative studies (laboratory and reserve estimation) • Decision making about economic feasibility and mining technical conditions
Mine development (planning and Infrastructure provision)	• Mine planning • Infrastructure acquisition • Environmental/social planning • Environmental impact assessment study
Mine operations	• Ore extraction and haulage • Crushing, grinding, concentrating • Waste rock and tailing management • Waste water management • Air quality management
Mine closure	• Site clean-up, reclamation, rehabilitation • Maintenance and environmental monitoring

Source: (RBS 2011).

Managing the mining cycle from exploration through to planning, construction, operation and finally mine closure can involve many datasets in different formats.



To be able to visualize all of these different datasets in one environment is important to locate mineral/ore deposits, moderate risks, increase mining efficiency, monitor the impact on the surrounding environment and communicate these factors to stakeholders. Typically, Geographical Information Systems (GIS) have been used to manage the life cycle of a mine (Terrington *et al.* 2015).

Figure 3: Mineral Resources Development Cycle

Source: <http://www.mineralsed.ca/s/MinDevCycle.asp>

2.3.Socio-economic impact of mining

Mining has a number of common stages or activities, each of which has potentially-adverse impacts on the society and cultural heritage, the health and safety of mine workers, and communities based in close proximity to operations (Kitula 2005). Living next to a mining area comes certainly with both, advantages as well as disadvantages. Advantages include employment opportunities and interesting career paths related to the mineral resource extraction or the improved infrastructure around the area. However, there are as well negative aspects. One of the largest impacts is certainly the necessity to relocate whole townships (Benndorf & Voncken 2014).

The major social issues related to mining activity have to do with cultural diversity and with decision-making processes. Mining activity affects health, culture and traditional roles within local communities and the power relationship between the local community and the national government. The progressive companies offer training to locals and frequently negotiate a variation of an affirmative action programme to ensure that community residents are used for as much of the labor in the mining activity as is considered possible. In addition to jobs and training, mining companies frequently build schools and hospitals or health facilities for workers and their families (UNEP 2000). Mining brings many other economic benefits such as the development of

infrastructure, which continues to be a major problem in most African countries. Many mining companies have, as part of their corporate social responsibility, provided infrastructure to support community development and, in some cases, have negotiated with communities on benefits (Twerefou 2009).

2.4.Environmental impacts of mining

Despite the benefits of mining to society, it often negatively affects landscape where resource extraction has taken place, and invariably affects other natural resources that human beings depend on (Ololade 2012). Three main types of changes are distinguished as a result of mining: change in the natural topography which results in restrictions in the possibilities of using the land for other purposes, changes in the hydro-geological conditions with consequences for both groundwater and surface water and finally changes in the geotechnical conditions of the rock (Jenny & Johan 2008).

Environmental degradation can occur during all the phases of a mining project, exploration, disposal of waste rocks and over burden, ore processing and plant operations, and tailings (processing waste) management. Some of the environmental problems caused by mining activities include; diversion of rivers, water siltation, landscape degradation, deforestation, and destruction of aquatic life habitat, widespread pollutions, and chemical poisoning. Deforestation for example, is usually intense in the vicinity of mining settlements, which translates into a loss of biodiversity and consequently a change in the nutritional habits of the adjacent local population (Maliganya *et al.* 2013).

Underground mining alters the Earth's crust, in some areas; mining and subsidence have lowered ground-water levels, causing some wells and streams to go dry, changes in water quality, and structural damage to buildings, roads, pipelines, and reservoirs (Hobba 1993). Due to its nature, especially opencast mining inevitably leads to serious degradation on ecological and aesthetic values of the landscape (Kuter 2013). Mining can become more environmental friendly and sustainable by adopting and integrating social, environmental and economic developments that minimize the environmental impact from mining operations. These include less usage of water and energy consumption, minimizing land disruption and waste production, preventing air, water and soil pollution at mine sites, and conducting successful mine closure, reclamation and rehabilitation

activities (Kumar 2014). This research will assess what kind of environmental impacts that the case study is facing due to the mining operations.

2.5. Mining and land use planning

According to AngloGold Ashanti Limited (AGA) from South Africa, mining is a temporary land use, and although activities can span many decades, if poorly controlled, residual impacts can last for many generations. The change of existing land use or securing access to land for new mining or exploration activities can be controversial, especially where communities are affected (AGA 2009). According to the Department of Mines and Petroleum and Environmental Protection Authority (DMP & EPA) in Australia, mine closure planning should be an integral part of mine development and operations planning and as such the level of information required will correspond to the life span of the mine and reflect the various stages of the life cycle of the project (DMP & EPA 2011).

According to International Council on Mining and Metals (ICMM), mining activity uses land at every stage of the mining cycle – exploration, construction, operation, closure and post-closure. The construction phase of the mining cycle is associated with the greatest direct land-use change. Areas of vegetation are often cleared for mining areas, project facilities such as buildings and infrastructure such as access roads, pipelines and power transmission lines. The construction of roads can also result in land-use change indirectly as they facilitate the opening up of forested areas to timber harvesting, additional mining activity, agriculture and settlement (ICMM 2011). The impact of mining and mineral resources extraction activities can be significant on the surrounding land, water and air bodies, in any operational area (Mondal *et al.* 2014). The siting of mineral operations depends upon the location and character of deposits. United Nations Environment Program (UNEP) stated that they may be in an area where mining is not a preferred land use, e.g., adjacent to or beneath an existing community or in an environmentally sensitive area (UNEP 2000).

Oxford Committee for Famine Relief (OXFAM) states that when extractive industries expand, they often move into territory already used by people who depend on farming, ranching, forestry, or fishing for their livelihoods (OXFAM 2014). Tools available to the mining industry to mitigate

this land-use change include environmental management systems and careful decision-making on infrastructure placement and mining area design (ICMM 2011). It is imperative from the above that the mineral resources extraction process must ensure return of productivity of the affected land (Sheoran *et al.* 2010).

According to the Maryland Office of Planning (MOP), competition among the planners' various objectives gives rise to a series of contemporary growth management and resources protection issues. The non-renewability of minerals, the loss of potential extraction sites, and the continuation of residential sprawl combine to make the planner's job of sorting out and balancing competing planning objectives all the more difficult. When the planner tries to fit surface mining into a comprehensive land use plan, he has a set of objectives with built-in conflicts. He wants to: (1) make available mineral resources for use in industry; (2) conserve minerals so that they can contribute to the local economy; (3) protect residential areas from noise, dust, vibration, traffic or unsightliness of pits and quarries; and (5) reclaim worked mines for a new land use that will fit a comprehensive plan (MOP 1997).

According to the International Institute for Environment and Development (IIED) and World Business Council for Sustainable Development (WBCSD) In an ideal world, integrated land use planning requires, first, a solid database about current land uses and land use potential. Establishing this can be complicated by imperfect information: the mineral potential and many other values of the land – from the wildlife species that inhabit it to its support of livelihoods of local villagers – are not well known by the planners. Second, the needs and preferences of those currently based on the land need to be canvassed. Third, a negotiation or arbitration mechanism is needed that seeks to balance local, regional, and national priorities. A mechanism is also needed to compensate those affected by development or by the loss of land or land-dependent livelihoods – or to resettle those who may be displaced (IIED & WBCSD 2002).

2.6.Mineral safeguarding in urban areas

Mineral resources extraction makes an essential contribution to national development and prosperity. However, unlike many other land uses, the location of sites where mineral resources extraction can take place is limited. The underlying geology dictates where mineral resources

occur and other factors, such as economics, environmental considerations, surface land use or technology can limit access. To ensure a continued, steady and adequate supply of the raw materials needed by society, it is important that mineral resources are not needlessly sterilized by new, non-mineral related, development (Wrighton *et al.* 2014)

According to European Commission (EC), once the presence of a potential minerals resource has been established through geological surveys (or any other kind of exploration process); the objective of safeguarding through the planning process is to protect mineral resources from sterilization by non-mineral development (housing, roads, etc). Safeguarding does not necessarily mean that the resource identified will be extracted, but rather it puts in place a check to ensure that extraction is at least considered before any form of sterilizing development can go ahead (EC 2010).

In England, advice on mineral safeguarding encourages Mineral Safeguarding Areas (MSAs) to be based on the best geological and mineral resource information available. This is principally provided by the British Geological Survey (BGS) in the form of mineral resource maps and digital data that has been prepared for each Mineral Planning Authority (Wrighton & Bide 2012). Defining MSA alongside environmental and cultural designations will ensure that the impact of any proposed development on mineral resources will be taken into account alongside other planning consideration. In urban areas, Mineral Planning Authority should define MSAs where they consider this will be of particular value. Mineral development on the fringes of the urban areas may be of economic advantage due to the availability of mineral on site for the development proposed or the shorter distance to market (Wrighton *et al.* 2011).

2.7. Overview of Rwanda s' mining industry

Rwanda contains many of the mineral commodities that are of major significance for the current high-tech industry worldwide. The main metals exploited in Rwanda historically and nowadays are tantalum-niobium, tin and tungsten (Mucheze *et al.* 2014). Studies of two major tin and tungsten deposits in Rwanda indicate that the metals are deposited in quartz veins resulting from metamorphism of granites at depth (Misener *et al.* 2011).

The artisanal nature of mining in Rwanda is associated with a number of adverse environmental ramifications. Owing to the low level of technological application and technical expertise, the country's miners predominantly use rudimentary technologies for prospecting as well as extracting and processing ore. As a consequence, open cast tin (cassiterite) mining activities on steep slopes allow ore residues to flow uncontrolled downhill into streams and rivers. Although available research has not directly interrogated the human toxicity potential of the resultant pollution, there is evidence of widespread arable soil toxicity. In addition, mine tailings contaminate surface and groundwater, making it difficult for local communities to access clean, unpolluted drinking water (REMA 2011).

2.7.1. Brief history of mining in Rwanda

Mining in Rwanda started in the beginning of the 20th century, with the Belgians hoping to find the same mineral wealth they had in the neighboring Congolese region (Teeffelen 2012). The first geological map of Rwanda was published in 1926, and mining began in 1930. After independence, the Government of Rwanda created a public mining company, SOMIRWA (Societe Minières au Rwanda), by combining all existing mining companies to strengthen the industry. In 1985 SOMIRWA went bankrupt and in 1989 another public company, REDEMI (*Régied'Exploitation et de Développement des Mines*), was established to continue mining and exploration. There was slow growth from 1994 but intensive privatization of state-owned mines from 2006 increased productivity while high commodity prices boosted the sector (Byamukama *et al.* 2011)

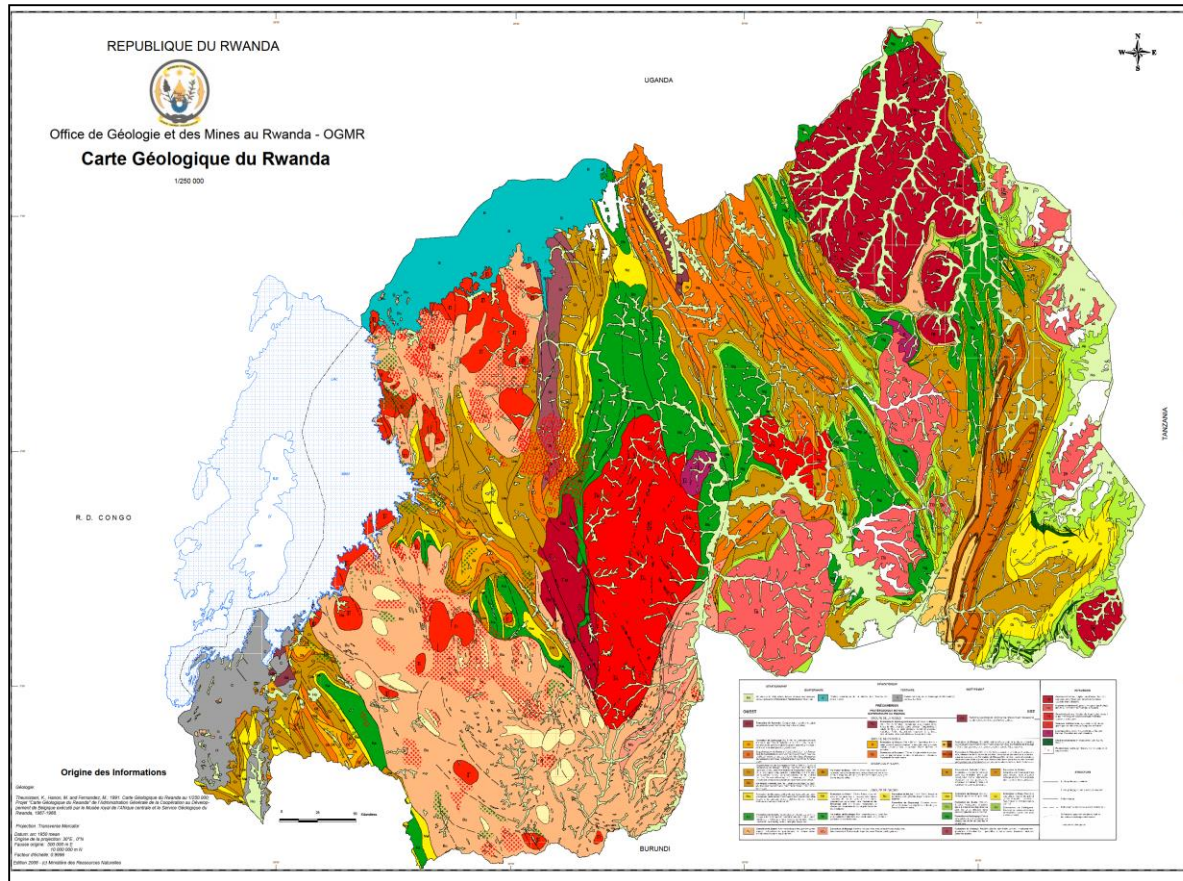


Figure 4: Geological map of Rwanda
Source: Rwanda Geology and Mines Authority 2010

Geological maps of the country are available, however, these are at a regional scale (1:100.000) and as such not straightforward to use for focused exploration and mine planning. Therefore, a more detailed geological mapping focusing on exploration and exploitation has been carried out. Regional zonation patterns of the mineral occurrences have been established which could be used as exploration vectors. A lithological and structural control on the mineralization has been recognized and several minerals have been identified that could be used as pathfinders for ore exploration (Mucchez *et al.* 2014)

Historically, Rwanda has been exporting tin ores since 1930, through Belgians settlers who started mining activities in Bugarama, Rutongo, Nyakabingo (Northern Province), Rutsiro, Sebeya, Giciye, Kabaya, Bisesero (Western Province), Gatumba, Mushubi (Southern Province), Rwinkwavu, Mirenge, Nemba, Musha, Ntunga, Bugarura, Bibare, Kuruti and Gahengeri in the

Eastern Province. In most cases, all these tin ores also contained both Colombo-Tantalite (commonly known as “Coltan”) and Wolfram, since these three precious metals are often exploited together as they are commonly found in the same geological deposits/rocks. On the other hand and for many generations, traditional exploitation of gold has been undertaken in Nyungwe Forest in Southern Province and Miyove in Northern Province (Nkundibiza 2013). The map in appendix 3 illustrates the spatial location of minerals in Rwanda.

In 2010, twenty one (21) prospective potential target areas (PTAs) have been delineated in Rwanda based on the results of previous airborne geophysical surveys by New Resolutions Geophysics (NRG) and Paterson, Grant & Watson Limited (PGW). Out of these, four PTAs were selected by the Rwanda Natural Resources Authority (RNRA) and the Ministry of Natural Resources (MINIRENA) for further investigation. In 2012, these surveys have been executed by Beak Consultants GmbH, Freiberg / Germany, in co-operation with Council for Geoscience (CGS), Pretoria / Republic of South Africa. Main target minerals were tin, tungsten, niobium, tantalum and gold. During the project, a unique database of previous and newly captured geological, geochemical and geophysical data was compiled (Knobloch *et al.* 2013).

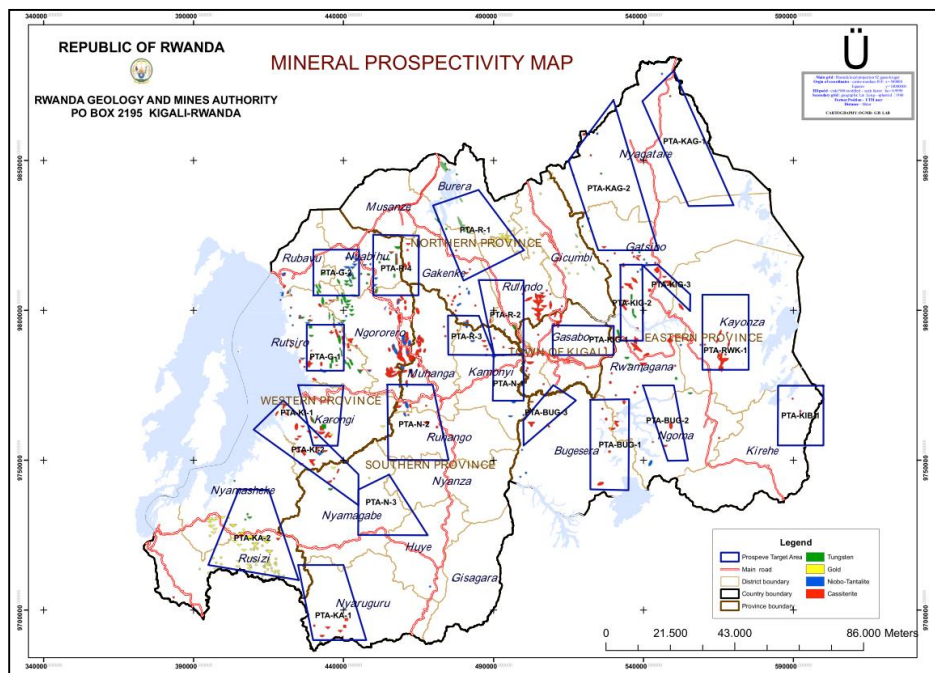


Figure 5: Mineral potential Targeted Areas in Rwanda
Source: Rwanda Geology and Mines Authority 2010

The figure n°7 indicates the location of mineralization zones in Gasabo District which are classified in two PTA-KIG-1 which is rich in Tin mineral and PTA-R-2 which is rich in Wolfram mineral.

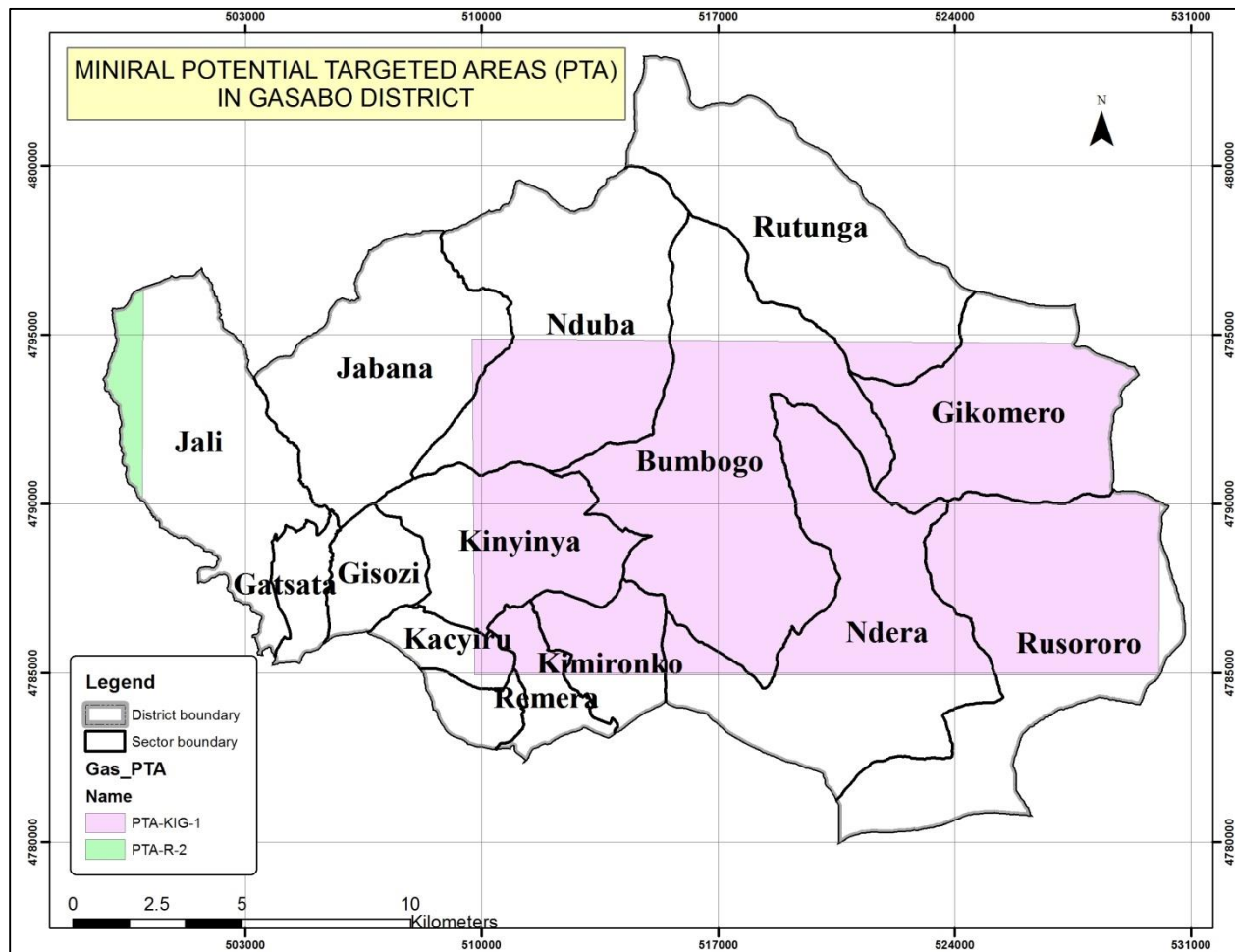


Figure 6: Mineral Potential Targeted Areas in Gasabo District
Source: RNRA, 2016

The mining sector in Rwanda faces a number of challenges to its growth and development, competition for land and negative perception of industry due to land use conflict are ones of these challenges which are listed in table n°3.

Table 3: Vulnerabilities of mining sector in Rwanda

Vulnerability domains	Vulnerability indicators
Economic/ Finance	• Low private investment as resources uncertain • Dominated by small scale miners • Royalties and taxes may result in under-reporting • High costs of fuel and electricity discourage investment • Limited access to reliable water supply
Social/ capacity	• Limited land available – competition for land
Technology/ R&D	• Low tech/not mechanized • High tech exploration done by consultants
Political	• Difficult to import ores from neighboring countries due to their conflict minerals • Obligation of required certified trading chain incurs added costs
Legal /Institutional	• Low capacity to implement law and policy • No requirement for reporting on energy and water use • Difficult to regulate artisanal miners
Environment /Climate	• Causes environmental degradation (e.g. river pollution) • Can cause deforestation • At risk from floods and storms • Workforce affected by disease, heat waves
Communication /Information	• Government funding difficult to obtain • Negative perception of industry due to land use conflict • Lack of data on energy and water sources and use

Source: Cole & Hogarth (2011)

2.7.2. Legal and regulatory framework of mineral resources extraction

In 2010 the new mining policy replacing the one of 2004 was put in place. The new mining policy covered wider aspects of regulation, institutional and investment framework for the mining industry, value addition and capacity building strategies as well as providing a clear plan of action to support the sub sector's growth. The mining policy covers not only mineral resources extraction, processing and export, but also quarrying, production of construction materials and extraction and processing of semi-precious stones.

Table 4: Type and duration of mineral licenses

Type	Duration
Exploration	An exploration license shall be valid for an initial period not exceeding four years and may be renewed once for a period not exceeding four years and after relinquishment of fifty percent (50%) of the unexplored area.
Exploitation	A small-scale mining license shall be valid for an initial period not exceeding fifteen years or the estimated life of the ore body proposed to be mined, whichever is shorter. Such a license may be renewed for further periods each not exceeding ten years.
	A large-scale mining license shall be valid for an initial period not exceeding twenty-five years or the estimated life of the mineral ore body proposed to be mined, whichever is shorter. Such a license may be renewed for further periods each not exceeding fifteen years.
	An artisanal mining license shall be valid for a period not exceeding five years. Such a license may be renewed for further periods each not exceeding five years.

Source: Government of Rwanda (2014)

Before the current mining law, there was also the prospection license with the objective of providing a preliminary assessment of the potential for mineralization over a relatively large area. This type of license was removed and its objective was combined with the ones of exploration license. According to the current Mining and Quarry Operations Law N° 13/2014 of 20/05/2014; one of the responsibilities of small-scale and artisanal mineral exploitation holders is to carry out rehabilitation and reclamation of mined out areas. This law is made effective by the following ministerial orders: Ministerial Order N° 001/MINIRENA/2015 of 24/04/2015 determining modalities and requirements for the financial guarantee of environmental protection and its use in mining operations; Ministerial Order N° 002/MINIRENA/2015 of 24/04/2015 on criteria used in categorization of mines and determining types of mine; and Ministerial Order N° 003/MINIRENA/2015 of 24/04/2015 determining modalities for application, issuance and use of mineral and quarry licenses.

To implement the above mentioned policy, law and ministerial orders; Head of Geology and Mines Department coordinates and manages all geology and mines department daily activities. Under

this department there are five units with the following respective responsibilities as indicated in the table n°5.

Table 5: Geology and Mines Department units and their respective responsibilities

Unit	Responsibilities
Mines regulations and inspection	• Regulation of mining companies/cooperatives on mining best practices including safety, security and environmental aspects at all mine sites in Rwanda. • Ensuring transparency in minerals produced in Rwanda through tagging minerals from the mine sites to the export level • Harmonize national standards with international standards in mining.
Mining cadastre and licensing	• To manage mining permits/license database (the computerized cadastre system)and continuously update management on the status of permits; • Receive and study compliance of applications with standard procedure; • Participate in settling of licence overlaps and conflicts
Geological surveying	• Develop geological, petroleum and mining exploration programs aiming at mining development • Carry out geological survey operations; • Make an inventory of the country's rocks and ores; • Identify drilling areas and supervise drillings;
Petroleum exploration	• Develop petroleum exploration programs • Prepare surface and sub-surface maps and diagrams that depict the stratigraphy and the composition of the basin and potential deposits of gas and oil; • Estimate oil reserves in proven or prospective fields, and consult with the petroleum engineers regarding drilling and production methods;
Mining business support services	• Develop programs towards the organization and strengthening of mining activities in the country • Linking miners to potential supporters of their ventures and potential investors into their ventures (building partnerships); • Working out comparisons between proposed mining projects with other competing investments (land uses);

Source: RNRA (2015)

In order to reduce the negative impact of mining activities on land, Geology and Mines Department work together with the Department of Lands to put in place actions that protect land resources from the various effects of land Degradation, promoting the involvement and sensitizing

of the public at all levels, especially those involved in mining, to introduce land use practices that are favourable to sustainable mining (RNRA 2012).

2.8. Overview of land use planning in Rwanda

Land use management is a fundamental tool in development. As Rwanda is characterized by acute land shortage, a land use plan has been developed to ensure its optimal utilization in urban and rural development (GoR 2012). EDPRS II states that: a functional planning system, coordinating actors at the central and the local government level, with clearly defined roles, participatory implementation and a strong monitoring component will be developed. This will require strengthening the alignment of development interventions to developed land use master plans and strengthened monitoring of economic planning to ensure spatial planning is well addressed (GoR 2013).

2.8.1. Legal, regulatory and institutional framework of land use planning

Guided by the National Land Policy and Organic Land Law responsibility for land use planning and land administration is today divided among several agencies and levels of government. Ministry of Natural Resources (MINIRENA) is the direct supervisor of Rwanda Natural Resources Authority (RNRA) and has several important mandates in land use planning matters. Rwanda Housing Authority (RHA) under the Ministry of Infrastructure (MININFRA) has mandates in urban land use planning matters. This institution is responsible for elaborating and monitoring the implementation of Urban and Rural Development Plans. At District level, each District is responsible for developing Integrated District Development Plan (MININFRA 2015).

The types of plans commonly prepared within the Rwanda's planning system are not conforming to the type of plans mentioned in the Law Governing Urban Planning and Building in Rwanda. The terminology used instead is: National Land Use Master Plan, Local Urban Development Plan, District Development Plan (sometimes District Land Use Plan), and Detailed Physical Plans (sometimes called Area Action Plans). Also, the type of areas which require urban master planning and land development planning are not clarified (MININFRA 2012). The Urban Planning Code (UPC) - elaborated by the Ministry of Infrastructure (MININFRA) in 2015 - provides the principles for the sustainable development and management of land used for human settlement. It

is binding for all categories of land within urban areas for any development and investment project, public institutional, tourist, public spaces, urban renewal and infrastructure servicing. The UPC is an important tool for the preparation and implementation of physical plans and provides a reference for government authorities, planners and professionals who undertake activities in urban planning and development (MININFRA 2015).

According to this UPC, mining land use is one of the categories of urban land use. This zone comprises the operation of mineral resources extraction, sand mining, brick-making, quarrying, and other mining-based industries. Supporting facilities include housing units, maintenance and storage buildings, and others. A mining area is subject to an environmental impact assessment and must have a land subdivision plan.

2.8.2. Urban and peri-urban areas

Today there is no uniform definition of an urban area. The National Land Use and Development Master Plan defines urban areas as a built-up agglomeration which exceeds 20 sqKm and has a population of more than 10,000 permanent living resulting in a population density of more than 500 persons/sqKm (Swedesurvey 2010). The distinction suggested by Rwanda Housing Authority between peri-urban, urban and rural areas follows: A village² with rural character lying within a proposed district urban boundary is classified as peri-urban area; a village holding important infrastructures/ built-up area lying within a proposed urban boundary is classified as urban area; and a village outside the proposed urban boundary is classified as rural area (MININFRA 2012).

The delineation of urban and peri-urban areas in Gasabo District followed the above mentioned criteria and this delineation was approved in 2012 by Gasabo District Council.

² Village refers to the smallest administrative entity in Rwanda context

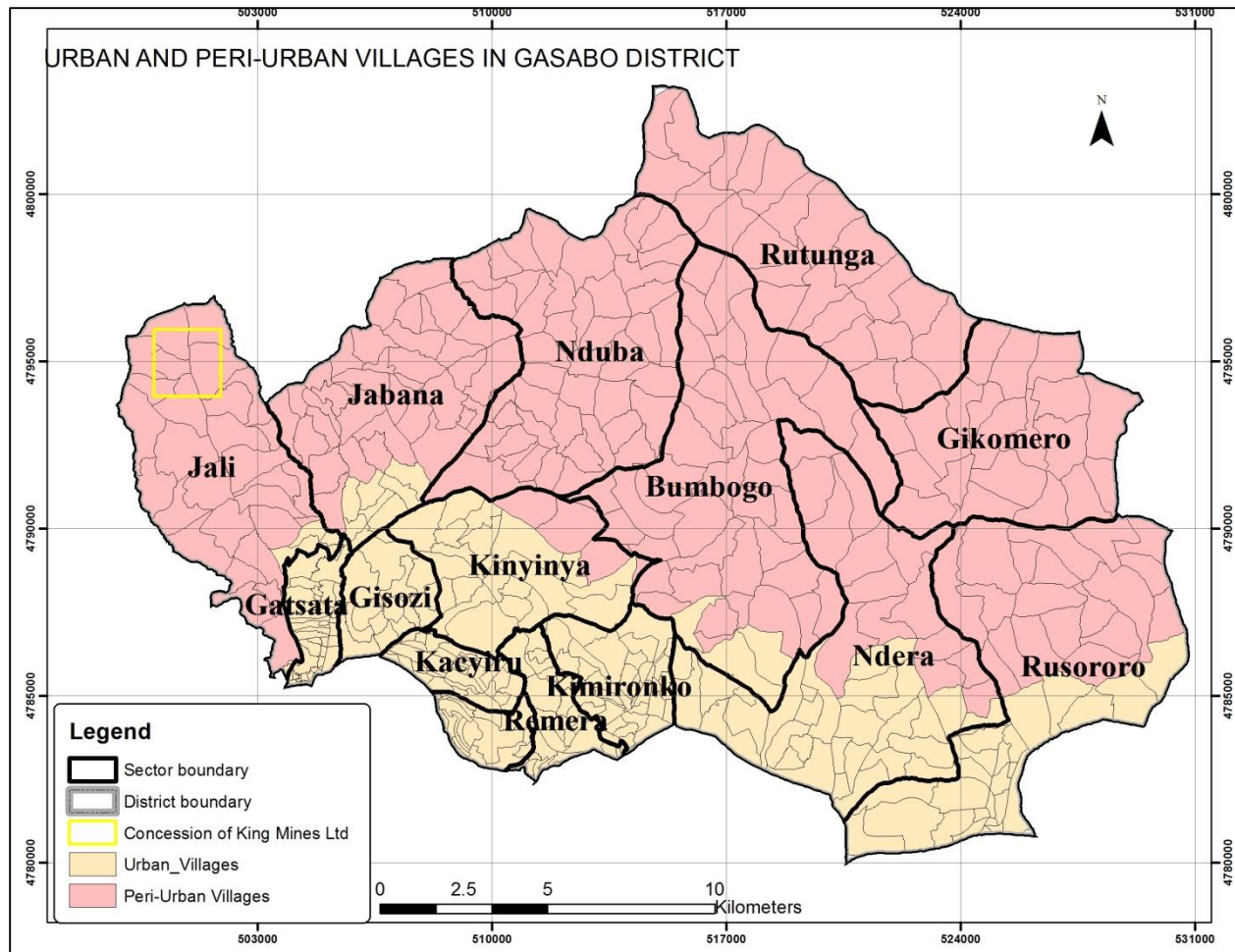


Figure 7: Urban and peri-urban areas in Gasabo District
Source: RHA, 2012

2.8.3. National Land Use and Development Master Plan

Vision 2020 states that Rwanda's scarce land resources still face a challenge of ineffective translation of the developed land use master plan into sector strategic plans and district development plans. In the coming years, Rwanda will ensure that every development plan is guided by the land use master plan (GoR 2012). The National Land Use and Development Master Plan accounts for the current situation of land management in Rwanda, land administration and institutional framework, laws and regulations that govern the use of land. It also addresses the current housing situation. By nature this national plan is a guiding plan which advises sector planning at central level and gives instructions for the preparation of the District Development Plan to harmonize with developments of national interest.

The main functions of the National Land Use and Development Master Plan are to apply national policies for the development of the country, to present land use proposals for all involved parties, to provide a coordinative framework for the production and implementation of District Development Plans, for making decisions on development issues on land use and to provide guidelines and priorities for the implementation of country-wide development programs and projects (Swedesurvey 2010) (see the map on national land use and development master plan in appendix 4).

2.8.4. District Development Plan for Gasabo District

While the District Development Plans (DDPs) are well placed to be prioritization and implementation tools of the National Land Use and Development Plan, it is recommended that they be significantly improved to serve as adequate tools for planning at local government level. Integrated District Development Planning (IDDP) is one of the key tools for local government to manage its new developmental role. In contrast to the relatively narrow role planning had in the past, integrated development planning is now seen as a function of municipal management, as part of an integrated system of planning and delivery (Swedesurvey 2010).

According to Gasabo District Development Plan, improved exploitation of minerals and quarry substances will facilitate the management of natural resources. Modernization of mining and quarry activities with the aim of environmental protection is one of the strategies to be undertaken in order to ensure the rehabilitation of ecosystem (Gasabo 2013).

2.8.5. Detailed Physical Plan for Gasabo District

The zoning plan for Gasabo District regulates the types of uses, the development intensity, the setting and height of buildings on any plot. As such, it serves as an effective planning tool to guide development in a logical and orderly fashion. The Zoning Plan is meant to provide landowners and developers with a clear picture of what can and cannot be developed on any particular plot. The Zoning Plan is made up of a Zoning Map and a set of Zoning Regulations. The Zoning Map identifies specific zoning districts within the planning area based on the predominant land use, and the desired intensity and building height for that area. The Zoning Regulations tabulate the uses into three categories: Permitted, Conditional and Prohibited uses.

Within the zoning ordinances, overlay zones provide more discretion & flexibility by allowing the City to protect certain areas as well as encourage or discourage certain types of development. Overlay Zones are mapped districts superimposed over the established zoning districts and can be used to impose supplement restrictions, permit or disallow various forms of density as well as provide bonuses and incentives to achieve the desired planning intent for that particular area. The parcel within the overlay zone will be thus subject to the regulations of the underlying zoning as well as the overlay zoning requirements. An overlay zone can cover more than one zoning district and even portions of several underlying zoning.

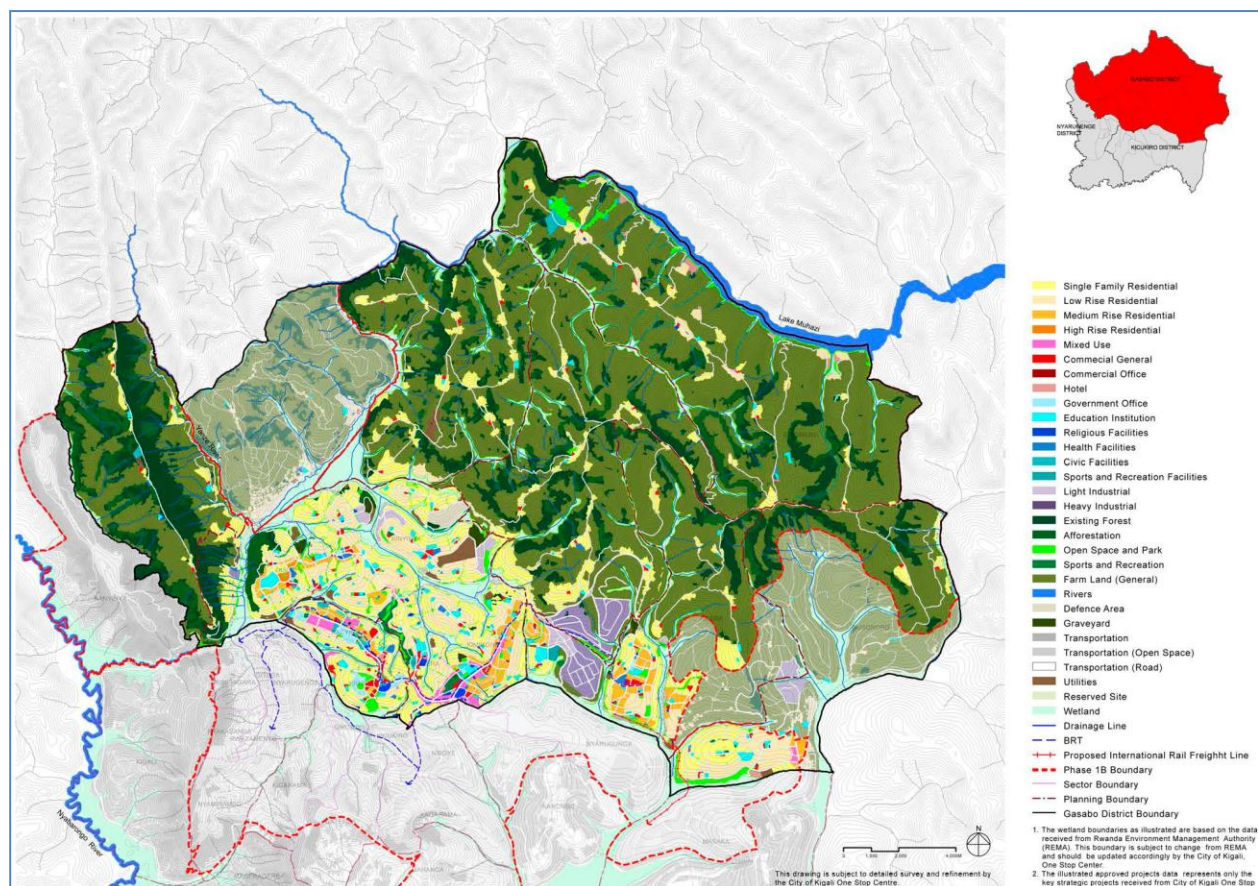


Figure 8: Proposed Gasabo Land use plan 2025

Source: City of Kigali 2013

The proposed Land Use Plan for Gasabo District provides the development plan for the intermediate term till the year 2025. This plan is developed based on existing context analysis. It also captures the approved projects and development trends in Gasabo District.

3. Chapter three: Material and Methods

The previous chapter reviewed literature on the study. It was intended to give an understanding of the research topic. The chapter provided in detail, issues on the mining industry and land use planning. The focus of this methodological approach chapter is therefore to outline the process of investigating the issues discussed in the previous chapter in the context of peri-urban area of Gasabo District. The methods used in this research was based principally on collecting and comparative analysis of facts gathered from different information sources, namely secondary data provided by different institutions, and also on information from interest groups and associations within the mining industry, and land use planning authorities and primary data collected during field visit. Data gathered and interpreted from a set of maps including land use and zoning plans, mine perimeters and mineral potential maps, social and physical infrastructure, and topography.

3.1. Study area description

3.1.1. Spatial location

The mine perimeter of Buhiza-Nkusi is situated in peri-urban area of North West region of City of Kigali, Gasabo District, Jali Sector, Buhiza and Nkusi Cells approximately 20 km from the Central Business District (CBD) of City of Kigali. This mine perimeter covers an area of approximately 400 ha; and this concession is owned by the mining company called King Mines Company Ltd with exploitation/extraction license of Tungsten (Wolfram).

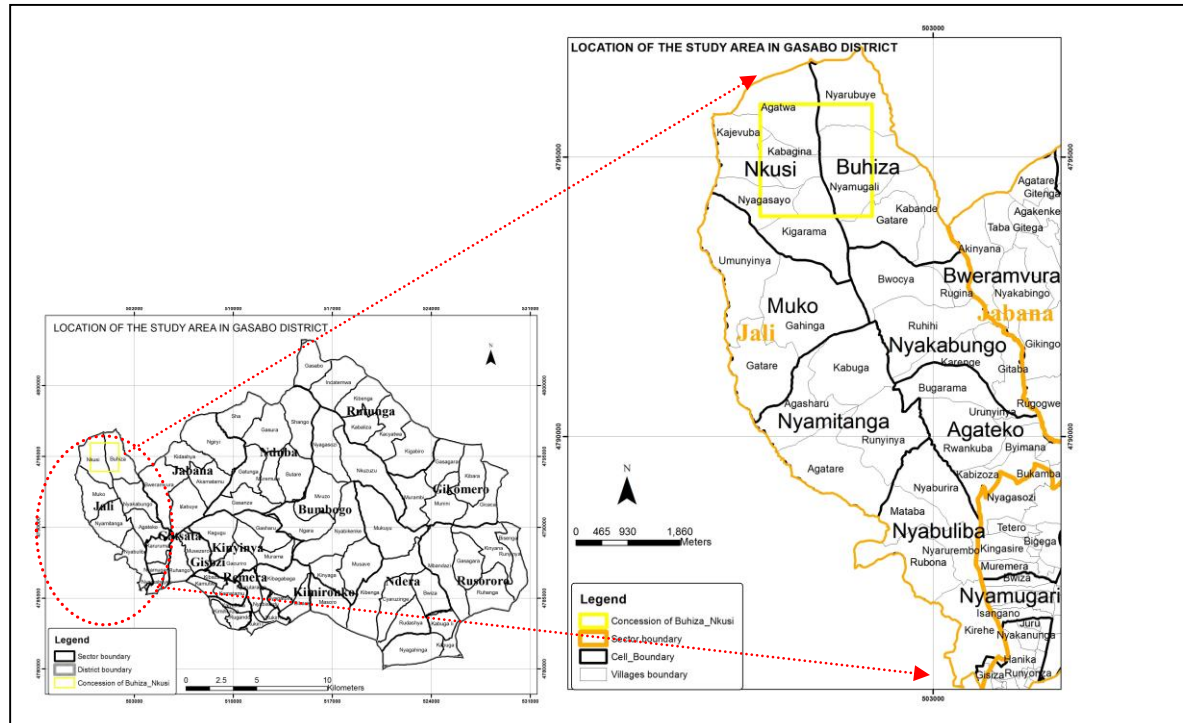


Figure 9: Administrative boundaries of the study area

Source: RNRA, 2016

3.1.2. Environment and topography

As the figures 12 and 13 show, the study area is characterized by the mixture of high mountains with average altitude from 1,340 meters to 2060 meters above sea level. This area constitutes of more aggressive relief due to the tight rectilinear ridges oriented northwest.



Figure 10: General overview of topography of the study area

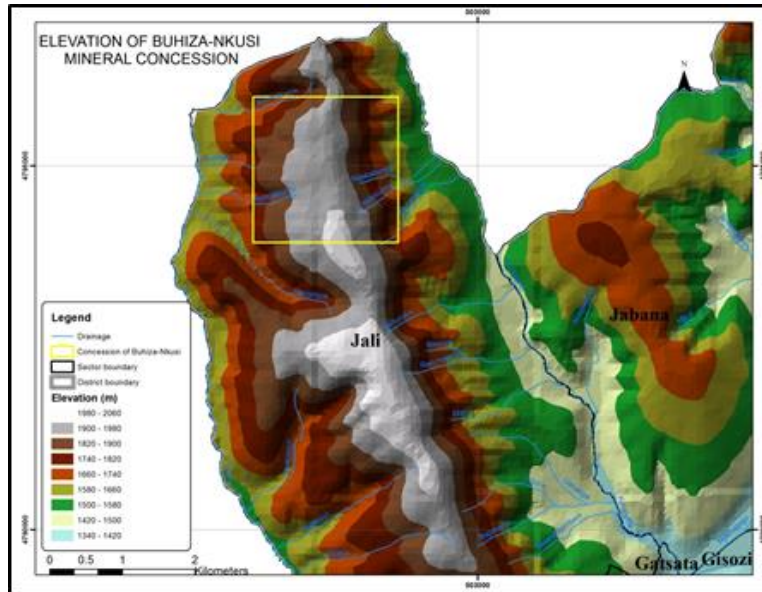


Figure 11: Elevation map of Buhiza-Nkusi mine concession

Source: RNRA, Modified by author, 2016

As the figure 14 shows, the area is generally flat at hill top (the slope range between 0% and 20%) and characterized by a steep sloping terrain (the slope ranges between 51% and 215%), which descends towards the alluvial plains of the Nyabarongo River.

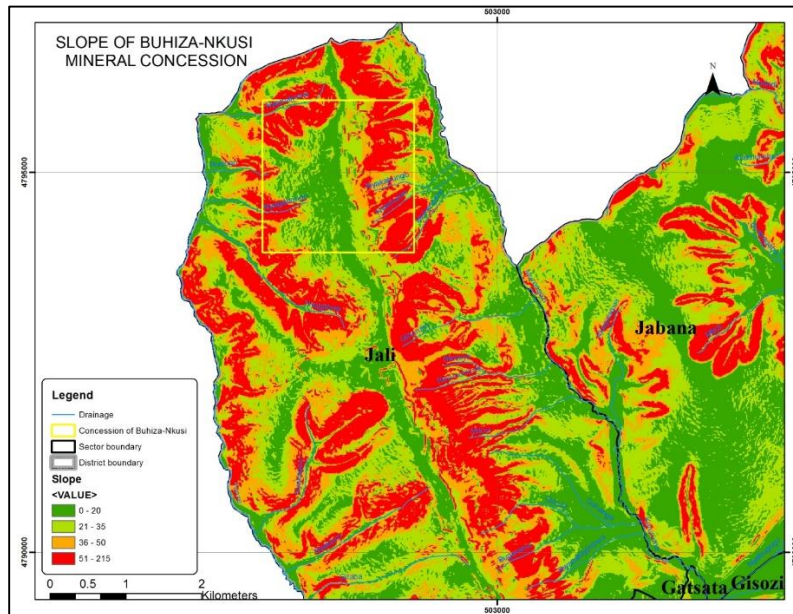


Figure 12: Slopes map of Buhiza-Nkusi concession

Source: RNRA, modified by author, 2016

3.1.3. Existing land use

The predominant land use of the study area is rural agriculture (crop land which is mixed with scattered settlement) and this is due to the tendency of local population to settle in the middle or beside their crop lands. Houses are constructed mainly in family compounds and most of inhabitants are on the hill tops and steep slopes.



USGS, 2015, modified by author



Figure 13: Existing land use of the study area
Source: Field observation, 2016

3.1.4. Geology

Buhiza-Nkusi mine concession is overlain by a metamorphic suite of rocks, pegmatite veins, and quartzophyllads, metaschistes, and quartzites which are actually part of the Kibaran belt.

The mine perimeter is mainly dominated by the magnetic alteration that contains several minerals including Wolfram.

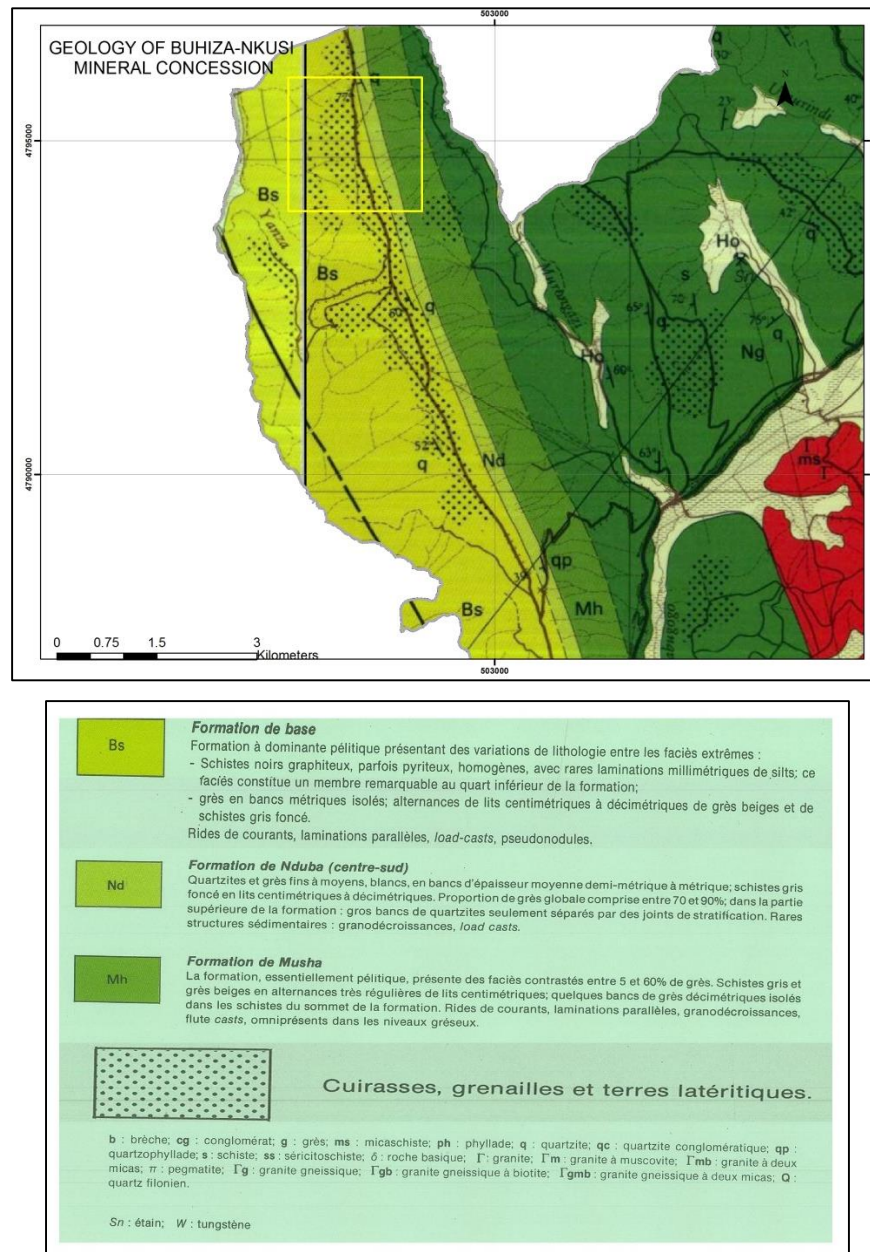


Figure 14: Geology of the study area

Source: Rwanda Geology and Mines Authority 2010

3.2. Literature review

The literature review was done initially to scan related concepts and trends about the topic and relevant data were collected from various official published materials. This serves as input to formulating the proposal and preparing the fieldwork activities.

3.3. Spatial data collection

The spatial datasets that were used in the present research includes GIS datasets such as administrative boundaries, aerial photo, Digital Elevation Model (DEM), hydrology, soil, precipitations, existing land use, land cover and zoning plans, mine concessions, mineral potential targeted areas, services and infrastructure. These data were collected from different institution such as RNRA, REMA, RHA and NISR. These spatial data facilitated to analyze and visualize the current aspects of environmental issues related to mining activities such land degradation and soil erosion, land use conflicts and water pollution among others in the study area.

3.4. Primary data collection

This section hence details the data collection methods utilized in the field. Four main methods were employed, and each is described within this section including household survey; key informant interviews; focus group; and field observation.

3.4.1. Sampling for households survey

The most reliable estimate of the target population was determined to come from a list of the number of households in each village, provided by the NISR. Based on this information, it was estimated that approximately 1455 households were located within the study area which is made up by (Buhiza and Nkusi Cells. Considering the extent and the scope of this research, the households from which a sample was to be drawn was not homogeneous. **Stratified random sampling** technique was thus applied in order to obtain a representative sample. Under this stratified random sampling technique, the households were divided into nine strata that are individually more homogeneous than the total population. The strata were formed based on administrative division where households residing in the same village of Buhiza Cell or Nkusi Cell are likely to experience the similar mining impacts.

For selection of households for the sample from each stratum, the **simple random sampling** method was used then the method of **proportional allocation** under which the sizes of the samples from the different strata are kept proportional to the sizes of the strata. The allocation of the sample size of each stratum followed the method of proportional allocation under which the sizes of the samples from different strata are kept proportional to the sizes of the strata. The sample size (n) was 150 heads of households and was drawn from a population of 1,455 which is the total number (N) of households within the study area. This population was divided into nine strata which is the number of villages of the study area and the number of households for each village represents a stratum i of the size N_i and P_i represents the proportion (N_i/N) of population included in stratum i , and the number of elements selected from stratum i is $n \cdot P_i$. Adopting proportional allocation, the table below illustrates the sample sizes for nine strata (nine villages):

Table 6: Sample size for nine villages

Cell	Village	Households (N_i)	P_i	Sample size ($n \cdot P_i$)
Buhiza	Gatare	147	0.10	15
	Kabande	237	0.16	25
	Nyarugali	165	0.11	17
	Nyamabuye	137	0.09	14
Nkusi	Agatwa	187	0.13	19
	Kabagina	169	0.12	17
	Kajevuba	124	0.09	13
	Kigarama	168	0.12	17
	Nyagasayo	121	0.08	13

Source: Household survey, 2016

3.4.2. Key informants interview

The selection of key informants for this research based on their specialized knowledge and unique perspectives on mineral resources extraction and land use planning. These key informants were drawn based from the following institutions.

Table 7: Key informant and their respective institutions

Topic	Institution	Key informant
Mineral resources extraction	MINIRENA	Director of Mineral licensing and Petroleum Unit
	RNRA	Head of Geology and Mines Department
		Director of Mines Inspection and Regulations Unit
		Director of Cadastre and Licensing Unit
		Safety Standards and Inspection Expert
Land Use Planning		Director of Land Use and Spatial Planning Unit
	RHA	Division Manager of Urban Settlement Division
	City of Kigali	Specialist in charge of Master Plan Implementation

Source: Household survey, 2016

At the end of each interview with key informant, interview summary sheet reducing information into manageable themes, issues, and recommendations was prepared. Each summary provided information about the key informant's position, reason for inclusion in the list of informants, main points made, implications of these observations, and any insights or ideas the interviewer had during the interview.

3.4.3. Focus group discussions

A small groups of seven people were brought together to engage in discussions pertaining to the mining operations and implementation of Gasabo Detailed Physical Plan. For this purpose, the neighborhood community or associations' representatives such as Local officials, Directors of schools, representatives of churches, miners' representatives, youth and women representative were invited to participate in discussion about the impacts of the mine operations in the study area as well as about the ongoing implementation of Gasabo Detailed Physical Plan. The interviews were face to face discussions to extract the viewpoints of the respondents who have in-depth knowledge about mining in the area, the implementation of Gasabo Detailed Physical Plan and the social status in the community.

This focus group discussion was useful as it enabled to understand the real situations happening within the communities surrounding mining operations. It also helped to gain insights into how local people see and express their general livelihood situation, their general attitudes, values and norms in relation to mineral resources extraction and land use planning, what kind of ideas and suggestions they would have for possible remedies. In totality, this method provided useful information on the local context for each village and study area as a whole.

3.4.4. Field observation

As part of the field work consisted in visiting the study area, and to observe and sample the area where the mine carried out their activities and to talk to the people that have lived or used the areas of the mine, a pass into the mining camp or/and in the closer settlements were required.

In this method, information was obtained by observing what was really happening and experienced by the people in the study area. In the field, direct observations were made on issues pertaining to socio-economic and environmental effects of mining operations in the study areas. Such issues included social development services, land degradation, water pollution, access to housing, job opportunities. The method assisted in supplementing information needed as it allowed the sharing of life experience of the group being observed.

4. Chapter four: Results and discussion

This section presents the results from the different investigated parameters and the relationships between mining operations and land use are discussed.

4.1. Socio-economic impacts of mining in Buhiza and Nkusi

The information collected from 117 representing 9 geographically distinct Villages reveals that there was a significant difference in gender among the surveyed households since only 4.3% were females and the remaining 95,7% were males. Regarding the boundary of the mineral concession, none of the respondents were aware of the extent of the perimeter. They only know where mining operations are taking place. The average age group of respondents who completed the

questionnaire was between 28 and 55. This age group consists mainly of active people who are employed by the mining company and the heads of households who reside in the vicinity of the mine. The table below shows that the main source of livelihood of the most respondents is agriculture and mining.

Table 8: Source of livelihood

Source	Respondents	%
Mining	31	26.5
Agriculture	65	55.6
Farming	3	2.6
Commerce	15	12.8
None	2	1.7
Other	1	0.9

Source: Household survey, 2016

The promise of jobs has been one of the major incentives for most Buhiza and Nkusi communities to open up mining activities. The respondent indicated that families who have any of their relative working at the King Mines Company Ltd have had an improvement in their livelihood. The evidence from the above figure indicates that 26.5% of respondents benefit from the existence of mining activities. Within the study area, some 55.6% of respondents benefit from agriculture; 2.6% from farming (livestock) and was found that only 1.7% of respondents in the study area are not able to precise their source of livelihood, while 0.9% benefit indirectly from mining, commerce and other activities.

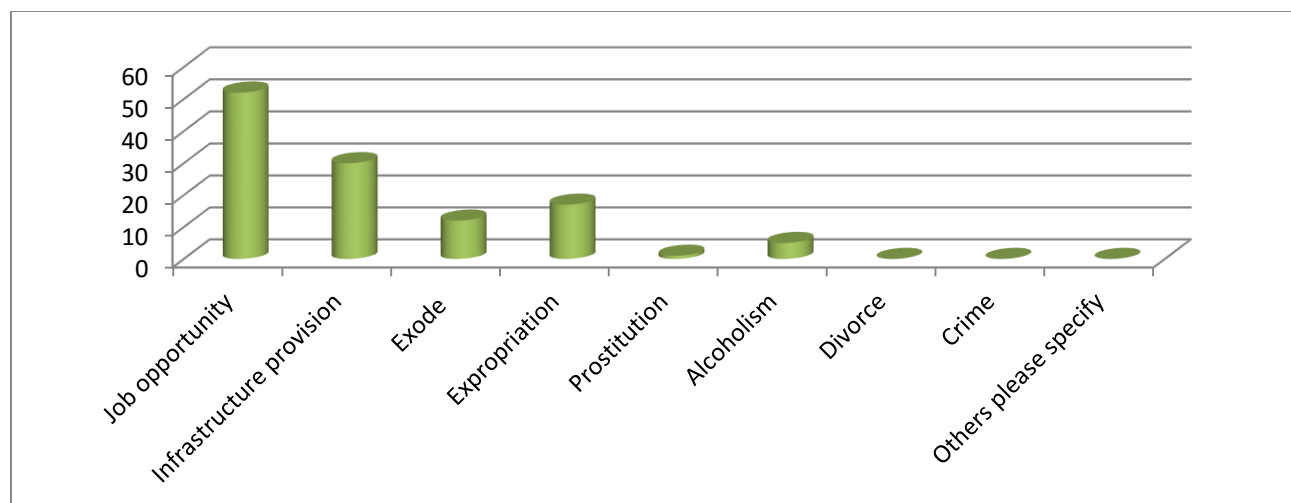


Figure 15: Impact of mining operations

Source: Household survey, 2016

According to the field observation, the built-up area expanded at high rate because of the population expansion due to workers migrating to the area in search of employment. Many informal settlement are developing in Buhiza and Nkusi Cells.

The results indicate that mining activities at King Mines Company concession have created job opportunities for the local inhabitants. Since mining operations started in 2014 local inhabitants benefited from a wide range of new services, including improved access to road and commercial activities. In additional, the opening of mining operations has resulted in high influxes of migrants in search of jobs. This, in turn, has resulted in expropriation of some local landowner due to the expansion of mining operations and some of respondents who have had their lands taken over by King Mines Company Ltd indicated that the compensation was not enough.

The local leader at cell level and the representatives of King Mines Company Ltd confirmed that poverty levels have reduced since mining began. Some people whose lands bought by King Mines Company have invested in other activities through different socio-economic activities, including sales from food crops and menial business activities. King Mines Company Ltd promised local residents to provide and improve the major infrastructure as well as other social support, and during the discussions with the authorities from MINIRENA, it was revealed that mining licensee is required to prepare the plan for corporate social responsibility in consultation with the Sector

where the mining activities is carried out and then provide this plan to the MINIRENA not later than three months from the date the license has been issued. However, the responses from the head of households on the above mentioned consultation with King Mines Company Ltd was completely negative.

Most of respondents living in the study area are not aware of the above mentioned requirements related to the corporate social responsibility. However, the representatives of King Mines Ltd claimed that they are putting efforts in helping the development of the sustainable environment for the community of Buhiza and Nkusi Cells.

4.2. Environmental impacts of mining in Buhiza and Nkusi Cells

This section is based on interviews with respondents, focus group discussion and personal observation of environmental impacts of mining. According to the surveyed households, almost 98.3% of respondents described Nkusi and Buhiza Cells as rural area. The existing land use shows that types of settlement is scattered and dominated by the croplands. Only the small proportion of the respondents (1.7%) consider this area as peri-urban area.

The field observation indicated that mining for Wolfram in the area have taken up some of the rich lands which are used for farming. Due to the mining operations, many trees are cut down making the place bare for easy wind and water erosion thereby reducing soil fertility. Majority of the respondents as indicated in the chart below said that Wolfram extraction operations has led to the ineffective farming activities due to land clearance, erosion and landscape degradation.



Figure 16: Scattered shafts
Source: field survey, 2016

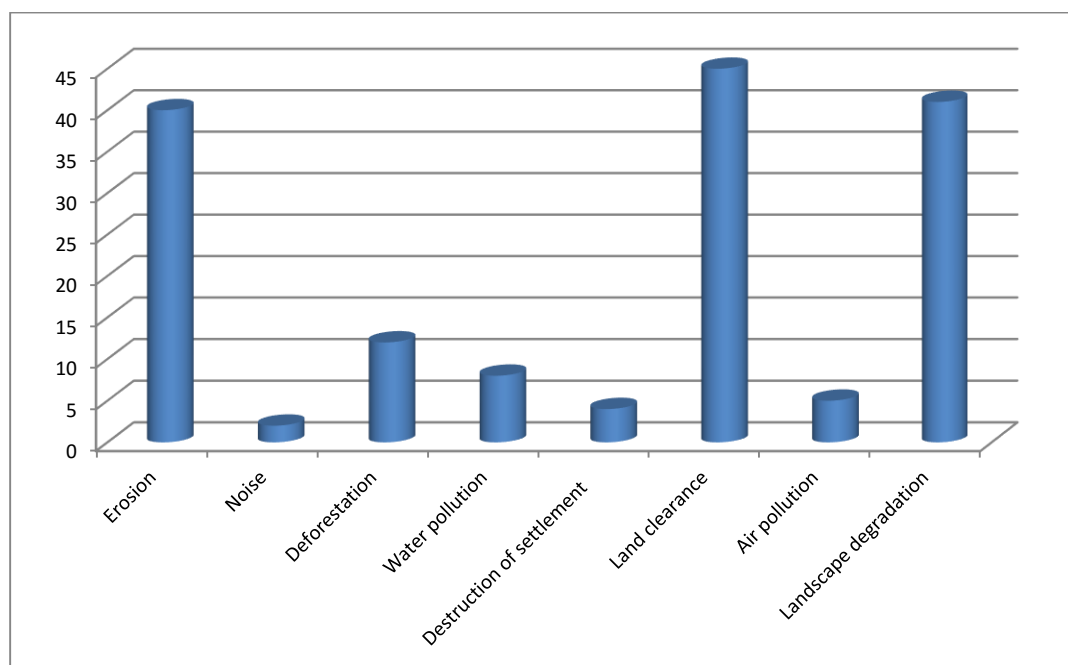


Figure 17: Environmental impacts of mining operations
Source: Household survey, 2016

According to the results from focus group discussion, both agricultural and grazing lands have been destroyed since the start of Wolfram extraction by King Mines Company Ltd in June 2014. Some of the typical environmental impacts caused by mining operations include water pollution, noise, landscape degradation, deforestation, and air pollution due to dust from tailings. Surprisingly, the representatives of King Mines Company Ltd did not show any significant relationship regarding the effects of mining on the environment. This was found out to be the result of respondent bias since they are benefiting directly from the mining activities, hence, refused to be objective on the issue.



Figure 18: Tailings deposits in the croplands, operational tunnel and one of the scattered shafts
Source: Field observation, 2016

Discussion with authorities from Geology and Mines Department, Every mining company shall be subjected to Environmental Impact Assessment (EIA), before obtaining authorization for mineral resources extraction. This EIA report includes the description of all activities associated with

mining operations, their environmental impacts and mitigation measures, and the proposed rehabilitation/closure plan.

King Mines Company Ltd understands also its environmental obligations. By the time of field survey they did not however have a competent person who was able to explain what is found in their Environmental Impact Assessment (EIA) report which was approved in 2014 by Rwanda Development Board (RDB). On the other hand, the part of this report on mine rehabilitation and resettlement action plan and compensation procedures is not clear and detailed as the table below indicates.

Table 9: Mine rehabilitation and resettlement action plan and compensation procedures

Item	Recommendation	Observation
Physical integrity	Consideration should be given to backfilling of mine workings.	When and how?
Chemical integrity	Leaching of chemicals into the environment should be prevented, so as to avoid endangering public health or safety water quality objectives in downstream surface water and ground water systems.	
Ecological habitat integrity	Replacement of habitat that is beneficial for future ecological use.	
Conservation of top soils	This stage will start during the phase of mineral resources extraction because scouring will be done while separating and by storing the topsoil and unproductive land.	
Re-vegetation and trees plantation	This phase will close the rehabilitation of mines immediately. Re-vegetation trees plantation will succeed immediately.	

Source: RNRA, 2014

As highlighted in the Table 9 above, this part of EIA which seems to be very important doesn't have the detailed information about the proposed strategies in order to answer how question; and the proposed timeframe related to when question for rehabilitating the mine. According to

Limpitlaw and Briel (2013), there is general acceptance that reclamation should not be a final set of on-mining site activities, but should rather consist of a progressive sequence of interventions, starting with the earliest stages of exploration and planning, integrated into the full life of the mine. These actions should, however, not be limited to land form re-establishment and re-vegetation but should include consideration of the post-mining re-use of infrastructure. For example, at a potash project in the Republic of Congo (Congo-Brazzaville); the mining company decided to locate processing and staff facilities away from the nearby national park, closer to an existing town which would act as a natural node of development over the course of the mine's life. This development would be more likely to be sustainable post-closure and would also reduce pressure on the park as it would have the effect of drawing people away from the park (Limpitlaw & Briel 2013).

During the field observation it was revealed that all respondents including miners are not aware of the tunnel orientation, in addition the construction permits are being issued without taking into consideration the current or the future orientation of tunnels.



Figure 19: Current and possible tunnel orientation
Source: field observation, 2016

As illustrated by the figure 19, due to the current underground methods of mineral extraction in Buhiza-Nkusi concession the tunnels may take different directions based on the mineral veins orientation. The development of any infrastructure above these tunnels may increase overall subsidence risk which may occur in the future.

The current mining policy and National Land use and Development Master Plan don't have any information about the underground impacts of subsidence due to mining operations and the means to lessen these impacts.

According to United States Department of the Interior (1983), Damage from subsidence over underground mines has been a serious problem in urban areas for many years and will become more widespread as the demand for resources. Planners must know whether these changes are complete or in progress, permanent or temporary; further mining may restore the original slope or close tensile fractures thereby rendering some remedial measures unnecessary or even harmful. Buildings and other structures can be designed to resist or tolerate subsidence deformations

A proposed mining plan is necessary for early input to the subsidence analysis. The plan should be based not only on and geotechnical data but also on mining methods, extraction location and sequence, location of panels, barrier pillars, and, in the case of multiple-seam deposits, the seams to be mined and the proposed sequence. The mining plan should anticipate the magnitude, location, and timing of surface disturbance. If the plan is revised, initial subsidence predictions may be altered (Lee & Fitzhugh 1983).

The following section emphasizes on the proposed zoning districts and then assess the role of mineral safeguarding areas and post land use plan where mining operations are taking place in the study area.

4.3. Proposed Zoning District in Buhiza and Nkusi Cells

The map bellow in Figure 20, which is extracted from Kigali Zoning Plan, indicates the zoning districts of the study area which are mainly agriculture, protected area and residential district.

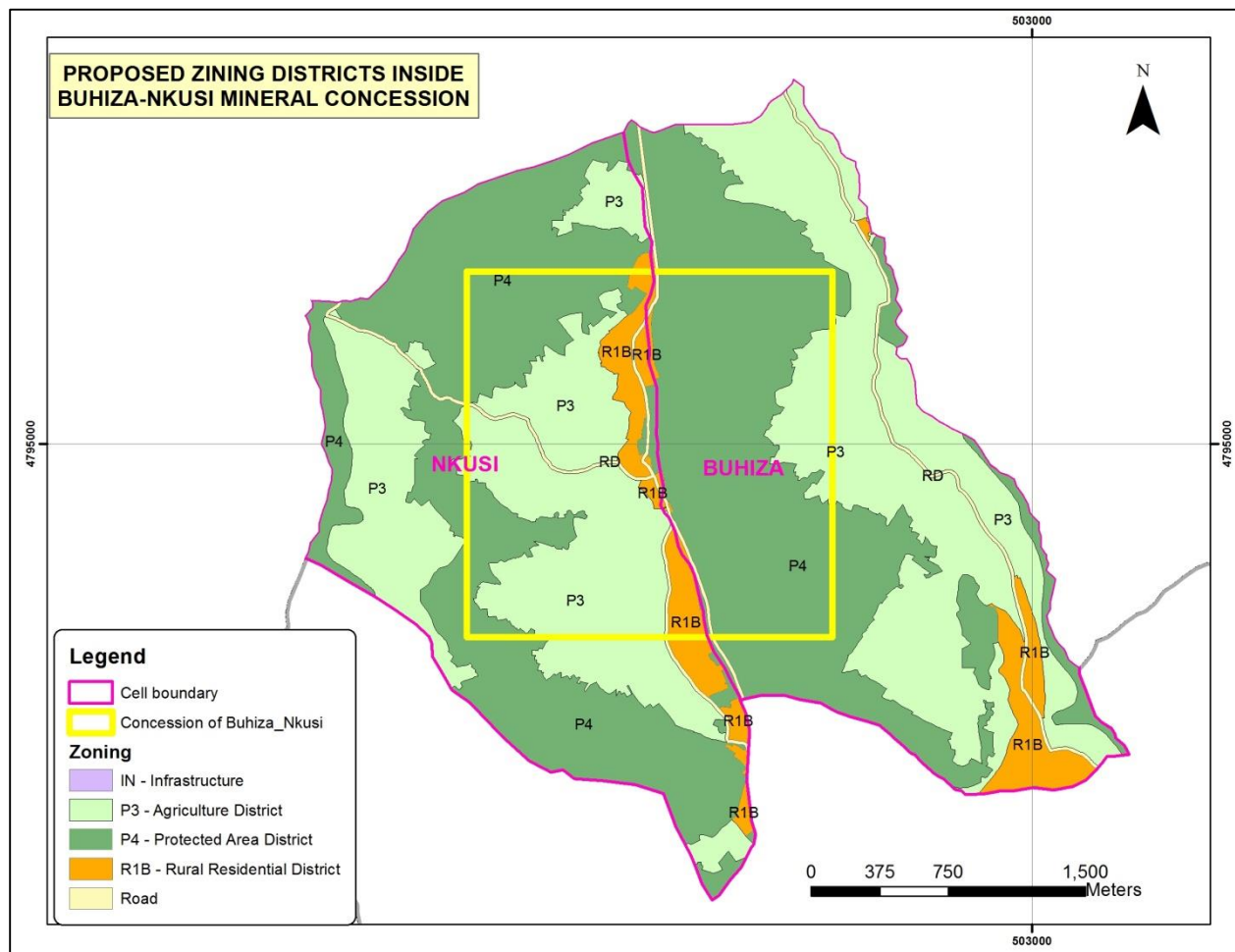


Figure 20: Proposed zoning regulations of the study area
Source: City of Kigali 2013

According to the land use planning authorities from City of Kigali, these regulations identify zoning districts and the types of uses permitted under each district. If a particular use is not listed as a conditional or permitted use, it is generally prohibited in that particular zoning district. A conditional use permit allows the local government to consider the specific operation, determine whether or not it meets the standards, and apply conditions for how the use operates.

Table 10: Description of proposed zoning district in the study area

Agricultural area (P3)		
Uses	Regulation	Remark
Permitted uses	• Agriculture Farms • Green houses	Not available
Prohibited uses	• All types of industrial uses • All types of residential uses • All types of commercial uses • All types of public facilities	Not available
Conditional uses	• Supporting Agricultural uses • Farmers residence not exceeding 150 m² Infrastructure	Not available
Protected area (P4)		
Permitted uses	• Forests • Wetlands • Rivers	Not available
Prohibited uses	• All types of industrial uses • All types of residential uses • All types of commercial uses • All types of public facilities	Not available
Conditional uses	• Infrastructure • Botanical gardens, arboretums and conservatories. • Outdoor recreational facilities, such as hiking and bicycle trails, greens and commons, sitting areas and picnic areas. • Park related public facilities such as public toilet/ changing room. • Minor Public Facilities • Restaurants • Small kiosk not exceeding 100 m²	• Development shall be allowable in only 10% of the plot area or 500 m² (whichever is lesser) • Developments in P4 zone require approval by review panel
Rural Residential District (R1B)		
Permitted uses	• Single family houses (all types)	Not available
Prohibited uses	• Residential apartments • General commercial uses • Industrial uses • Major infrastructure	Not available

Conditional uses	• Standalone food outlet with less than 50 seats • Public facilities • Convenience stores not exceeding 60 m² of floor area	Not available
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Source: City of Kigali 2013

During the household survey, almost 97, 2 of respondents are familiar with the term of "*Kigali Master Plan*". However they don't know exactly what kind of use is permitted, prohibited or permitted with conditional on their land and this answer was the same from the representatives of King Mines Company Ltd. Only a small fraction of 2.8% of the respondents is aware of the proposed zoning district in the study area.

Regarding public awareness on proposed zoning of City of Kigali; authorities in the field of land use planning from RNRA, RHA and City of Kigali mentioned that all stakeholders including the developers and professionals, most importantly the end users shall be engaged while developing or reviewing the Master Plan, or implementing the Catalytic and Capital Improvement Projects in the City. This will ensure stakeholder's support in the long run.

4.4. Mineral Safeguarding Areas in peri-urban areas

Regarding the issue of Mineral Safeguarding Area (MSA) in peri-urban area; the authorities from Geology and Mines Department (GMD) indicated that this area will be very important and this should be defined based on factual information on the physical location of minerals as well as the mineral reserve estimate. According to these respondents, once this area is defined the buffer zone between 200 and 300 meters should be established and only different land uses such as health center, agriculture and conservation area should be allowed after a deep analysis. The respondents proposed that once this MSA is approved it can be integrated into existing zoning districts.

Regarding the integration of MSAs into detailed physical plan, the authorities from City of Kigali, indicated that the review of the zoning districts is recommended to be conducted together with the detailed physical plan at an interval of five years and this zoning district review shall take into consideration the immediate market forces and trend in industries to meet the changing environmental, cultural and social objectives. The advice provided by Wrighton *et al.* (2014), the

inclusion of policies in relevant land use planning documents detailing how mineral safeguarding will be put into practice is fundamental to an effective safeguarding system. Essentially, these policies should set out how to manage the planning application process for non-mineral development proposed within an MSA. The following are seven step methodology for mineral safeguarding (see the figure 21).

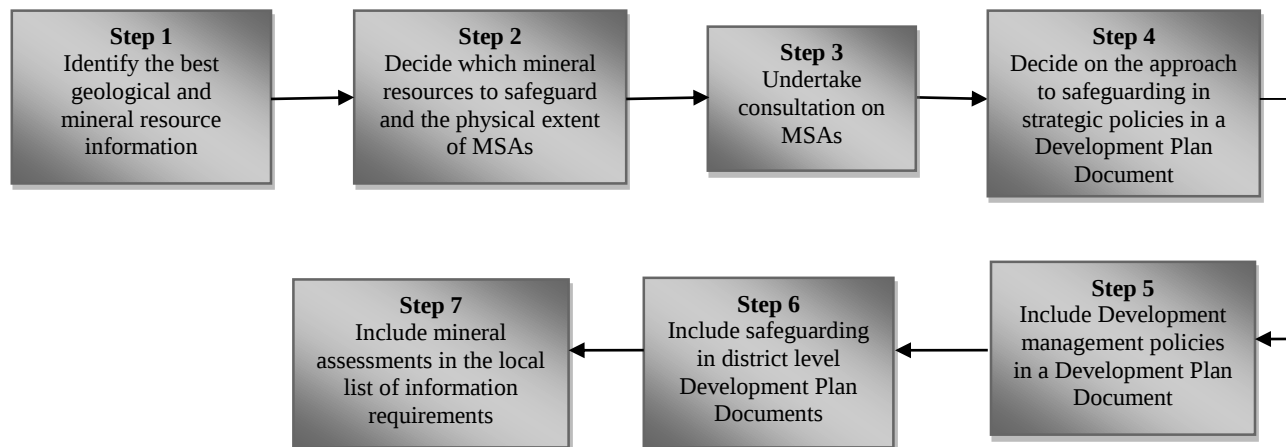


Figure 21: Methodology for mineral safeguarding in urban areas
Source: Adapted from Wrighton et al. (2014)

This research considers both the information collected from key informants in terms of MSAs and the above mentioned methodology and then recommends how MSAs can be integrated into detailed physical planning in Rwanda context. The proposed framework for integrating mining into physical planning is indicated in figure 24 under the section on conclusion and recommendations.

5. Chapter five: Conclusion and recommendations

5.1. Conclusion

The main purpose of this research was to investigate the role of integrating mining operations into detailed physical planning in peri-urban areas. This research found that peri-urban areas were defined based on formal political-administrative boundaries. Meanwhile, the functional

boundaries of peri-urban areas are dynamic and often cut across these traditional, artificial and rigid boundaries. This thesis didn't explore the patterns and processes of utilization and dynamics of peri-urban land use. This research explored the current status of integrating mining operations into detailed physical plan in peri-urban areas, it is not focused on mine operational area but the land use conflict associated with and the impacts driven by mining activities. The research was not carried out without certain constraints. Among the constraints, there was lack of the required amount of data and information available about the study area such as mineral reserve estimate, soil properties, quality and grade of extracted minerals, detailed geological data as well as the respondent's bias and reluctance to answer some questions. Due to these constraints, this research has not been able to determine whether Buhiza-Nkusi mine concession can be considered as mineral safeguarding area. Considering all parameters subject to investigation, environmental degradation, is the only one of the negative result for the mineral resource extraction. This environmental issue is typically categorized under mineral resources extraction, which is one of the components of this research. In all other investigated aspects, mining operations play an important role in creation of job opportunities. The gap that this research filled was to suggest that there is need for a clear comprehensive framework to integrate mineral resources extraction into detailed physical planning in peri-urban areas. The analysis of relevant literature review and data collected during field observation and household survey has indicated that with the increase of mining operations more land will be required and this will have always direct and indirect conflict with agricultural, conservation and residential land uses.

According to the evidences presented in this research: *"Despite the fact that mining operations have a small share of City of Kigali's total land use, conflict can arise at the local level where mineral resources extraction is perceived as competing with other land uses"*. With the knowledge and information gained and collected during the course of this research, it can be concluded that the land use conflict can arise once mining operations are not considered during land use planning process. The hypothesis of this research is, therefore approved. As much as we acknowledge the economic benefits of mining activities in Rwanda, there is the need also to recognize the land use conflicts that come with it in order to find ways of dealing with them.

5.2. Recommendations

After a thorough research and analysis of the problem and all its ramifications as indicated in the preceding chapters, the following recommendations are made to address the conflict between mining operations and other land uses in peri-urban areas:

- Mining operations has to deal with environmental issue from the feasibility study;
- Allowing local population to grow perennial crops means that when the mining companies activities reach such areas may have to pay more in compensations associated with mining the lands;
- Closure planning should commence during the feasibility stage of a mining development project, as closure should be one of the aspects to consider when deciding whether a project should be developed or not;
- The post mining land use must generate or sustain employment opportunities for local communities and/or redundant mine employees.
- Exploring new approaches to rehabilitation may present an opportunity to integrate the disturbed landscapes and the community;
- Zoning regulations should prohibit mineral development in certain zones where such activities would be incompatible with neighbouring land uses. It might also prohibit mineral development within a certain distance from incompatible uses like residential uses;
- Zoning regulations should prohibit any form of development within a Mineral Safeguarding Area that is incompatible with safeguarding mineral.
- Once Mineral Potential Targeted Areas are defined in peri-urban areas, MSA should be delineated and integrated into detailed physical plan as proposed land use with related zoning regulations (see the figure 24).

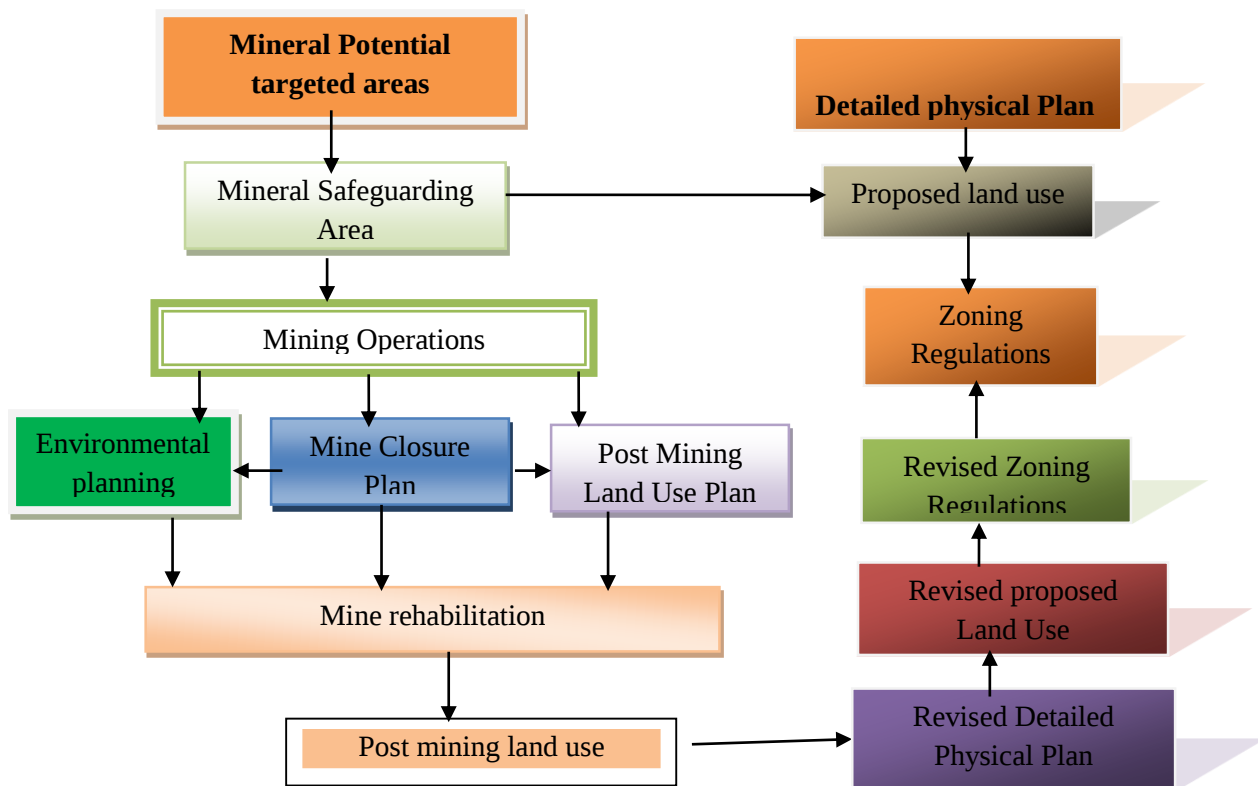


Figure 22: Proposed framework for integrating mining into physical planning
Source: Author, 2016

These recommendations can be achieved through a good stakeholder consultation process would arguably go a long way to providing the necessary mineral information in both the elaboration and revision phases of detailed physical plan. A steering committee from government and the private sector should be established from the Ministry of Natural Resources (MINIRENA), Geology and Mines Department (GMD) and Land and mapping Department (LMD) from Rwanda Natural Resources Authority, Rwanda Environment Management Authority (REMA), Rwanda Housing Authority (RHA), Rwanda Development Board (RDB), City of Kigali (CoK), Ministry of Local Government (MINALOC), Mining Company, and representatives from Rwanda Mining Association (RMA). This steering committee should be organized and headed by the Ministry of Natural Resources.

6. Reference

- AGA (2009). Inclusion of community considerations in the land use management process. In: *Management standards*. AngloGold Ashanti Limited, Johannesburg, p. 7.
- Arteaga F. (2014). The Mining Rate in Open Pit Mine Planning. In: *School of Mechanical and Mining Engineering*. University of Queensland Queensland, p. 110.
- Australia G.o. (2006). Mine closure and completion. In: *leading practice sustainable development program for the mining industry*. Department of Industry, Tourism and Resources Australia.
- Benndorf I.j. & Voncken J.H.L. (2014). Best Practices On-Shore and Challenges Off-Shore. In: *Sustainability in Mineral Resource Extraction* (ed. Benndorf Ij).
- BRGM (1987). Plan Mineral du Rwanda. In: (ed. MINIMART). Ministere de l'Industrie, des Mines et de l'Artisanat Kigali, p. 590.
- Brumfitt I.M. (2013). Reconciling mining and land-use planning law: challenges facing cooperative governance in South Africa. In: *Institute of Marine and Environmental Law*. University of Cape Town Cape Town, p. 118.
- Byamukama B., Carey C., Cole M., Dyszynski J. & Warnest M. (2011). National Strategy on Climate Change and Low Carbon Development for Rwanda. In: *Baseline Report* (ed. King D). Smith School of Enterprise and the Environment United Kingdom, p. 112.
- Cole M. & Hogarth R. (2011). Mining sector working paper: Appendix B. In: (ed. Cole M). University of Oxford United Kingdom, p. 60.
- DCLG (2006). Planning and Minerals: Practice guide. In: (ed. DCLG). Department for Communities and Local Government, UK.
- DMP & EPA (2011). Guidelines for preparing mine closure plans. In: (ed. EPA Da). Department of Mines and Petroleum and Environmental Protection Authority, p. 78.
- EC (2010). Exchanging the best practice on land use planning, permitting and geological knowledge sharing. In: *Improving framework conditions for extracting minerals for the EU*. European Commission, p. 71.
- Euromines (2011). Mineral Resources in Land Use Planning. In: *Why Consider Minerals in LUP?* European Association of Mining Industries Brussels, Belgium, p. 24.
- Ferguson G. (2015). An Evaluation of Aboriginal, Government, and Mining Industry Relationships and Policies in Manitoba: Accessing Land for Mineral Exploration and Mine Development. In: *Natural Resources Institute*. University of Manitoba Manitoba, p. 197.
- Gasabo (2013). District Development Plan (2013-2018) In: (ed. District G). Gasabo District Kigali, p. 97.
- GoR (2012). Vision 2020, Revised 2012. In: (ed. MINECOFIN). GoR Kigali, p. 40.

- GoR (2013). Economic Development and Poverty Reduction Strategy II (2013-2018). In: (ed. Planning MoFaE). GoR Kigali, p. 172.
- GoR (2014). Law n°13/2014 of 20/05/2014 on mining and quarry operations. In: (ed. Resources MoN). MINIRENA Kigali, p. 55.
- Hildebrando P. (2006). Assessing Landscape Change in a Mining Area of the Peruvian Andes. A Case Study in The Yanacocha Mine, Cajamarca. In: *Department of Geography*. University of Bergen, p. 94.
- Hobba W.A. (1993). Effects of Underground Mining and Mine Collapse on the Hydrology of Selected Basins in West Virginia. In: *United States Geological Survey Water-Supply Paper*. United States Geological Survey, Virginia, p. 85.
- ICMM (2011). The role of mining and metals in land use and adaptation. In: *Climate change* (ed. International Council on Mining and Metals). International Council on Mining and Metals, London, p. 8.
- ICMM (2012). Mining's contribution to sustainable development. In: *The role of mining in national economies* (ed. Metals ICoMa). International Council on Mining and Metals London, p. 20.
- IIED & WBCSD (2002). Breaking new ground. In: *Mining, Minerals, and Sustainable Development project*. International Institute for Environment and Development and World Business Council for Sustainable Development UK & USA, p. 455.
- Jenny N. & Johan R. (2008). Environmental Impacts and Health Aspects in the Mining Industry: A Comparative Study of the Mining and Extraction of Uranium, Copper and Gold. In: *Department of Energy and Environment*. Chalmers University of Technology Göteborg, Sweden, p. 119.
- Kitula A.G.N. (2005). The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District. *Journal of Cleaner Production* 14 (2006) 405e414, 14 (2006), 10.
- Knobloch A., Legler C., Barth A., Ndacyayisenga A., Billay A., Biryabarema M. & Kanzira H. (2013). Detailed Surveys of Mineral Potential Areas Recently Identified in Rwanda: Perspectives for National Development. In, p. 2.
- Kumar N.P. (2014). Review on Sustainable Mining Practices. *International Research Journal of Earth Sciences*, Vol. 2(10), 4.
- Kuter N. (2013). Reclamation of Degraded Landscapes due to Opencast Mining. In: *Advances in Landscape Architecture* (ed. Kuter N). INTECH, p. 36.

- Lee & Fitzhugh T. (1983). Subsidence from underground mining: Environmental Analysis and planning considerations. *Geological survey circular 876*. United States Department of Interior, p.34
- Limpitlaw D. & Briel A. (2013). Post-mining land-use opportunities in developing countries. The Southern African Institute of Mining and Metallurgy, p.6
- Maliganya W., Simon S.M. & Paul R. (2013). Large Scale Mining Activities and the Livelihood of Adjacent Communities in Tanzania: A Case of Geita Gold Mine. In: *Policy research for development Research on Poverty Alleviation*, p. 54.
- McEvoy F.M., Cooley J., Hobden K., Bee E. & Hannis S. (2007). A guide to mineral safeguarding in England. In: *Open report OR/07/035* (ed. Survey BG). British Geological Survey Nottingham, p. 36.
- McKenna G.T. (2002). Sustainable mine reclamation and landscape engineering. In: *Department of Civil and Environmental Engineering*. University of Alberta, Edmonton, p. 660.
- MININFRA (2012). Urbanization and rural settlement sector: Strategic plan 2012/13-17/18. In: (ed. MININFRA). MININFRA Kigali, p. 86.
- MININFRA (2015). Ministerial n°04/Cab.M/015 of 15/08/2015 determining urban and building planning and building regulations: Annex I: Urban Planning Codes. In: (ed. MININFRA). MININFRA Kigali, p. 796.
- MINIRENA (2015). All about development stories in mining sector. *The mining corner newsletter*, 8.
- MIRENA (1982). Carte des gites minéraux. In. Ministère des Ressources Naturelles, Rwanda Kigali.
- Misener D.J., Biryabarema M. & Barritt S. (2011). Mineral potential of Rwanda: Prospective target areas at depth as interpreted from airborne gravity and aeromagnetism. In: *GEM Beijing 2011: International Workshop on Gravity, Electrical & Magnetic Methods and Their Applications* (ed. SEG). The Society of Exploration Geophysicists Beijing, China, p. 4.
- Mondal S., Chakravarty D. & Bandayopadhyay J. (2014). Cadastral Maps for Socio-Economic Data Visualization and Integration for Land Use in Raniganj Mining Areas. *International Refereed Journal of Engineering and Science*, Volume 3, 9.
- MOP (1997). Managing Maryland's Growth: Models and Guidelines. In: (ed. Environment MDot). Maryland Office of Planning, Baltimore, Maryland.
- Muchez P., Hulsbosch N. & Dewaele S. (2014). Geological mapping and implications for Nb-Ta, Sn and W prospecting in Rwanda. In. Ph.Muchez, Belgium, p. 18.
- Nkundibiza A.P. (2013). Contribution of Environmental Impact Assessment to decrease mining impact in Rwanda. In: *International postgraduate course on environmental management for developing and*

- emerging countries*. Centre for International Postgraduate Studies in Environmental Management Dresden, German, p. 29.
- Ololade O.O. (2012). Evaluation of the sustainability and environmental impacts of mining in the Rustenburg Region. In: *Faculty of Science*. University of Johannesburg Johannesburg, p. 204.
- OXFAM (2014). Geographies of conflicts. In: *Mapping overlaps between extractives industries and agricultural land use in Ghana and Peru* (ed. America O). OXFAM America, p. 40.
- RBS (2011). Mining and quarrying — Code of practice. In: (ed. Standards RBo). Rwanda Bureau of Standards, Kigali, p. 65.
- REMA (2011). Atlas of Rwanda's changing environment: Implications for Climate Change Resilience. In: (ed. REMA). Rwanda Environment Management Authority, Kigali, p. 110.
- RNRA (2012). Strategic plan for the mining sub-sector 2013/14-2017/18. In: (ed. Authority RNR). RNRA Kigali, p. 79.
- Sheoran V., Sheoran A.S. & Poonia P. (2010). Soil Reclamation of Abandoned Mine Land by Revegetation: A Review. *International Journal of Soil, Sediment and Water*, 3, 21.
- Surbana (2013a). Detailed District Physical Plans for Gasabo and Kicukiro: Gasabo District Zoning Plan Report. In: (ed. Kigali Co). City of Kigali Kigali.
- Surbana (2013b). Detailed physical plans for Gasabo and Kicukiro Districts. In: (ed. CoK). City of Kigali Kigali, p. 237.
- Swedesurvey (2010). Rwanda National Land use and Development Master Plan. In: (ed. RNRA). Rwanda Natural Resources Authority Kigali, p. 135.
- Teeffelen J.V. (2012). The EU law materials policy and mining in Rwanda: Policy Coherence for Development in practice. In. Evert Vermeer Foundation Amsterdam, p. 33.
- Terrington R., Napier B., Büchi A. & Procópio P.M. (2015). Managing the mining cycle using GeoVisionary. In: UK, p. 10.
- Travis L., H., Frederick D., F. & Geoffrey S., P. (1999). Metal mining and the environment. In: (ed. Institute AG). American Geological Institute Alexandria, Virginia, p. 68.
- Twerefou D.K. (2009). Mineral Exploitation, Environmental Sustainability and Sustainable Development in EAC, SADC and ECOWAS Regions. In: (ed. Africa UNECf). United Nations Economic Commission for Africa, p. 55.
- UNEP (2000). Mining and sustainable development II: Challenges and perspectives. In: *industry and environment* (ed. UNEP). United Nations Environment Programme, Paris, p. 96.

- Wrighton C.E., E.J.Bee & J.M.Mankelow (2014). The development and implementation of mineral safeguarding policies at national and local levels in the United Kingdom. *Journal of Cleaner Production* 14 (2006) 405e414, 41, 11.
- Wrighton C.E. & Bide T.P. (2012). Integrated mineral resource mapping and safeguarding: A national-scale example from Wales. In. British Geological Survey Nottingham, p. 7.
- Wrighton C.E., McEvoy F.M. & Bust R. (2011). Mineral safeguarding in England: Good practice advice. In: *Minerals and waste programme* (eds. Cowley J, Hannis S & Hobden K). Natural Environment Research Council Nottingham, p. 53.
- Yager T.R. (2010). The Mineral Industry of Rwanda. In: *2008 Minerals Year Book*. US-Geological Survey USA, p. 5.

Appendix 1: Questionnaire

Introduction

I'm BYIRINGIRO Alexis, student in Master of Geo-Information for Environment and Sustainable Development, College of Science and Technology/University of Rwanda.

This interview questionnaire is a research instrument for my master thesis on “**Need for Integrating Mineral Extraction into Detailed Physical Planning in Peri-urban areas: The case study of Gasabo District**”. This is an academic exercise and all information collected will be treated confidentially and will only be used for the intended purpose. Your cooperation would be very much appreciated.

I. INTERVIEW GUIDE FOR HEADS OF HOUSEHOLDS

This section is based on interviews with the Heads of households in Buhiza and Nkusi Cells, Jabana Sector, Gasabo District.

Village.....

Cell.....

1) Gender

- ☐ a) Male
☐ b) Female

2) Age

- ☐ a) <18
☐ b) 18-21
☐ c) 21-30
☐ d) 31-40
☐ e) 41-50
☐ f) 51-60
☐ g) >60

3) What are the main sources of your livelihood?

- ☐ a) Mining
☐ b) Agriculture
☐ c) Farming
☐ d) Commerce
☐ e) None/nothing
☐ f) Others please specify.....

4) How do you describe your area?

- ☐ a) Urban

- ☐ b) Peri-urban
- ☐ c) Rural
- ☐ d) Others please specify.....

5) Why do you describe it as such?

- ☐ a) Infrastructure
- ☐ b) Services
- ☐ c) Population density
- ☐ d) Others please specify.....

6) Are you aware of the boundary of Buhiza-Nkusi mine concession?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

7) Have your living conditions changed for better or worse with start of mining operations?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

8) What is the impact of mining operations on your family?

- ☐ a) Job opportunity
- ☐ b) Infrastructure provision
- ☐ c) Exode
- ☐ d) Expropriation
- ☐ e) Prostitution
- ☐ f) Alcoholism
- ☐ g) Divorce
- ☐ h) Crime
- ☐ i) Others please specify.....

9) What is the impact of mining operations on surrounding environment with the coming of King Mines Ltd?

- ☐ a) Erosion
- ☐ b) Noise
- ☐ c) Deforestation
- ☐ d) Water pollution
- ☐ e) Destruction of settlement
- ☐ f) Others please specify.....

10) Has there been any new health problem in your family since the mining activities started in this area?

- ☐ a) Yes

- ☐ b) No
- ☐ c) Others please specify.....

11) Do you worry that mining operations will cause environmental damage that will impact future generations?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

12) Are you willing to accept the risks of mining operations because the benefits of mining worth it?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

13) Are you aware of the risks of mining in this area?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

14) If you have a question about the risks of mining operations, is it easy to find some preventive/intervention measures in order to avoid or reduce these risks?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

15) If the previous answer is yes, which of the following institutions do you get information?

- ☐ a) Cell level
- ☐ b) Jabana Sector
- ☐ c) Gasabo District
- ☐ d) City of Kigali
- ☐ e) Rwanda Natural Resources Authority
- ☐ f) Rwanda Housing Authority
- ☐ g) King Mines Ltd
- ☐ h) Others please specify.....

16) What have been the greatest environmental challenge, problems and damages in the community since mining operations started?

- ☐ a) Farms
- ☐ b) Land
- ☐ c) Forest
- ☐ d) buildings
- ☐ e) hydrology
- ☐ f) Others please specify.....

17) Which institution played a role in rehabilitating or compensating these damages?

- ☐ a) Buhiza/Nkusi Cell
- ☐ b) Jabana Sector
- ☐ c) Gasabo District
- ☐ d) City of Kigali
- ☐ e) Rwanda Natural Resources Authority
- ☐ f) Rwanda Housing Authority
- ☐ g) Non Government Organization
- ☐ h) Others please specify.....

18) Are you aware of Environmental Protection Measures planned by King Mines Ltd?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

19) Are you aware of the tunnels orientation?

- ☐ d) Yes
- ☐ e) No
- ☐ f) Others please specify.....

20) If the mine operations are closed, what do you plan to do?

- ☐ a) to move
- ☐ b) to stay
- ☐ c) Others please specify.....

21) If the mine closes their activities what would you recommend in terms of post mining land use?

- ☐ a) Conservation
- ☐ b) Agriculture
- ☐ c) Tourism

22) Are you aware of the zoning plan of your area?

- ☐ a) Yes
- ☐ b) No
- ☐ c) Others please specify.....

23) If the previous answer is yes, what is the permitted land use in this area?

- ☐ a) Residential
- ☐ b) Commercial
- ☐ c) Protected
- ☐ d) Agriculture
- ☐ e) Mineral extraction
- ☐ f) Others please specify.....

Thank you for your valuable contribution

Translation of Heads of Households Questionnaire in Kinyarwanda Language

Ikusanyamakuru

Intangiriro

Nitwa BYIRINGIRO Alexis, Niga muri Kaminuza y'u Rwanda/Ishami ry'Ikoranabuhanga, mu cyiciro cya gatatu.

Iki kiganiro kigamije kubona amakuru nzifashisha mu gitabo ndi kwandika kugirango nsoze amasomo yanjye; nkaba ndi gukora ku nyigo yo “ **Kureba uburyo ibikorwa by'ubucukuzi bw'amabuye y'agaciro byakwitabwaho mu gihe cyo gutegura igishushanyombonera cy'umuji, by'umwihariko mu nkengero zawo. Nkaba nzibanda ku Karere ka Gasabo, Umurenge wa Jabana.** Amakuru mumpa akaba azakoresheka gusa mu rwego rwo kuzuza ibisabwa kugirango mbone impamyabumenyi y'icyiciro cya gatatu cya kaminuza.

Umudugudu.....

Akagali.....

1) Igitsina

- ☐ a) Gabo
- ☐ b) Gore

2) Imyaka

- ☐ a) <18
- ☐ b) 18-21
- ☐ c) 21-30
- ☐ d) 31-40
- ☐ e) 41-50
- ☐ f) 51-60
- ☐ g) >60

3) Ni iyihe mirimo yawe ya buri muni ?

- ☐ a) Ubucukuzi
- ☐ b) Ubuhinzi
- ☐ c) Ubworozi
- ☐ d) Ubucuruzi
- ☐ e) Ntayo
- ☐ f) (Ibindi).....

4) Ni ikihe cyiciro ubariramo agace utuyemo?

- ☐ a) Umujyi
- ☐ b) Inkengero z'umujyi
- ☐ c) Icyaro
- ☐ d) Indi nyito.....

5) Kubera iki ako agace utuyemo ugashyira muri icyo cyiciro?

- ☐ a) Ibikorwa remezo
- ☐ b) Ubucucike bw'abaturage
- ☐ c) Serivisi
- ☐ d) (Ibindi).....

6) Waba uzi imbibi zaho sosiyeti yemerewe gukorera imirimo y'ubucukuzi?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

7) Imirimo y'ubucukuzi yaba yarahinduye imibereho yawe?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) Ibindi.....

8) Ni uruhe ruhare ibikorwa by'ubucukuzi byagize ku muryango wawe?

- ☐ a) Gutanga akazi
- ☐ b) Ibikorwa remezo
- ☐ c) Abimukira
- ☐ d) Kwimurwa
- ☐ e) Uburaya
- ☐ f) Ubusinzi
- ☐ g) Gutandukana kw'imiryango
- ☐ h) Ubugizi bwa nabi
- ☐ i) (Ibindi).....

9) Aho ibikorwa by'iyi sosiyeti bitangiriye ni iki ubona cyahindutse ku bidukikije?

- ☐ a) Isuri
- ☐ b) Urusaku
- ☐ c) Gutema amashyamba
- ☐ d) Kwanduza amazi
- ☐ e) Amazu yarasenyutse
- ☐ f) (Ibindi).....

10) Waba ufite impungenge ku buzima bw'umuryango wawe kubera ko utuye hafi ya mine?

- ☐ a) Yego

- ☐ b) Oya
- ☐ c) (Ibindi).....

11) Waba ufite impungenge ko ibikorwa by'ubucukuzi bizangiza ibidukikije bikazagira ingaruka ku rubyiriko rw'ejo hazaza?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

12) Wihanganira ingaruka mbi ziterwa n'ubucukuzi kuberako zenda kungana n'inyungu zabwo?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

13) Waba uzi cyangwa wamenyeshejwe ingaruka z'ubucukuzi?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

14) Iyo hari ikibazo ugize ku ngaruka z'ubucukuzi bikorohera kubona ubufasha?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

15) Niba bikorohera kubona ubufasha ubukura mu zihe nzego?

- ☐ a) Akagali
- ☐ b) Umurenge
- ☐ c) Akarere ka Gasabo
- ☐ d) Umujyi wa Kigali
- ☐ e) Ikigo cy'Igihugu Gishinzwe Umutungo Kamere mu Rwanda
- ☐ f) Ikigo cy'Igihugu Gishinzwe Imiturire
- ☐ g) Sosiyeti y'ubucukuzi
- ☐ h) (Ibindi).....

16) Ni iki gikabije waba uzi ibikorwa by'ubucukuzi byangije ku bidukikije?

- ☐ a) Imirima
- ☐ b) Ubutaka
- ☐ c) Amashyamba
- ☐ d) Amazu
- ☐ e) Imigezi
- ☐ f) (ibindi).....

17) Niba hari icyangijwe ni uruhe rwego rwagize uruhare mu kugisana?

- ☐ a) Akagali ka Buhiza/Nkusi

- ☐ b) Umurenge wa Jabana
- ☐ c) Akarere ka Gasabo
- ☐ d) Umujyi wa Kigali
- ☐ e) Ikigo cy'Igihugu Gishinzwe Umutungo Kamere mu Rwanda
- ☐ f) Ikigo cy'u Rwanda Gishinzwe Imiturire
- ☐ g) Umuryango utagengwa na Leta
- ☐ h) (Ibindi).....

18) Waba uzi ko hari ingamba sosiyeti y'ubucukuzi yafashe mu rwego rwo kurinda ibidukikije?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

19) Mwaba muzi icyerekezo cy'imyobo icukurwamo?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) (Ibindi).....

20) Ibikorwa by'ubucukuzi nibisozwa urateganya iki?

- ☐ a) Kwimuka
- ☐ b) Kuguma hano
- ☐ c) (Ibindi).....

21) Ibikorwa by'ubucukuzi nibirangira urifuza ko aho byakorerwaga hajya iki/hakorerwa iki?

- ☐ a) Amashyamba
- ☐ b) Ubuhinzi
- ☐ c) Imiturire
- ☐ d) Ubukerarugendo
- ☐ e) Kuhihorera
- ☐ f) (Ibindi).....

22) Mwaba muzi ibyo igishushanyo mbonera giteganyiriza aho mutuye?

- ☐ a) Yego
- ☐ b) Oya
- ☐ c) Ibindi.....

23) Niba ari yego, ni ibiki byemwe gukorerwa hano?

- ☐ a) Gutura
- ☐ b) Ubucuruzi
- ☐ c) Harakomye
- ☐ d) Ubuhinzi
- ☐ e) Ubucukuzi bw'amabuye y'agaciro
- ☐ f) (Ibindi).....

Murakoze ku bisubizo byanyu byiza.

II. INTERVIEW GUIDE FOR FOCUS GROUP DISCUSSION

This section is based on interviews with the community/associations representatives in Buhiza and Nkusi Cells, Jabana Sector.

1. How do you describe your area in terms of urban, rural or peri-urban?
2. Why you describe it as such (E.g. land use, infrastructure, services etc)?
3. What about the living conditions community of Buhiza and Nkusi Cells before mining operations started? (E.g. occupation, lifestyle of the people, the landscape and natural resources, main sources of livelihood etc).
4. What is the impact of mining operations by King Mines Ltd on local community?
5. What is the impact of mining operations by King Mines Ltd on surrounding environment with the coming of King Mines Ltd and mining operations?
6. Have people of Buhiza and Nkusi Cells' living conditions changed for better or worse with start of mining operations by King Mines Ltd in the community?
7. Do you worry about your family's health because you live near the mine concession?
8. What is your opinion on mining operation in this community? Is it beneficial or not? Please justify your answer
9. What are the main sources of livelihood for population living in this area?
10. Have the community's livelihood changed because of mining activities? If yes, what is new source of livelihood for the people?
11. Do you think that King Mines Ltd operation is destroying the environment and other natural resources in the community?
12. If the previous answer is yes, please explain negative effect of mining on environment (E.g. Land degradation, land subsidence, pollution of water bodies, deforestation, noise, and landscape aesthetics). If so how?
13. What have been the greatest environmental challenge, problems and damages in the community since mining operations started?
14. Is any form of compensation for such environmental destruction by the mining companies to the community?
15. Are you aware of the zoning plan of your area?

Thank you for your valuable contribution

III. INTERVIEW GUIDE FOR KING MINES Ltd COMPANY

This section is based on interviews with the Company of King Mines Ltd representatives

1. Have people of Buhiza and Nkusi Cells' living conditions changed for better or worse with the start of your mining operations in Buhiza-Nkusi community?
2. Are local populations involved in planning and provision of development projects in the community or is it just carried out by the company?
3. Was there any development project planned for local populations by your company and by other authorities before mining agreement was made for this area?
4. Do you think that the King Mines Ltd operation is destroying the environment and natural resources in this area?
5. Are there some mechanisms in place to restore the destroyed natural resources and environment in the community by the community itself or King Mines Ltd?
6. What have been the greatest environmental challenges, problems and damages in Buhiza-Nkusi community since mining operations started?
7. Do you have a closure plan for this mine concession?
8. If the previous answer is yes, please explain how do you plan to rehabilitate this area?
9. Do you think that the methods of operation by the mining company have some effects on the natural environment? If yes, what are some of the effects?
10. Are there some efforts for reducing the environmental impacts?
11. If the previous answer is yes, are these efforts effective or not. Please explain how.
12. Have you conducted an Environmental Impact Assessment before starting your activities
13. Are you aware of the zoning plan of this area? If yes how do you manage to reduce land use conflicts which can occur in your concession?

Thank you for your valuable contribution

IV. INTERVIEW GUIDE FOR KEY INFORMANTS

This section is based on interviews with the mineral extraction experts and land use planning experts from Rwanda Natural Resources Authority, Rwanda Housing Authority and City of Kigali.

A. Mineral resources extraction

1. Could you list the key stakeholders in mining sector in Rwanda? How do you rank them? What do base on?
2. What are you considering when providing mining licenses?
3. Can mineral extraction be compatible with other land uses?
4. What kind of zoning regulations (e.g. permitted, prohibited and conditional land use) could you propose in the vicinity/buffer zone of the mining operations area?
5. Do you consider Mineral Safeguarding Areas (MSA) in peri-urban/urban areas of Kigali City very important?
6. If yes, what are the main criteria would you recommend so that an area can be classified as Mineral Safeguarding Areas (MSA)?
7. Do you consider post mining land use very important?
8. If the previous answer is yes, what are the main criteria can you recommend to be included in the post mining land use plan?
9. In your opinion, what should the mining companies do to enhance peaceful co-existence between mining operations and the other land users?
10. In your planning practices, is there any principle that would ensure the integration of mining activity into land use planning?
11. How do you monitor the mining operations?

B. Land use planning

1. Can you list the key stakeholders in land use planning processes? How do you rank them?
2. Is the land use planning processes incorporate mineral resources considerations?
3. Do you consider post mining land use very important?
4. If the previous answer is yes, what are the main criteria can you recommend to be included in the post mining land use plan;

5. What kind of zoning regulations (e.g. permitted, prohibited and conditional uses) could you propose in the vicinity/buffer zone of mining operations area?
6. Which methods and techniques used when you are monitoring the implementation of the Master Plan of City of Kigali?
7. Did you meet any constraint related to the land use conflicts during the implementation of Kigali Master Plan?
8. If the previous answer is yes, could you provide some one example?
9. Which methods and techniques used when you are monitoring land use conflicts?
10. In your planning practices, are there any principle that would ensure the integration of mining issues into urban planning?
11. In your opinion, what should the mining companies do to enhance peaceful co-existence between mining operations and the other land users?

Thank you for your valuable contribution

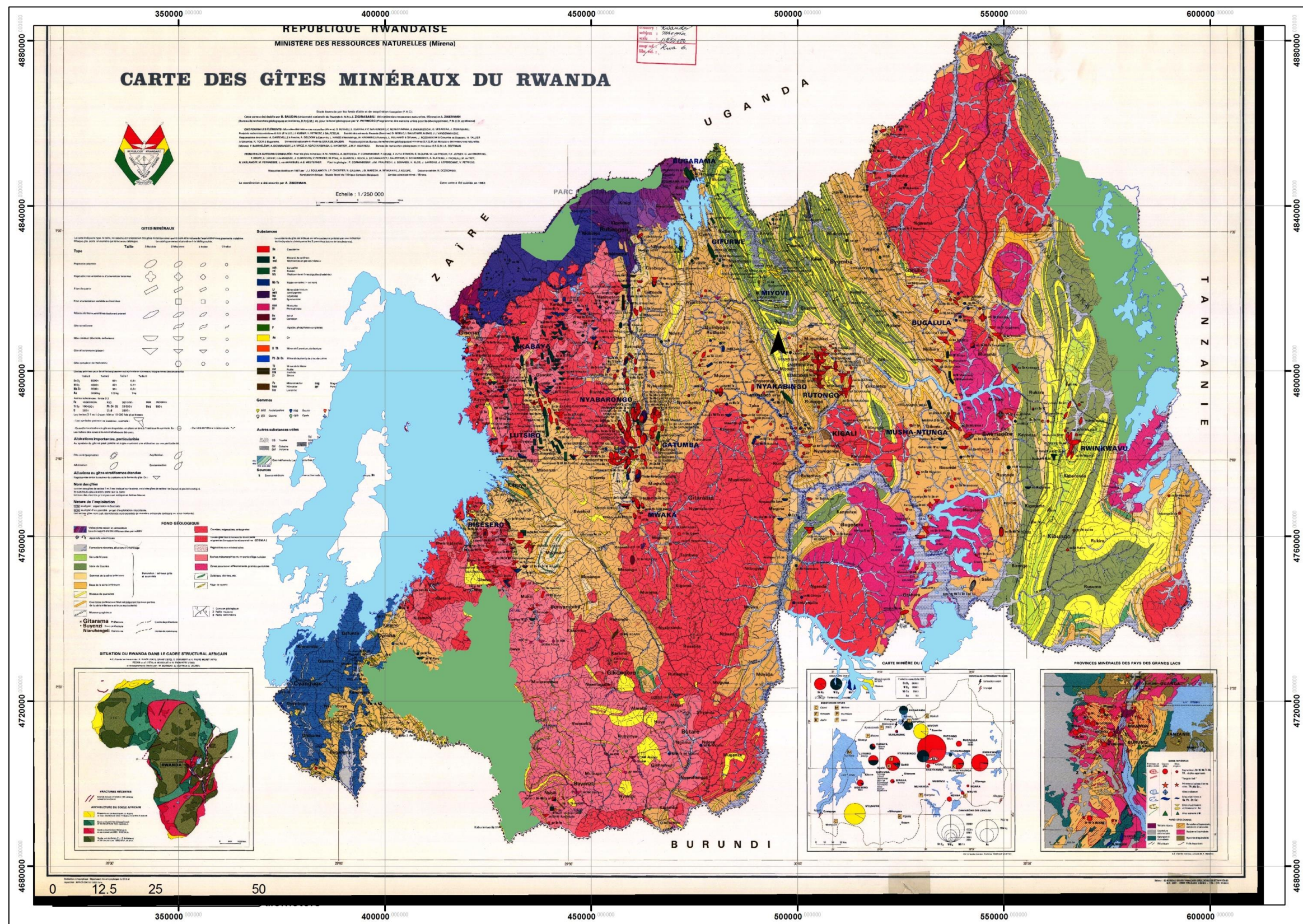
Appendix 2: Research compatibility matrix

Research objective	Research questions	Data requirements	Methods and techniques	Data Sources	Outcome
1. To assess the current status of mineral resources extraction and land use planning in Rwanda	What is the current status of mineral resources extraction in Rwanda?	Policies, Laws and regulations on mining Geological map Mine concession Mine sites	Literature review	MINIRENA RNRA	Understanding of the current status of mineral resources extraction regulations in Rwanda and proposing some improvements if any
	What is the current status of land use planning in Rwanda?	Land use policy, Law National land use and development master plan, Detailed physical plans, Kigali conceptual master plan	Literature review	MINIRENA RNRA RHA MINAGRI City of Kigali	Understanding of the current status of land use planning in Rwanda and proposing some improvements if any
2. To identify the positive and negative impacts of the mine life cycle in operational and adjacent area.	What are the social impacts of mining on surrounding community?	Gasabo District Development Plan Land ownership Expropriation law	Literature review Household survey	MINALOC MINIRENA City of Kigali, Gasabo District RNRA MINIJUST	Understanding the negative and positive impacts of mining operations on the adjacent community

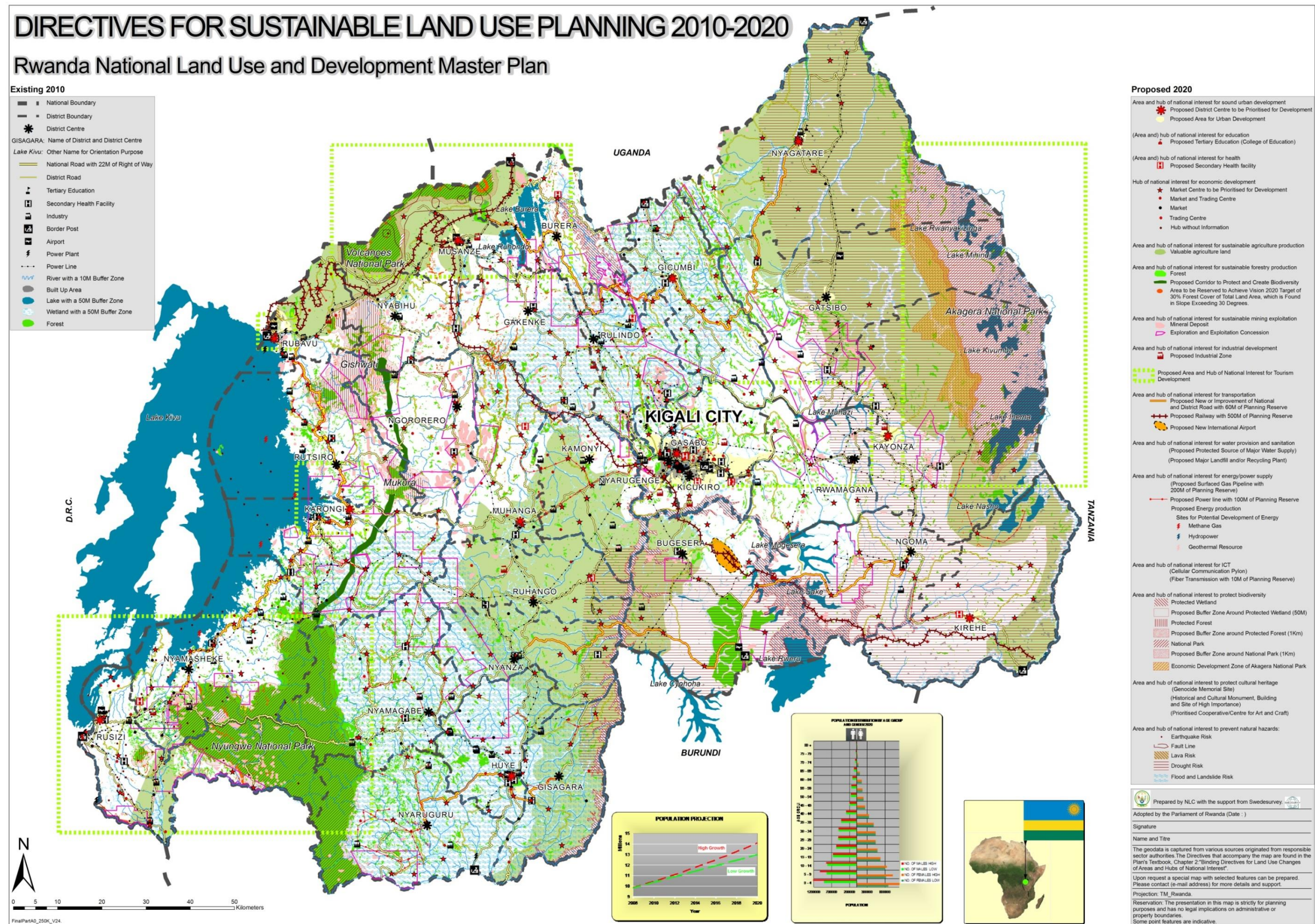
	What are economic impacts of mining on surrounding community?	Gasabo District Development Plan EDPRSII VISION 2020 Mining Subsector Strategic Plan (2013-2018)	Literature review Household survey	MINALOC MINICOFIN MINIJUST MINIRENA	The Economic role of mining activities is indicated
	What are environmental impacts of mining on operating area?	DEM Watershed Wetland Erosion rate Land cover Land use Infrastructure Community facilities	Literature review Household survey Mapping with ArcGIS 10.1 Data collection using GPS Garmin Field observation	REMA MINIRENA RNRA CGIS-UR	Negative environmental impacts of mining are indicated and the prevention measures are proposed.
3. To propose a framework for mineral resources extraction can be integrated into land use planning in Rwanda	Is there a framework on how detailed physical plan is elaborated and implemented?	District Detailed Physical Plan for Gasabo District.	Literature review Interview with relevant institution	City of Kigali Gasabo District RHA RNRA	The improvement of the framework on detailed physical plan is indicated.
	Is there a framework on exploration and exploitation of mineral resources?	Mining regulations Mining laws and policies.	Literature review Interview with relevant institutions	MINIRENA RNRA	The improvement of the framework on mineral resources exploration and

					extraction is indicated.
	Is the role of post mining land use focused on?	Mining regulations Mining laws and policies.	Literature review Interview with relevant institutions	MINIRENA RNRA	The components of post mining land use plan are indicated.
	How mineral resources should be safeguarded in peri-urban area?		Literature review	Library Online documents	Principles on safeguarding mineral resources are indicated
	How mine life cycle can be integrated into detailed physical planning process?	National Land Use and Development Master Plan District Detailed physical plan for Gasabo Mining regulations	Literature review	RNRA MINIRENA City of Kigali Gasabo District RHA	A framework on how the mine life cycle can be integrated into detailed physical plan is proposed.

Source: MIRENA (1982)



Appendix 4: National Land Use and Development Master Plan



Source: (RNRA, 2010)