Mining and Sustainability? Systems and Stakeholder Analyses of Uranium Mining in Namibia

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of Uranium Mining in Namibia

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**Abstract:** Roughly 10% of the Namibian GDP and over 40% of total exports are dependent on the mining sector. Namibia is one of the five leading uranium producing countries worldwide with perspectives to triple the production in the following years. This study aims to identify the implications to sustainable development of the country carried by such a strategy to stimulate the economic growth. The complexity of the issue is addressed by an interdisciplinary set of methods leading to a better understanding of processes linking uranium mining in Namibia with the environment, society and the global economy. Regulatory, trade and production systems are outlined and assessed, after which a stakeholder analysis is conducted in order to determine who are the most influential actors as well as parties affected by the uranium production in Namibia. The results reveal a great dependence of the Namibian uranium mining sector on external factors, with the government perceived as the most affected stakeholder.

**Keywords:** Sustainable Development, uranium, mining, systems thinking, stakeholder analysis, Namibia

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Mining and Sustainability? Systems and Stakeholder Analyses of Uranium Mining in Namibia

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Summary: Namibia is a developing African country with a relatively elevated per capita income contrasted to high poverty and inequality levels. It is also one of the top five global uranium producing countries. Extraction of this non-renewable resource plays an important role in the country’s economy by creating employment, stimulating the development of local businesses and tax contributions to the state budget. At the same time, it causes certain negative impacts on the environment and poses health hazards to miners and local population. While uranium is designated to produce nuclear power considered as nearly free of greenhouse gases emissions, the mining activities put a great pressure on resources regionally, which results in a need to satisfy the increased energy demand from fossil fuels.

The case of Namibia reflects pursuing development by attracting investments in the extractive sector, which is relevant to many other countries. However, the unique features of uranium - including its radioactivity and potential use in nuclear weapons - result in a specific character of this type of mining. This paper describes the regulatory, trade and production systems related to uranium production in Namibia and analyses who and how influences and is affected by this economic activity, in order to find its implications for the sustainable development of the country.

Keywords: Sustainable Development, uranium, mining, systems thinking, stakeholder analysis, Namibia

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1. Introduction

The recent disaster in Fukushima has led to the return of nuclear power into political and public debates in the European countries. The common questions have concerned possible accident risk, radioactive waste or economical and strategical considerations such as low operating costs, while the first phase of the nuclear fuel cycle, namely uranium mining has rarely been mentioned. It can be explained by the fact that almost all the resource is imported from other continents - in 2011 the European Union (EU) member states produced less than 400 tonnes of uranium (WNA, 2012b), when the statistics for 2013 estimated uranium requirements of all nuclear power plants in the EU to roughly 19500 tonnes (WNA, 2013a). The effects of uranium mining are thus concentrated elsewhere.

Namibia is an African country endowed with rich mineral deposits. The mining industry there creates approximately 10% of GDP and is responsible for over 40% of total export revenues (Conde, Kallis, 2012:603). After 2010 Namibia was ranked as the 4-5th global uranium producer with perspectives to become the leader in the near future (OECD, IAEA, 2012). Mining carries certain benefits like taxes or employment, while it is also associated with a number of negative consequences. In the case of uranium, there are a few additional risk factors. Apart from being a heavy metal, uranium is radioactive and can be used to produce nuclear weapons. These issues are critical to address, considering that the African uranium mining countries are stated not to have sufficient institutional capacity to enforce effective regulations in this field (Dasnois, 2012:15). The fact that Iran - internationally accused of pursuing nuclear weapons programme - is a 15% stakeholder of the company operating the oldest uranium mine in Namibia (Rössing Uranium, 2012) can be also a concern. At the same time, the uranium mining industry in Namibia claims to integrate the idea of sustainable development as a guiding principle in its practices (ibidem; Paladin Energy 2012b).

Are mining activities truly compatible with the concept of sustainability? Over the last 30 years the idea of sustainable development has entered into international negotiations, national policies and regulations as well as business discourse. It has constituted the central subject of books, articles and academic programmes. Yet, still the vagueness of the term and its definitions allows for a wide range of different interpretations. In this paper 'sustainability' is used interchangeably with 'sustainable development' defined as: "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987), which is based on four interdependent pillars: environment, society, politics and economy.

This master thesis aims to clarify the implications of uranium mining in Namibia and find out what the driving forces behind the current developments are. To achieve this goal, analyses of regulatory, trade and production systems related to uranium production will be conducted. Also, the questions who and how is affecting, as well who and how is affected by the uranium mining activities in Namibia will be addressed. Later, the results will be used to discuss the declared relation between the uranium mining and sustainable development of Namibia. Before the actual analysis, background information is necessary to understand the context and the complexity of the issue at stake.
2. Background

2.1 Uranium mining

Uranium (U) is the heaviest element naturally occurring on Earth. It is fairly common and can be found in most rocks with the average concentration ranging between 2 and 4 parts per million (0.0002-0.0004%). It is present also in seawater, though in significantly lower concentrations. Uranium occurs in few different forms, which are known as isotopes. The most important are uranium-238 (U-238) and uranium-235 (U-235). Natural uranium is found as a mixture of these two isotopes\(^1\), where U-238 normally constitutes around 99.3% and U-235 approximately 0.7% (WNA, 2012a).

U-235 is a ‘fissile’ isotope, which means that it can be used in nuclear reaction. When hit by a moving neutron, nucleus of U-235 splits in two, while releasing heat and additional neutrons. These neutrons can hit other nuclei, thus resulting in chain reaction, where a lot of energy is released from relatively little uranium. U-238 is not fissile, but it can be described as ‘fertile’, which means that it can absorb a loose neutron - which happens during nuclear reaction - and change into plutonium-239 (Pu-239), whose properties make it similar to U-235 (ibidem). Nuclear power generation is currently a primary use of uranium. Throughout history, especially between the 1940s and the 1980s, uranium application in nuclear weapons manufacturing has been an important source of demand. Furthermore, heat from reactors can be used for domestic and industrial purposes as it is the case in Sweden and Russia. It can also serve for desalination of sea water. Another use of uranium is in maritime propulsion, mostly of submarines. Finally, radioisotopes made from uranium are widely applied in medicine, agriculture or industry (ibidem).

The global demand for uranium is shaped primarily by nuclear reactor requirements. In 2010 they amounted to 63 875 tonnes of Uranium (OECD, IAEA, 2012:75). However, the peculiarity of the current uranium market is that not all the demand is supplied by production from mines. Up to 1990 global uranium production outstripped civil power demand (Fig. 1). The surplus was mostly used in the military nuclear programmes, but a lot of uranium was also stockpiled. That resulted in a situation, in which after Cold War a bulk of reactor requirements was met from disarmament programmes or stocks. In 2010, 85% of total requirements were supplied from primary sources (ibidem:13), which compared to 54% in 2002 (OECD, IAEA, 2004:10) signalises a trend of an increasing importance of mines.

![World Uranium Production and Demand](image)

*Fig. 1. World Uranium Production and Demand (World Nuclear Association, 2010).*

Uranium produced globally in 2010 amounted to nearly 55 000 tonnes, which was 25% more than in 2008 (ibidem). Although uranium occurs practically everywhere, conventional production takes place only in case

\(^{1}\) Other isotopes can be found there as well, but in a trace amount.
when uranium concentration allows for economical extraction of the mineral\(^2\). A special category - 'identified resources' was created to present how much uranium is there to mine taking into account current costs and state of technology. It specifies that uranium needs to be recoverable at a cost lower than $260 per kilogram to be considered as a 'resource' (ibidem:15). In 2011 the global identified resources equalled 7 100 000 tonnes of uranium (tU), which at current reactor requirements will suffice for more than 100 years (ibidem). Nevertheless, it is important to bear in mind that both the demand and identified resources are variables and can be influenced at any moment by political decisions concerning energy for the first and discoveries of new deposits\(^3\) for the latter. Australia, Kazakhstan, Russia, Canada, Namibia, USA and Niger respectively have the biggest identified uranium resources (Fig.2). The same countries plus Uzbekistan, but in a slightly different order are also current top 8 producers. Three of the biggest uranium producing companies - Rio Tinto, Paladin and Areva - are present in Namibia (Table 1).

### Table 1. Biggest uranium producing companies in 2011 (WNA, 2012)

<table>
<thead>
<tr>
<th>Company</th>
<th>tonnes U</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>KazAtomProm</td>
<td>8884</td>
<td>17</td>
</tr>
<tr>
<td>Areva</td>
<td>8790</td>
<td>16</td>
</tr>
<tr>
<td>Cameco</td>
<td>8630</td>
<td>16</td>
</tr>
<tr>
<td>ARMZ - Uranium One</td>
<td>7088</td>
<td>13</td>
</tr>
<tr>
<td>Rio Tinto</td>
<td>4061</td>
<td>8</td>
</tr>
<tr>
<td>BHP Billiton</td>
<td>3353</td>
<td>6</td>
</tr>
<tr>
<td>Navoi</td>
<td>3000</td>
<td>5</td>
</tr>
<tr>
<td>Paladin</td>
<td>2282</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>8521</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>54 610</strong></td>
<td></td>
</tr>
</tbody>
</table>

Prospecting and exploration are terms used to describe the process of looking for minerals. To be legally able to conduct these activities, a company has to obtain a prospecting or exploration licence tied to a specific area and issued by a government body. Prospecting is usually associated with the first phases of exploration. In the beginning samples of soil, surface rock, plants as well as water are collected and analysed. Conducting a geophysical survey from air or surface is an important step. Up to this point there is no major interaction with the environment (IAEA, 2009:9). However, following stages include more intrusive methods such as drilling to obtain direct data about mineral concentrations in various points of potential deposit, which might result in surface or groundwater contamination (ibidem).

After the features of the mineral deposit are recognized, a feasibility study of the whole project is needed. The study ideally should take under consideration costs connected to complete life cycle of the planned mine, including closure and rehabilitation. However, this depends on a regulatory context and might not always be the case. At this stage, conducting an Environmental Impact Assessment is internationally recognized as the best practice. Also, decisions regarding technical aspects of mines are necessary then. Careful assessment of the best options with regard to climate, hydrological conditions, setting, ore grade\(^4\), planned throughput and mining method is undertaken to allow mines to achieve the best results with the lowest negative impacts possible (ibidem:10). After obtaining governments consent for the operation - usually given as mining licence - the construction phase may begin.

There are currently five established methods of commercial uranium mining:

- Open pit mining - used in case of shallow deposits, involves drilling and blasting to remove overlying rock in order to access ore. This method produces a lot of waste rock, which can release contaminants and radioactive decay products to the environment. It also results in high amounts of dust and released

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\(^2\) Usually it is over 0.1%, but sometimes in case of shallow deposits and favourable geological conditions even uranium from lower concentrations can be recovered with profit.

\(^3\) Uranium deposit is defined as: "A mass of naturally occurring mineral from which uranium could be exploited in present or in the future" (IAEA, 2009).

\(^4\) Ore - rock containing minerals. Ore grade - concentration level of minerals in the ore.
radiation and radon gas, which are hazardous especially for workers, but also for the environment and local inhabitants (IAEA, 2009:11). The ore is then subject to milling and processing in order to recover uranium. These procedures create a number of environmental and health hazards, from which the tailings storage is considered to be the most problematic.

- Underground mining - takes place when deposits are situated deeper. It requires construction of tunnels and access shafts. The environmental and health risks are similar to the ones resulting from open pit mining, with a difference that dust and radon gas are not released directly to the atmosphere, but will accumulate inside, causing even greater health hazard for miners. An appropriate ventilation system is needed to effectively minimise the dangers. The rest of the processing is similar as in the previous method.

- In situ leaching (ISL) (Fig.3) - can be conducted only in favourable mineralogy and geological conditions. It saves a few steps in comparison with the previous two conventional mining methods, where ore has to be leached after extraction from the ground. Here a leaching solution is directly injected underground and a "fertile" solution containing uranium is pumped back to the processing plant on the surface. This method decreases the operating costs while presenting a lower health risk for workers. Furthermore, it does not create tailings, which are considered as one of the main environmental and radiation hazards resulting from the other types of uranium mining. Nevertheless, in situ leaching can result in groundwater contamination and the natural pre-mining conditions are not possible to restore after the operation is terminated (Diehl P., 2011).

- Heap leaching - sometimes considered as a part of open-pit mining. It is used to recover uranium from low-grade ore when a mill would make the operation unprofitable. Mined ore is put in form of a heap and leaching solution is spread from the top of the pile. Then solution containing uranium is collected below the pile and pumped to a processing plant. This type of mining is hazardous as radon gas, dust and leaching solution are released while processing. In case of neglecting appropriate safety measures, heap leaching might result in a permanent contamination of groundwater (ibidem).

- By-product recovery - uranium ore is often found in combination with other minerals. Gold, phosphate and copper mines sometimes extract ore relatively rich in uranium, which they can recover on site of their primary production (OECD, IAEA, 2012:66)

Tables 2 and 3 present global share of production methods in 2007 and 2011. From the statistics a rapid increase in ISL use, which is relatively cost-efficient can be observed. It was stimulated primarily by mine developments in Kazakhstan, where sandstone deposits allow for such a method of uranium extraction. (ibidem)

<table>
<thead>
<tr>
<th>Method</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional underground</td>
<td>37.7</td>
</tr>
<tr>
<td>Conventional open pit</td>
<td>23.7</td>
</tr>
<tr>
<td>In situ leach (ISL)</td>
<td>27.7</td>
</tr>
<tr>
<td>By-product</td>
<td>8.4</td>
</tr>
<tr>
<td>Heap leaching</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 2. Distribution of production methods in 2007 (IAEA, 2009:11).

<table>
<thead>
<tr>
<th>Method</th>
<th>tonnes U</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional underground</td>
<td>16059</td>
<td>30</td>
</tr>
<tr>
<td>Conventional open pit</td>
<td>9268</td>
<td>17</td>
</tr>
<tr>
<td>In situ leach (ISL)</td>
<td>25296</td>
<td>46</td>
</tr>
<tr>
<td>By-product</td>
<td>3987</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3. Distribution of production methods in 2011. Heap leaching is included in Conventional open pit category (WNA, 2012b).

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5 Ore after extraction usually is crushed, grounded and then leached in a uranium mill.
At the oldest uranium mine in Namibia (Rössing) uranium production is divided into 12 steps (Rössing Uranium, 2013). While this scheme and each step can vary depending on mine and its geological conditions, it creates a general picture over the process of conventional uranium recovery:

1. Drilling and blasting - this is the way in which uranium ore is extracted from the ground. Then, it is loaded on the trucks and scanned by radiometric scanners, which indicate the amount of uranium. Based on this information, the truckloads are sent either to crushers or to the low-grade stockpile.
2. Crushing - ore passes through a number of crushers to achieve a size smaller than 19mm.
3. Grinding - fine ore is ground by steel rods, which turns it into a muddy slurry.
4. Leaching - large mechanically agitated tanks serve for combined leaching and oxidation of uranium content.
5. Slime separation - after leaching uranium solution contains sand and slime particles, which are separated here and sent to tailings disposal area.
6. Thickening - another stage of removing small particles, which results in clear, "pregnant" uranium solution.
7. Continuous ion exchange (CIX) - special resin beads serve to absorb uranium ions, which later on can be extracted, creating purified, concentrated uranium solution.
8. Solvent extraction (SX) - an organic solvent is added to the solution, which takes up the uranium component. Later an ammonium sulphate solution is added which captures uranium-rich liquor.
9. Precipitation - adding gaseous ammonia results in precipitation of ammonium diurate, which is thickened to yellow slurry.
10. Filtration - with the use of rotating drum filters ammonium diurate is recovered from the slurry.
11. Drying and roasting - used to eliminate ammonia, which leaves uranium oxide ready to pack into metal drums.
12. Loading and despatch - uranium ready to export. This is the last step of mining and milling operations.

This is just the first stage of nuclear fuel cycle (Fig. 4). Only 0.7% of produced uranium is 'fissile', so it has to be subjected to further processing before it will serve as fuel in a nuclear reactor\(^6\). After production, uranium oxide \((U_3O_8)\) is exported to conversion plants. There, it is processed to uranium dioxide \((UO_2)\)\(^7\) and then to uranium hexafluoride \((UF_6)\). The latter is then sent to an enrichment plant, where the amount of U-235 is gradually increased, until it reaches 3-5% of the total mass\(^8\). Such uranium is needed to produce fuel rods, which are used in the majority of current nuclear power reactors (WNA, 2012c).

\(^6\) Or in nuclear weapons.
\(^7\) Which can be used in a heavy water nuclear reactor.
\(^8\) For the nuclear weapons, it has to be enriched to at least 90%.

*Fig. 4. A simplified graph presenting nuclear fuel cycle (WNA, 2013).*
After the uranium resources of a deposit are depleted, there is a need for the last steps in the life-cycle of mine - decommissioning and remediation. It is important that the mine closure plan is implemented since the beginning of operations, because many operators of currently depleted mines neglected this phase, leaving the environment in a catastrophic state. (IAEA, 2009:21,40)

2.2 Namibia

Namibia is a country located on the South-West coast of Africa (Fig.5). With a surface of 824,292 km² and 2,1 million inhabitants, it is one of the most sparsely populated countries in the World. Two deserts - Kalahari along the border with Botswana and Namib along the coastline - cover a large part of the total area. Dry and temperate climate is strongly influenced by the cold oceanic Benguela current (Government of Namibia, 2013).

Namibia has a rich cultural heritage with over 11 indigenous languages spoken and huge variety of preserved ancient rock paintings and engravings (ibidem). Some authors believe that the cradle of humanity had its place at the territory of the contemporary Namibia (Berg, 2011). The San people are considered to be the oldest inhabitants of the land. Bantu-speaking communities, which currently constitute over 50% of the population, arrived around 1500-2000 years ago (Government of Namibia, 2013). At the end of the 19th century, the area was colonized by Germany and since then was known as South West Africa. South Africa took over the territory during World War I and in 1920 was given administrative mandate by the Council of the League of Nations. After the Second World War newly created United Nations suggested putting the Namibian territory under a trusteeship agreement. However, South Africa opposed the idea and maintained control over South West Africa. The international stance towards this occupation had been becoming harder over the following decades, which was represented in the UN decisions. Meanwhile, the South West Africa People's Organisation (SWAPO) was founded in 1966 to fight for the independence. In 1971, the International Court of Justice stated that the South African presence in Namibia was illegal and all its administration should be withdrawn immediately, which was not respected. (UN, 2001)

In 1974 the Decree for the Protection of the Natural Resources of Namibia, which prohibited extraction of any natural resources in the country, was enacted by the UN to increase the pressure on the occupation. However, it did not succeed, as in 1976 the first uranium mine in Namibia - Rössing - commenced production. Run by British Rio Tinto it has been in operation ever since. After a long struggle Namibia gained independence in 1990. SWAPO won the first elections and despite having considered Rössing as a symbol of foreign control over Namibia earlier in the 1970s, it strongly supported the company, which was declared as fundamental for the economy of the newly created state (Hecht, 2012:147-168).

Currently Namibia is considered as one of the most developed African countries. Although it is ranked 120th in 2011 Human Development Index (UNDP, 2011), this is the second place in the sub-Saharan Africa - only Botswana figures higher on the list. The difference is not significant as the eastern neighbour of Namibia appears on the 118th position. Both countries could be listed higher if not for relatively short life expectancy⁹ (ibidem) caused by high HIV prevalence rate in the southern Africa¹⁰.

In terms of GDP (PPP) per capita, Namibia is overtaken also by South Africa, which gives it the 3rd place in the sub-Saharan Africa (ibidem). Nevertheless, considerable structural differences remain noticeable in the economy in comparison to the OECD countries. Income distribution in Namibia is one of the most unequal in the World and 20% of households live below the nationally set poverty line (World Bank, 2012). Unemployment rate in 2008 amounted to 51.2% (AIDB, OECD, UNDP, UNECA, 2012). After more than 20 years from independence Namibia still remains strongly dependent on mining. With 9.6% of GDP share, it was the 5th most important sector in 2010 after finance, trade services, manufacturing and government services. It accounted also for over 50% of all exports in the same year (ibidem).

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⁹ 62.5 years in Namibia, 53.2 in Botswana (2011)
¹⁰ 13.4% of total population in Namibia, 23.4% in Botswana (2011)
2.3 Uranium mining in Namibia - the context and current developments

Diamonds and uranium production constitute two main branches within the mining sector. While the diamond industry is expected to reduce sales in the near future, the contrary is anticipated for the uranium extraction in Namibia (ibidem). The second mine - Langer Heinrich run by Australian Paladin Energy - commenced production in 2006 and has already undergone 3 stages of expansion. The two operating mines are together capable of producing 10% of global mining output, which in 2010 gave Namibia the 4th place in total production after Kazakhstan, Canada and Australia (WNA, 2012b).

Furthermore, a number of uranium projects is currently under development in Namibia. Rising prices of the resource until 2007 attracted an influx of foreign exploration companies. This phenomenon was also known as the 'Uranium Rush'. The governmental administration feeling that it was unable to effectively control such a situation, issued a moratorium on new prospecting licences for foreign companies in 2007. Time was needed to set up required regulations\(^\text{11}\)\(^{11}\)(SOMO, WISE, 2011). To understand better the environmental and social impacts from the predicted developments, a Strategic Environmental Assessment commissioned by the Ministry of Mines and Energy was conducted by Southern African Institute for Environmental Assessment in 2010-2011. It presented four different scenarios, which assume that two to ten new mines will be opened before 2020. Three to five additional operations were considered to be the most likely scenario (MME, 2010). The SEA, however, was published before the Fukushima disaster, after which a downward trend in the uranium prices has been visible. This situation influenced French Areva, which runs the Trekkopje project previously scheduled to be opened in 2012, to postpone the commercial production start until the market conditions improve (Duddy J-M., 2012). Three other projects: Husab, Valencia and Etango, which would contribute with doubling production capacities of the country are expected to start operations in 2015 and 2016 (OECD, IAEA, 2012:71).

All the planned projects, as well as Rössing and Langer Heinrich operations are located in the Erongo region (Fig. 6). It is a popular tourist destination thanks to a number of picturesque views, such as vast sand dunes or "Moon Landscape". Despite the arid climate, Erongo is also characterised by a rich biodiversity with many endemic species (MME, 2010). Swakopmund, located on the coast is the main holiday destination. Walvis Bay, the second major town in Erongo, has rather an industrial character. It is known as the principal port of Namibia, which serves also as a transport hub for Botswana, northern South Africa, as well as Zambia, Zimbabwe and the Democratic Republic of Congo. Apart from tourism, transport and mining, fishing is an important industry in Erongo. In 1998 it accounted for almost 1/3 of the employment in the region (ibidem). Nevertheless, that figure is likely to have changed taking into account the developments in uranium mining.

There are many anticipated effects of the current developments. Influx of people will put a pressure on the available accommodation and can also have negative implications such as increase in crime, prostitution and HIV prevalence. Rapid immigration combined with the development of necessary infrastructure will very likely result in higher energy and water use as well as bigger amount of waste. Namibia is currently dependent on energy imports from other countries, therefore to meet the requirements of new uranium mines, a coal-fired power plant is planned. Having scarce water resources, the region risks over-abstraction and water pollution (MME, 2010). A desalination plant was built by Areva, but it might not meet all the industry needs (ibidem).

\(^{11}\) Environmental Management Act was passed in 2007, Radiation Protection and Waste Disposal Regulations were adopted only in 2011 (with 2 mines already operating).
Nevertheless, there are some expected benefits. The government will receive gradually more income from various taxes. Mines and needed infrastructure will provide between 2000-6000 jobs up to 2020 and disposable income of residents as well as local economy will grow, possibly stimulating greater provision of education and healthcare. Currently, two other sectors - tourism and fishing - are besides mining the most important in Erongo. The developments of uranium industry might reduce the attractiveness of the region, resulting in a lower number of tourists. On the other hand, a cooperation between sectors could turn beneficial for both of them (ibidem).
3. Methodology

3.1 Systems and stakeholder analysis

To understand and describe such a complex and multidimensional issue as uranium mining in Namibia, an interdisciplinary set of methods is necessary. Systems and stakeholder analyses are chosen to capture the essence of the problem and present it in a comprehensible way. The first method is characterised by an organisational quality and a holistic view, which addresses complexities of reality (Olsson, Sjösted, 2004:18). In this paper, systems analysis aims to identify and describe the context in which uranium mining companies operate, while emphasising the inter-linkages between different actors, as well as processes that connect them. Three crucial systems related to uranium were chosen, each of them corresponding to one pillar of sustainability. Regulatory system represents the political pillar, trade system reflects the economic dimension and production system assesses impacts on the environment. The analyses have a qualitative character, but they often refer to numerical data. A simplified visual scheme of the system analysed is provided in each section. Visual data including graphs and tables is used to illustrate certain important aspects supporting the analyses.

Systems analyses are also conducted to help in identifying the parties affected by and affecting uranium mining in Namibia, who constitute the subject of the following chapter. Stakeholder analysis is a pragmatic method that focuses on people and their real life conditions in a specific context (Chevalier, Buckles, 2008), thus addressing primarily the social pillar of sustainable development. In this paper, fourteen categories of stakeholders are identified for the purpose of analysis. A survey was conducted among the stakeholders to determine the perceived level of stakeholder influence on the issue addressed, as well as the perceived extent to which uranium mining in Namibia affects them. For two categories of stakeholders who are not able to express their opinions - future generations and the environment - a young student and a member of environmental NGOs are chosen for representatives. The stakeholders are mapped according to the aggregated results of the survey and each of them is described shortly. In the following chapter, the findings of all analyses are discussed jointly with regard to sustainability.

3.2 Data collection

The data for the background chapter was collected through online research and literature review. The same methods were used for analysing the systems relevant to uranium mining in Namibia. Additionally, some information was acquired through e-mail exchange. To conduct stakeholder analysis an online survey was undertaken. Stakeholders were found on the public lists of stakeholder meetings for the Strategic Environmental Assessment of "Uranium Rush" in Namibia (MME, 2010) or recommended by the specialists contacted, which ensured that their level of knowledge about the issue is sufficient. The aim was to obtain one response from a representative of each identified stakeholder group. Nine responses were collected, which accounts for the majority of the categories. The survey with the results is attached to this thesis in the Appendix A. The stakeholders' descriptions were based primarily on the results of systems analyses and information found online.

3.3 Limitations

The first major limitation is represented by the character of data used in this thesis. Comprehensive publications addressing uranium mining are released primarily by international organisations or associations, which are ideologically connected to nuclear power promotion. Specific information concerning Namibia was collected through the industry, governmental and NGO reports, newspaper articles, academic publications as well as e-mail exchange with stakeholders. All of these sources are influenced by ideology and values of the authors, which is a major limitation to the positivist ideal of scientific objectivity.

The same is valid for the author of this thesis. The attempt to present the results of the paper in a neutral way was certainly biased by my own beliefs. Indeed, the concept of sustainable development - chosen as a central approach in this thesis - can be perceived as highly ideological. At the same time, the imprecision of the term 'sustainability' allows for a wide range of different interpretations, which represents another major limitation.

The geographical distance between the researcher and the issue assessed has also influenced the final results. Lack of possibility to conduct the research on place constituted a serious impediment in systems and stakeholder
analyses as well as in capturing the context, since the author's perception of the issue assessed was based mostly on the secondary data. This problem was partially overcome by a direct contact through Internet with a number of stakeholders. Unfortunately, too often a request for information was left without any answer. This was the case with five out of fourteen stakeholder categories, which have not participated in the survey. Moreover, basing the analysis only on one survey from each stakeholder category is certainly a major simplification. Nevertheless, the short research time frame and the difficulty in reaching Namibian stakeholders from Europe had decided that the minimal amount of respondents would be targeted. Despite the low number of participants, the survey results represent tendencies in general perception of uranium mining stakeholders. They are a valuable indicator of the actual degree of influence on stakeholders and the level of power to affect the issue possessed by different groups. Still, a more comprehensive study would need to be conducted in order to achieve more accurate results.
4. Systems analyses

4.1 Regulatory system for uranium mining in Namibia

Mining operations usually take place on a territory belonging to a certain country. Therefore, they function within a framework of laws and regulations of that country. Regulatory system defines the procedures needed to be followed by a mining company, with a goal to protect the country's environment and society from the negative impacts of mining. In case of uranium production two additional factors result in a need for further regulations. Radioactive properties of uranium should be addressed, because of related health hazards and its potential to be used in nuclear weapons calls for more stringent systems of control of international trade in uranium.

The Constitution of the Republic of Namibia from 1990, which is the supreme law of the country, states in the article 94 that:

"The State shall actively promote and maintain the welfare of people, by adopting inter alia policies aimed at the following: ... (l) maintenance of ecosystems, essential ecological processes and biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future; in particular, the Government shall provide measures against dumping or recycling of foreign nuclear and toxic waste on Namibian territory."

This article embeds the main principles of sustainable development in the legal system of Namibia. At the same time it could be used, rather loosely, to refer to uranium mining activities. The development of mines and accompanying infrastructure can endanger certain species and continuity of ecosystem processes. Nevertheless, as stated in the Environmental Management Act (2007), a new mining or infrastructural project needs to obtain an environmental clearance certificate from the Minister responsible for environment before commencing construction. To fulfil the requirements for the certificate, the company has to present an Environmental Impact Assessment for the project, which has to be accepted by the Ministry.

The last sentence in the cited article from the Constitution concerns "dumping or recycling of foreign nuclear and toxic waste on Namibian territory". Waste rock or tailings contain radioactive elements, which can be released to the environment. A significant amount of other contaminated waste is produced during uranium production. Handling above mentioned types of waste, as well as radioactive material itself are regulated by
Radiation Protection and Waste Disposal Regulations (2011), which were released as part of Atomic Energy and Radiation Protection Act from 2005. Atomic Energy Board (AEB) and National Radiation Protection Authority were established as the controlling bodies. The Act falls under the competence of Ministry of Health and Social Services. It introduces the obligation of registration of every radiation source and nuclear material and obtaining a special licence to perform actions involving registered objects (2005:s.16-21). These legal documents were incorporated into the legal system of Namibia recently - Radiation Protection and Waste Disposal Regulations were prepared in response for growing interest of international mining companies in Namibian uranium at the end of the previous decade (Shindondola-Mote, 2009:15). Nevertheless, the Langer Heinrich mine had been already operating for 5 years and Rössing for 35 years without this legal instrument in place.

The mining process is regulated by the Minerals (Prospecting and Mining) Act (1992) and is managed by the Ministry of Mines and Energy. The Act introduces an obligation of a licence while performing any reconnaissance, prospecting or mining operations. For exploration purposes, an interested party is granted an Exclusive Prospecting Licence (EPL) assigned to a certain territory. There is a number of requirements: the applying party has to prove technical and financial capabilities, the first EPL can be valid up to 3 years and later it can only be prolonged twice for two years each time unless given exemption by the Minister. The application fee is US$250, so in the second half of the last decade, when the uranium price was sky-rocketing the Ministry could receive more than 50 applications a day, which overburdened institutional capacities (Shindondola-Mote 2009:18-19). This resulted in the before-mentioned moratorium on issuing new prospecting licences. As of March 2013, there are 30 EPLs granted for nuclear fuel held by 17 companies (MME, 2013a). Most of the companies is owned by Australian (7) and Canadian (4) proprietaries, though a number of Chinese (3) and Russian (2) companies is also active. 28 out of 30 EPLs are located in Erongo region. In the future, all prospecting licences for uranium are planned to be granted to state-owned Epangelo Mining Ltd (WNN, 2011).

To be able to perform mining operations a company needs to obtain a mining licence. Currently, an environmental clearance certificate from the Ministry of the Environment and Tourism is required before the licence is issued. The Minister of Mines and Energy grants a licence on recommendation of special committee, which cross-checks all the requirements (Shindondola-Mote 2009:18). A mining licence is issued for a period of maximum 25 years. Apart from Rössing Uranium and Langer Heinrich, which currently run their operations, 4 companies have already been granted with a mining licence (MME, 2013b). Valencia Uranium Mining owned by Canadian develops Valencia project. Uramin Namibia - a subsidiary of French Areva - is in the possession of the Trekopje project. Swakop Uranium owned by Chinese Taurus Minerals is going to produce uranium from one of the biggest uranium deposits worldwide (Williams L., 2012). Very little is known about the Chinese company - Zhonghe Resources - which was granted the most recent mining licence on 30 November 2012.

The Minerals Act of 1992 states that licence holder after finished operations has to rehabilitate the land under threat of a fine of N$100000 or five years imprisonment\(^\text{12}\). However, it does not set the requirement for closure plan in order to obtain a mining licence. The Environmental Management Act of 2007 introduces for mining companies the obligation of sending mine closure plans every 3 years and providing guarantees of after-closure rehabilitation (MME, 2010:6-10). Additional regulations that can be related to uranium mining concern water management (Water Resources Management Act of 2004\(^\text{13}\) and Namibia Water Corporation Act of 1997), cultural heritage (National Heritage Act of 2004), land use (Townships and Division of Land Ordinance of 1963 and Town Planning Ordinance of 1954).

Uranium mining is governed also on the international level. Only in 1997 International Atomic Energy Agency\(^\text{14}\) (IAEA) created Additional Protocol in which uranium mines were recognised as nuclear facilities. Before this change, natural uranium was not considered as "nuclear", which facilitated untraceable international trade in this mineral (Hecht, 2012). The Additional Protocol established a set of new safeguards - every country, which ratified Additional Protocol, has to declare the production of all mines on its territory, as well as all the exports and imports of uranium for nuclear purposes; and for non-nuclear purposes if the quantity of uranium exceeds 10 tonnes. It also introduces possibility of inspections by IAEA delegates, in order to verify compliance (IAEA, 1997). Preventing new states and non-state actors from obtaining nuclear weapons is the main rationale standing behind strengthening the international safeguards. The Additional Protocol is in force for Namibia since the 20th February 2012 only (IAEA, 2012). At the same time, Iran - internationally recognized as a country, which

\(^{12}\) ~US$10800; 1NAD=0.108USD (26.03.2013)

\(^{13}\) Operational from 2010. Before water management was regulated by the Water Act, 54 of 1956, which was considered as imprecise in many points (MME, 2010:6-3).

\(^{14}\) To which Namibia is a member.
pursues nuclear weapon programme - remains a 15%-shareholder in Rössing Uranium.

4.2 Uranium trade system

4.2.1 Economic factors in uranium mining

The possibility of making profit is usually the main motivation standing behind making investments in uranium mining. One can argue that depending on the place and the point in time, other factors such as energy security, military security or international prestige have been equally, if not more important (Hecht, 2012), but the present state of international uranium market and its implications for Namibia, where most of the planned mine developments are currently on hold due to low global uranium prices, prove that economics play the main role in the dynamics of uranium industry.

Besides the external demand, ore availability, characteristics and accessibility are primary decisive factors for the development of a uranium mine. The amount of uranium to extract has to be big enough to ensure returns on investment. Geological features, in which uranium occurs will determine the optimal method of production. The level of ore grade would be reflected in the amount of work and resources used to recover uranium. Shallow deposits will be relatively easier to exploit than deeper ones. Other crucial factors, which would influence significantly the cost of operation would include infrastructure, regulatory system in the country of investment (especially taxes), cost of labour force, materials, services needed to support the mining activities, as well as costs of environmental and waste management during and after the operation.

Organisation for Economic Cooperation and Development (OECD) with the IAEA in the most recent of biannually published reports: Uranium 2011: Resources, Production and Demand (2012) divided identified resources into cost categories taking under consideration above-described factors and segregated countries according to these categories. While Namibia, with over 500 000 tonnes of uranium recoverable at prices lower than $260/kgU, is situated on the 5th place globally, not far from Canada, Kazakhstan and Russia, only 50% of its uranium could be extracted profitably with the prices below $130/kgU, when it would be 76%, 77% and 75% respectively for the other three countries. For Australia, which has identified resources of over 1 500 000 tU, this
factor equals to 95.5% (ibidem:18). With the current spot market price of $110/kgU\textsuperscript{15} Namibian resources seem not to be competitive. Nevertheless, contrary to other above mentioned countries that reported the data themselves, the figures for Namibia are mentioned as a secretariat estimate, which puts the accuracy of the numbers into question.

The main disadvantage of the uranium deposits found in Namibia is that they consist of low-grade ore. The amount of uranium in rocks varies mostly between 0.01% and 0.05%, while in Australia or Canada it is on average about 10 times higher (WISE Uranium, 2013). Despite the low grade, the uranium deposits in Namibia are relatively large and shallow (MME, 2010:4-29), which means that they are fairly easy to exploit and can be mined over a long-time period. Moreover, almost all currently developed projects are located in Erongo region, not far from Walvis Bay - the main Namibian port. Taking under consideration that the infrastructure in Namibia is in a very good state compared to other African countries (ibidem:4-2), it greatly facilitates the exports of uranium and imports of required materials.

Nevertheless, while the costs of operation are rather easy to predict for a longer period of time, the price of uranium reflecting global demand and supply trends can change significantly over just few years. Although uranium transactions are kept confidential, it is known that globally the majority of contracts concerns long-term deliveries, for which price is negotiated between the contrahents (OECD, IAEA, 2012:117). Around 40% of these contracts sets the first delivery within a year and 28% within two years (TradeTech, 2013). Less than 25% of uranium is sold with regard to immediate or near-time deliveries (OECD, IAEA 2012:117), when the price is usually based on a special indicator - uranium spot market price, produced by a small number of consulting/brokering companies (UxC, 2013). Even if it is accurate only for a small percentage of global uranium transactions, it also indicates the trends, which influence terms of long-term contracts. Recent developments in spot market prices are shown on the figure below (Fig. 9).

\textbf{Fig. 9.} A graph presenting the evolution of uranium spot market price over the last 10 years (Cameco, 2013)

Between 2003 and 2007 the price of uranium increased more than tenfold, peaking in June with $354/kgU. This situation had many causes. A growing perception of stockpiles running out, which can be seen on Fig. 1, problems encountered by crucial nuclear fuel cycle facilities, changes in the value of American dollar, speculation, and plans of building many new nuclear reactors in emerging countries - Russia, China and India are just few possible reasons for the uranium price change (OECD, IAEA, 2012:113). Intensified exploration worldwide was a response to the rapidly rising prices of uranium. Only in 2007, the number of uranium mining and exploration companies increased globally from 570 to 940 (Shindondola-Mote, 2009:2). This was reflected in Namibia by an influx of companies applying for exclusive prospecting licences, which in the light of insufficient governmental capacities and regulations resulted in a moratorium on issuing the licences introduced in 2007 by the Ministry of Mines and Energy in Namibia (MME, 2010:1-1).

\textsuperscript{15} As of 25 March 2013. Own calculation - prices are given in $/lb \text{U}_3\text{O}_8
After 2007 the spot market prices of uranium began to fall. It can be perceived as a natural process of market correction as the afore price increase had a speculative character. The pace of the price decrease was also affected by the global financial crisis in the beginning (OECD, IAEA, 2012:113). After settling down on a level close to $100/kgU, the prices started a quick recovery in the second part of 2010. However, the Fukushima disaster and its political consequences around the world had a negative influence on the price, which started to fall down again. This shows that random events affecting political and economical systems can have enormous effects on volatile uranium prices, and thus, on global developments in uranium mining. It can be illustrated by the fact that in every recent case when a country with high nuclear power use declares nuclear phase out or reducing reliance on nuclear energy, it has an immediate negative effect on the uranium spot market price. In the case of Germany such a situation took place in May 2011 (Dempsey, Ewing, 2011) and the indicator fell from $148/kgU that month to $137.5/kgU in June and by another 10 dollars until August (Cameco, 2013a). Japan and France announced their turn away from nuclear energy in the first part of September 2012 (Schaps, Gloystein, 2012) and the price fell from $125.5/kgU in August to $108.55/kgU in October (Cameco, 2013a).

Nevertheless, as noted previously, uranium transactions are dominated by long-term contracts. Since they have a long time-span, the choice of a pricing mechanism will determine financial results for the companies selling uranium, as well as its buyers.

- **Specified Pricing** is the first method. It introduces one price or a series of defined prices, sometimes coupled to economical indicators, especially inflation (Trade Tech, 2011). Its advantage is that it is very predictable, giving the contrahents a clear picture over expected costs/profits and a sense of stability. However, in the case of strong market fluctuations one side can lose much more. To illustrate this, an imaginary example based on the Fig. 9 can be brought: in 2003 an uranium mining company signed a contract for uranium deliveries over 8 years (2004-2011) at a price of $50/kgU. What looked promising at the moment of transaction, turned out to be much worse than selling uranium for a spot market price.

- **Market-Related Pricing** (ibidem). It is tied to market variables such as the spot market price. To protect the uranium supplier from loses, a so called "floor price" - the lowest price for which the company agrees to sell - is introduced. Similarly, a "ceiling price" is often included in the interest of the buyer (ibidem). That type of pricing is better adapted to the market dynamics and can be more just in perception of the contrahents. However, the unpredictability involved can be seen as harmful for the management.

- Few other pricing mechanisms, which are currently not very popular, include Negotiated Pricing (common only in China, Japan and Canada), Hybrid Pricing and Cost-Related Pricing (ibidem).

Typically, uranium contracts are concluded with companies managing nuclear facilities (Cameco, 2013b). However, between uranium mining and milling and nuclear energy production there are three additional steps - uranium conversion to uranium hexafluoride (UF\(_6\)), uranium enrichment and fuel fabrication. Usually, the companies managing nuclear power plants have contracts with facilities at each stage of the front nuclear fuel cycle and suppliers are responsible for transporting the product to the following stage. Sometimes, transactions between different levels are facilitated by brokers and traders (ibidem).

### 4.2.2 Global uranium market overview

The uranium trade system is characterised by historically developed division into two blocks - American and EU countries, South Korea and Japan confronted to Russia, Eastern Europe, Central Asia and China at the other side (ibidem). However, taking under consideration the statistics from U.S Energy Information Administration and Euratom Supply Agency, where Russia, Kazakhstan and Uzbekistan are among the major suppliers for USA and the EU (2012, 2013a) the increasing globalization constantly reshapes the global uranium market.

Another feature of the uranium trade system worldwide is that despite the high complexity and few stages of production, the number of active actors within the system is moderate. Cameco (2013b) states that there are less than a 100 companies involved in the uranium trade within the "Western block". Uranium: Resources, Production and Demand Report (OECD, IAEA, 2012) listed 67 operating mines in the World. There are only 10 uranium hexafluoride conversion facilities in 8 countries (WISE Uranium, 2013b) and 22 enrichment facilities in 13 countries (ibidem). The number of operable nuclear power plants equals to 430 located in 30 countries. Table 4 presents the distribution of nuclear facilities and utilities among countries.

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16 Complete in case of Japan, only partial in case of France.
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Table 4. Distribution of uranium mines and production, converters, enrichment facilities and nuclear power plants with uranium requirements among countries (OECD, IAEA, 2012; WNA, 2012b; WNA, 2013a; WISE Uranium, 2013b).
Analysing data in the above table allows for a better understanding of the present situation of the uranium global market. Kazakhstan is currently a clear leader in uranium production worldwide and the biggest exporter of that mineral. The visual data (Fig.9; Fig. 10) shows that a rapid increase in production there followed the uranium price peak in 2007. However, only two new mines are planned in the near future, which might result in levelling off the production in the light of short life-spans of a few uranium operations in Kazakhstan (OECD, IAEA, 2012:290-291).

In 2011 Canada was the second producer, as well as exporter, even though it needs some uranium for its nuclear power plants. Australia followed on the 3rd position in these two categories. However, both countries experienced a significant decrease in their production since 2005. In 2004, Niger recovered a similar amount of uranium as Kazakhstan. In 2011 it reported a slightly higher production than seven years earlier, yet the result was four times lower than the one achieved by Kazakhstan. Namibia was on the 5th place after Niger, followed by Uzbekistan. All these three countries produce uranium solely for export purposes, contrary to the three next in order: Russia, USA and China, which need uranium to feed their extensive nuclear programmes.

USA, France and China are the top 3 uranium consumers followed by Russia, Japan and South Korea. Since the numbers in the table are WNA estimates, especially the uranium demand from Japan might turn inaccurate, because after the Fukushima disaster almost all nuclear power plants in this country are on a temporary standby programme, which aims in increasing the reactor safety (Inajima, Okada, 2013). None of the major uranium consumers is able to satisfy its requirements with the domestic production.

There are over 220 nuclear power plants expected to be built within the next couple of years (WNA, 2013a). This is more than half of the currently operating plants. Even taking under consideration that a lot of reactors will be shut down due to political decisions or age, the growth in new NPPs is expected to be steady, which will translate into an increase in uranium requirements by 30000-65000 tU/year in the next 20 years (OECD, IAEA, 2012:117). China with 80 new reactors will very likely stand behind the most of additional demand for uranium. Russia and India with 27 and 25 new nuclear power plants will also have greater uranium requirements. Furthermore, there are many countries, which are going to diversify their national energy systems by adding nuclear reactors to their grids. Poland, Turkey, United Arab Emirates and Vietnam, for example, are going to build 4 to 6 nuclear power plants each (Fig.9). All new “nuclear” countries will build 28 NPPs, which is going to impact significantly the dynamics of global uranium markets.

The bigger expected uranium demand is projected to evoke a response from the supply side. There are 44 new uranium mines planned worldwide to increase uranium production in the upcoming years (OECD, IAEA, 2012). Most of the mines are going to be opened in countries with established uranium industry or in states, whose uranium requirements are expected to increase sharply. However, there are also two new countries with large projects - Mongolia and Tanzania.

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17 At the moment of writing.
The planned mine developments in major countries can significantly affect uranium supply within the next 7 years (Fig. 11). The figures represent the intended production capacity, which often needs some time to be reached, thus they should be treated as estimates. Moreover, the exact data for Chinese and Mongolian mines is lacking, so they are not marked on the graph, even though they are of considerable importance for the overall situation. Also, the figures for some US mines were not accessible, so the number could be much higher. Nevertheless, it is visible that serious mine developments are planned worldwide. If all these developments were completed, almost 50000 tonnes of additional uranium could be produced each year. In comparison, uranium requirements in 2020 are forecast to be only 12000-26000tU higher than in 2011 (ibidem:99). Therefore, it is doubtful that all the planned projects will be realised.

Surprisingly, the highest expected increase in production capacity is attributed to Namibia (ibidem), whose identified resources are not as economically competitive as those in Australia, Canada or Kazakhstan, but which thanks to the expected developments would become the second largest uranium producer globally. After Namibia, there is Russia, which will need much more uranium for its nuclear power plants. Niger, traditionally a resource base for French nuclear reactors (Hecht, 2012), where currently AREVA is developing giant Imouraren mine, along with Canada are situated on the third place.

![Fig. 11. Projected additional uranium production capacity resulting from mine developments until 2020 (OECD, IAEA, 2012:70-71, 430).](image)

### 4.2.3 Uranium trade system in Namibia

Uranium mining had been taking place in Namibia fourteen years before the country gained independence. However, until 2006 it was only one mine - Rössing - which produced uranium. Currently, apart from the 2 companies having fully-operational projects, 4 new companies have already been granted with a Mining Licence and 2 more are awaiting the decision of Ministry of Mines and Energy (MME, 2013b). With the entry of new actors, the already intricate uranium trade system in Namibia might gain even more complexity.

#### 4.2.3.1 Mines

Rio Tinto\(^\text{18}\), one of the major mining companies worldwide, started developing the Rössing mine in 1966 (Hecht, 2012:96). Having been situated on the territory under South African occupation, since the very beginning it was perceived as a controversial project. Before the mine opened in 1976, Rio Tinto had already signed long-term contracts for uranium delivery with the United Kingdom Atomic Energy Authority and Japan (ibidem: 96-100). In case of United Kingdom, a few thousand tonnes of uranium was designated for nuclear weapon purposes (ibidem:86). Nevertheless it was the illegal - in the light of international law - occupation of Namibia by South African apartheid state, which brought controversies. In 1974 the United Nations Commissioner for Namibia (UNCN) issued a decree prohibiting any extraction of natural resources on the occupied territory. Nevertheless,
Over the following years the mine continued operations despite the mounting international pressure on South Africa and Rio Tinto. The new customers of uranium from Rössing included Spain, West Germany and Iran (ibidem:155). The latter country is reported by the IAEA (2004) to have imported at that time 531 tonnes of $\text{U}_3\text{O}_8$, some of which has been used in its nuclear weapons programme. South Africa also had a similar programme in the 1980s, which was proved in 1994, when this country announced disarming from 6 atomic bombs it had produced (Hecht 2012:145). Rössing experienced some economical problems in the late 1980s, when the international political pressure and activism against uranium from Namibia impeded trade with uranium from the mine. Nevertheless, in 1988 an independence accord of Namibia was signed and Rössing was kept as an economic foundation for the new state (ibidem:168). Interestingly, Sweden was a country attracted by the idea of helping the new independent state by signing a contract for uranium purchase from Rössing (ibidem).

The Rössing mine is owned by Rössing Uranium company, a 69% subsidiary of Rio Tinto, which is effectively managing the operations. The remaining shareholders in Rössing Uranium are Iranian Foreign Investment Company with 15%, Industrial Development Corporation of South Africa with 10%, Government of Namibia - 3% and 13 individuals - 3% (Rössing Uranium, 2012). The continued Iranian presence in the company raises questions in the context of its nuclear programme and United Nations Security Council Resolution 1929 (UNSCR 1929), which prohibits Iran from having any interest in foreign business involving uranium mining or nuclear technology. However, Rössing Uranium (2012) states that it excluded Iranian members from Board meetings since February 2010 and suspended dividend payments since 2008.

The second uranium mine in Namibia, fully owned by Langer Heinrich Uranium - a 100% subsidiary of an Australian company - Paladin Energy, produces uranium since 2006 (Paladin Energy, 2012a). The company opened another uranium mine in Malawi in 2009 and has been developing a few projects in Australia.

Four companies have already been granted a Mining Licence, which can be seen as a green light for the construction of a mine:

- In 2007 French Areva, who supplies uranium for Électricité de France (EDF), took over Uramin, which had been developing Trekkopje project (Bezat, 2012). The transaction was later widely criticised as it was conducted while the uranium price was at the peak, so Areva is believed to have largely overpaid for the Canadian company (ibidem). It has borne significant costs associated with construction, since to provide the water supply, a desalination plant was built on the Namibian coast. Moreover, the changing market conditions and a reduction of resource estimates lead to suspending the Trekkopje project last year until the uranium price improves (Duddy J-M., 2012).

- Husab deposit owned by Swakop Uranium, is claimed by the company to be the third largest worldwide (2012). In April 2012, Swakop Uranium was bought by Taurus Minerals, which is a subsidiary of China Guangdong Nuclear Power Holding Corporation (CGNPC) and China-Africa Development Fund (ibidem). Production is supposed to start in 2015.

- Zhonghe Resources is another Chinese company active in Namibia. The company is 58%-owned by the China Uranium Corporation; 42% of the remaining interest belongs to Namibia-China Mineral Resources Investment and Development (Zhonghe Resources, 2011). The company was granted a mining licence in November 2012, but little is known about other developments as Zhonghe Resources neither have any website, nor it appears in the local media.

- Forsys Metals from Canada, through a locally-registered subsidiary, develops the Valencia deposit. It is planned to commence production in 2015.

Bannerman Resources from Australia is another important company investing in an uranium project in Namibia. It is still pending for the mining licence19, but once it is allowed to build the mine, the construction phase is planned to take 30 months (Bannerman Resources, 2012).

The table 5 presents all projects that are currently on stream or will commence production in the upcoming years. The ownership confronted with the data from Table 4 might clarify the reasons why above-listed companies have engaged in uranium mining in Namibia. Australian and Canadian uranium mining industries are well-established and there are none or small uranium requirements for the nuclear reactors respectively. Therefore, Paladin

19 As of March 2013.
Energy, Forsys Metals or Bannerman Resources are primarily there for profit-making purposes. Similarly, Rio Tinto - a giant mining corporation - can be included in this group. However, Areva (2012) signed last year two contracts for delivery between 2014 and 2035 of over 30000 tonnes of uranium with EDF, which operates the nuclear power plant fleet in France. Areva may be seeking diversification of sources as the uranium from its other mines might not be able to satisfy future French requirements. Looking at the number of upcoming nuclear power plants in China, it is clear that the Chinese companies will principally deliver uranium for domestic purposes.

4.2.3.2 Production and contracts

<table>
<thead>
<tr>
<th>Uranium mine</th>
<th>Start of operation</th>
<th>Production capacity (tU/year)</th>
<th>Life of mine (years)</th>
<th>Resource grade (ppm)</th>
<th>Identified Resources (MtU)</th>
<th>Major shareholder</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rössing</td>
<td>1976</td>
<td>4500</td>
<td>?</td>
<td>290</td>
<td>38</td>
<td>Rio Tinto</td>
<td>UK</td>
</tr>
<tr>
<td>Langer Heinrich</td>
<td>2006</td>
<td>2000</td>
<td>20</td>
<td>550</td>
<td>47</td>
<td>Paladin Energy</td>
<td>Australia</td>
</tr>
<tr>
<td>Trekkopje</td>
<td>2012</td>
<td>1600-2550</td>
<td>10 to 15</td>
<td>?</td>
<td>26</td>
<td>Areva</td>
<td>France</td>
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<td>Valencia</td>
<td>2015</td>
<td>1750</td>
<td>20</td>
<td>175</td>
<td>36</td>
<td>Forsys Metals</td>
<td>Canada</td>
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<td>Husab</td>
<td>2015</td>
<td>5800</td>
<td>20</td>
<td>460</td>
<td>138</td>
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<td>?</td>
<td>700-1000</td>
<td>10 to 15</td>
<td>230</td>
<td>?</td>
<td>China Uranium Corp.</td>
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<tr>
<td>Etango</td>
<td>2016</td>
<td>2300-3000</td>
<td>16</td>
<td>194</td>
<td>46</td>
<td>Bannerman Resources</td>
<td>Australia</td>
</tr>
</tbody>
</table>

Table 5. Summary of current and planned uranium operations in Namibia (OECD, IAEA, 2012; Companies' Environmental Impacts Assessments, activity.financial/sustainability reports and websites).

Over the last 6 years, levels of uranium production in Namibia oscillated mostly around 4500tU. Only in 2007, when Langer Heinrich commenced the commercial production and in 2011, when unexpected problems were encountered by Rössing, the uranium yield was much lower. Paladin has been steadily increasing the production from year to year in line with the planned expansions. In 2012, it recovered 1955tU, only slightly over 300 tonnes less than Rössing with 2289tU. The latter has been experiencing some problems, since to get access to higher grade ore, it has to do a significant amount of waste-stripping (Rössing Uranium, 2012). This is explainable by a very high level of accumulated production - from 1976 until 2012 the company has already delivered over 100 000 tU to its customers (ibidem). However, by 2014, an improvement in the production is expected (ibidem). In 2012, the third mine started its pilot-plant production. Trekkopje produced 251tU, even though it suspended the start of
Rio Tinto is responsible for marketing uranium produced in Rössing. Uranium is sold almost exclusively under long-term contracts (Rössing Uranium, 2012). North America, which equals United States in this case (ibidem), is the major consumer of Rössing. In 2011, Europe was responsible for the second biggest amount of uranium purchased from Rössing. However, over previous three years the demand from Asia, that is China and South Korea, was much greater. Since the 1970s Japan has remained a steady customer of the company. Statistics for 2012 were not yet published at the moment of writing, but it would be interesting to observe how Japanese role in imports changed after the Fukushima disaster.

Paladin Energy indicates the destination of uranium from the two African mines it owns in its first Sustainability Report (2012b:46): "All uranium concentrates are sold solely for use as fuel in commercial nuclear power reactors in accordance with international nuclear non-proliferation rules, and is shipped directly to conversion plants in France, Canada, and the USA. Currently, more than 80% of production is consumed in the United States with the balance being consumed in Asia".

Therefore, basing on the data above, it can be stated that USA is the primary customer of two Namibian mines, while China is the second common customer of both companies. In 2010, Paladin Energy signed a Memorandum of Understanding with CGNPC establishing a long-term supply contract for uranium. Rössing started uranium deliveries to China in 2004 (WISE Uranium, 2013c). Recently, Paladin Energy (2012c) signed a long-term contract with Électricité de France for uranium off-take between 2019 and 2024.

4.2.3.3 Revenues and taxes

Sales of uranium are the main profit-bringing activities for the mining companies. However, running such complex operations results in many costs for the firms and needs some other form of financing. For example, main costs reported annually by the companies include: production and sales cost, depreciation and amortisation, taxes or impairment costs. To have enough money for investment, mining companies usually issue a number of shares. Depending on the financial results, shareholders have then a right to the dividend. In this way, Namibian Government receive dividends for a year in which Rössing reports net profits. Apart from being present on stock exchanges, uranium mining companies also use a number of other financial instruments such as bonds, loans, currency exchange or investment in other companies.

Revenue diminished by costs and taxes for a given year equals net profit (or loss), which indicates how a company performs financially. Table below presents the results of the two operating mines in Namibia. After
reporting a profit of over $100mln in 2008\textsuperscript{20} Rössing financial performance deteriorated and the company reported losses in 3 consecutive years since 2010. It can be associated with the uranium market price decrease and with lower production in the mine due to the waste-stripping programme. On the other hand, the results of Langer Heinrich demonstrate a rising trend. Again, it can be supported by the increasing production in the mine along with another stages of expansion.

\textit{Fig. 14: Profits and taxes of Rössing Uranium and Langer Heinrich Uranium (Rössing 2012; 2013b; Paladin Energy quarterly and annual financial reports 2008-2013).}

Taxes paid by the uranium mining industry (Fig. 14), which give the most revenue for the state budget comprise a corporate income tax, mining royalties and an employment tax. The corporate income tax in Namibia equals to 37.5\% of the gross profit generated by the company (ten Kate, Wilde-Ramsing, 2011). Since it is tied to the results achieved by a company, it is rather an unstable source of income. Nevertheless, when uranium production and prices are high, it can bring a substantial revenue. For example, in 2008, which was a successful year for Rössing, the Government received from the company nearly $100 mln of the corporate income tax. Apart from not being paid in case a company reports a loss, this type of tax in Namibia has another beneficial feature for the mining industry. Deferred tax has place when a company, which is facing difficulties in operation (e.g. it has just started production), postpones its tax payments until the following years, when it expects to be gaining more profits (ibidem). Sometimes it leads to a situation when a company reports a negative tax for a given year. All the aspects described above are best presented by the Rössing tax line on the Fig. 14, which indicates how the company reported lower tax along with decreasing profit, which finally turned negative in face of the problems experienced in 2011.

Mining royalty is another type of tax important for the Namibian Government. It is a fixed percentage of all uranium sales in a given year. Currently, the royalty rate is set at 3\% for Paladin Energy and since 2009 at 6\% for Rössing Uranium, which had not paid any royalties before (ibidem). Compared to corporate income tax it is more stable. It is tied to uranium sales and through them to production, which are not as volatile as corporate finances. Between 2009 and 2011 it stayed on a level of about $20 mln for Rössing (2012) and between 2 and 4 million dollars for Paladin Energy.

Employment taxes are subtracted from salaries and paid to the government, therefore they are sometimes not counted as direct taxes of the mining companies. Nevertheless, they remain a significant contribution to the country's budget. In years 2009-2011, Government of Namibia received each year more than $10mln from Rössing workers, while salaries themselves amounted totally to $45-80mln (ibidem). Dividends constitute another form of revenue for the Government of Namibia as it holds 3\% of shares in Rössing Uranium. However, similarly to corporate income tax dividends are paid only in case of reported profit and contrary to this tax they are considerably smaller. Dividends received by the Government of Namibia in 2008 amounted to $1.3mln and 2009 - $0.7mln. To give a comparison to these numbers, Rössing in 2011 spent about $350mln\textsuperscript{21} on procurement, out of which $230mln was paid to Namibian companies (ibidem). This reveals that in fact a uranium mine has a bigger effect on the national economy through the direct actions than through its tax contribution.

\textsuperscript{20} Rössing reports in Namibian dollars. For the purpose of this study exchange rate of 0.112USD for 1NAD was used.
\textsuperscript{21} average rate from 2011 - 1NAD = 0.135USD
4.3 Production system - resource flows

Uranium production system was described in section 2.1 of the thesis. Here, the aim is to assess the physical inputs to and outputs from the system. A uranium mine interacts with the environment around it by absorbing resources and releasing emissions. The main groups are identified in the following graph and discussed below in the Namibian context.²²

²² Labour force will be discussed in Chapter 5.
4.3.1 Inputs to the uranium production system in Namibia

4.3.1.1 Land use

Every uranium mining project is situated within a specified area delimited in a mining licence. Even during the exploration phase a certain amount of land is disrupted. Furthermore, mining projects also indirectly influence land use patterns through construction of supporting infrastructure. Since the land is used only temporarily by the mining companies, a crucial question is to what extent previous conditions will be recovered after the termination of operations. Another issue concerns the level of disruption of other systems already existing at the area concerned. Every project will directly affect any ecosystems or social systems in the designated territory. Predicted impacts are required to be thoroughly described in an Environmental Impact Assessment of the mine, followed by an Environmental Management Plan to minimise negative impacts related to the land use and to optimise land rehabilitation after the end of operations.

Rössing Uranium (2012) states that the mine currently disturbs 2400ha of land. The company has three principal rules regarding the land use - avoidance of expanding the operations on undisturbed areas, mitigation of negative impacts on the already disturbed area and rehabilitation of land. However, it states that before the planned mine closure in 2023, only 10 percent of the mines' footprint is going to be rehabilitated (ibidem). A vast area will need to be restored while no uranium will be produced by the mine bringing no profits. Nevertheless, the Annual Report 2011 (GSN, 2012) for the Strategic Environmental Management Plan (SEMP) of the Uranium Rush, states that the Rössing mine closure plan is currently under review, but there are financial guarantees in place for employee retrenchment, mine demolition, rehabilitation and post-closure monitoring and maintenance costs.

The Langer Heinrich mine is located within the borders of Namib-Naukluft National Park. As much as 28 species from the red list of International Union for Conservation of Nature are present on the mining lease area (Paladin Energy, 2012b). The company has a Biodiversity Management Plan, which addresses the endangered species. Additionally, to offset its negative impact, it funds two environmental projects. The area disturbed in 2012 amounted to 537ha, while only 9ha have been rehabilitated (ibidem). Taking the setting into account, a Mine Closure Plan was established according to IAEA guidelines (GSN, 2012:82). It aims in a complete rehabilitation of the land assuming its possible use for tourist purposes. Land rehabilitation is supposed to be conducted progressively and the costs are included in the current operating costs (ibidem:82-84). That explains why the SEMP Annual Report 2011 does not mention any financial guarantees for mine closure provided by Paladin Energy.

The Trekkopje project in 2012 disturbed 1436ha of land (ibidem:62). Contrary to Langer Heinrich, it is not located in an ecologically sensitive or a touristically attractive area. Nevertheless, it might have some impacts on biodiversity (MME, 2010:7-81). A mine closure plan with the cost estimates was included in the Environmental and Social Impact Assessment from 2008. It is going to be regularly updated and financial guarantees for that purpose will be provided and externally audited (GSN, 2012:83-85).

Husab project developed by Swakop Uranium is situated in a 'red flag' biodiversity area with many endemic and endangered species (MME, 2010:7-81). Nevertheless, it has been granted a Mining Licence. It can be explained by the stance of the Ministry of Mines and Energy, which "does not currently have a formal policy whereby red flag areas can be recognized" (GSN, 2012:61). The company has developed a Mine Closure Plan, which will be regularly updated and audited. Nevertheless, since it has not started the operations, the financial guarantees are not yet in place (ibidem:85).

The remaining projects comprising Valencia, Etango and Zhonghe Resources are all located in the areas, which are important from a biodiversity perspective (MME, 2010:7-81-83) and have medium archaeological significance (ibidem:7-95). Only Bannerman is mentioned in the GSN Report (2012:82-85) as having specified its mine closure plans. Zhonghe Resources has presented an initial decommissioning plan and associated cost estimates in its Environmental Impact Assessment (2011:82-86).

4.3.1.2 Energy

Uranium is produced with a primary aim to be used as an energy source. Nevertheless, during the extraction and processing of the mineral, as well as during the mine construction and decommissioning phases a considerable...
amount of energy is used. Namibia is not self-sufficient in terms of electricity production (MME, 2010:7-49). It has four power stations feeding the grid: hydro-power Ruacana (240MW), coal-fired van Eck (120MW) and two diesel generators in Walvis Bay\(^{23}\) (46W), which function on a standby basis. That equals to 360-406MW, while the total demand for electricity in 2010 was estimated to oscillate around 550MW with the balance imported from other Southern African countries (ibidem).

In 2010 the Rössing mine used 1996TJ (Rössing Uranium, 2012). This means that the energy consumption rate in Rössing equalled 63.3MW, which is 11.5% of the demand in the scale of the country. However, this number has only an illustrative function as the company does not state how much of the energy it produced on its own and how much was purchased from the national supplier. In 2011 the energy consumption in Rössing amounted to 1897TJ (ibidem), which translates into slightly more than 60MW.

Between July 2010 and June 2011, Langer Heinrich mine consumed 795TJ, out of which 320TJ was purchased from the national grid operator - NamPower and 475TJ was produced on-site from non-renewable sources (Paladin Energy, 2012b). Total consumption rate equals 25.2MW, while the use of electricity from the grid exceeds 10MW. In the Australian Financial Year (FY) 2012\(^{24}\) these numbers were higher - 1350TJ consumed in total, 1004TJ produced on-site primarily from burning automotive diesel and heavy fuel oil and 346TJ delivered by NamPower. That translates into total energy consumption rate of 42.8MW, with the purchased electricity share of 11MW.

The energy use at Rössing and Langer Heinrich combined correspond to some 1/4 of the total electricity production capacity in Namibia. If all the new uranium projects were to be realized, the demand for energy from mines would rise up to 278MW (MME, 2010:7-49). Adding to that associated urban growth and developments in supporting industries, the combined energy demand from the "Uranium Rush" could increase to 380MW (ibidem), which is more or less the current electricity production capacity in Namibia. It is therefore clear that new power plants need to be added to the grid in order to meet the projected requirements.

Areva and Rössing have conducted feasibility studies over use of solar and wind power to supplement the energy mix for the mines. These options turned out to be technically possible, but not economically feasible (GSN 2012:23). In the Strategic Environmental Management Plan for the Uranium Rush (2010) a gas power plant was recommended, because there are natural gas deposits in southern Namibia. Another option, which was claimed to be cheaper and faster to construct (MME, 2010), was a coal-powered plant (150-300MW) in Erongo. After some discussions, the first option was chosen by the Government of Namibia (Isaacs, 2012). A gas power plant (800MW) will be built at the south of the country with expected commissioning in 2017/2018 (ibidem). Nevertheless, until that time, the demand is projected to increase. Therefore, two additional industrial supply applications for Erongo were approved by NamPower - one from a local electricity supplier - Erongo Red (80MW) and the second from the Husab mine (110MW) (GSN, 2012:22).

4.3.1.3 Water

Erongo is characterised by scarce freshwater resources. There are four ephemeral rivers flowing through the region: Omaruru, Khan, Swakop and Kuiseb. Water flows on the surface only after periodical rainfalls, but there is a steady movement of groundwater. Mainly Omaruru and Kuiseb rivers are used to supply water to domestic and industry users in the region. Khan and Swakop aquifers are more sensitive to abstraction, because their physical characteristics separate them into 'compartments', which are recharged faster by rainfalls and floods rather than by the lateral flow (MME, 2010:7-33). As a result, the water there is saline and does not qualify for human consumption. Nevertheless, water from these aquifers is crucial for many ecosystems, as well as for agricultural production (ibidem:7-40). The situation of the two rivers was exacerbated by the construction of two dams in the upper stream of Swakop in the 1970s. Since then, the water levels in these aquifers dropped on the average by 32% (ibidem:7-33). All the mining projects are located closer to Khan and Swakop rivers, which in case of unregulated water abstraction from these aquifers can lead to serious consequences for local agriculture and the environment.

Rössing purchases water from the national supplier - NamWater, which extracts it from the Omaruru and Kuiseb aquifers. In 2011, it used on average 8 390 m³ of freshwater per day, which in scale of a year amounted to

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\(^{23}\) one of them - Anixas was commissioned only in November 2011.

\(^{24}\) July 2011- June 2012 - Paladin Energy as an Australia-registered company reports in such system.
3.06mln m³ (Rössing Uranium, 2012). This corresponded to roughly 20% of the general freshwater consumption in the Erongo region (MME, 2010). The total use of water was much higher - 21 368 m³ per day (or 7.8mln m³ per year), but about 61% of water used was recycled from the tailings dam (ibidem). Rössing also holds a permit to withdraw groundwater from Khan river. 600 m³ per day is extracted, which is claimed to be below the allowable abstraction level (ibidem). Due to its saline properties, the water from Khan river is used for dust suppression purposes only.

Langer Heinrich meets its water requirements by purchasing the resource from NamWater, extraction from boreholes, collection of run-off water and recovery from tailings (Paladin Energy, 2012h:15). Water abstraction from bore field is limited to 500 000 m³/year, but in FY 2012 Paladin reported extraction of only 231 000 m³ of water from this source. During the same period Langer Heinrich purchased 1.522 mln m³ of freshwater (10% of regional consumption), while recycled water amounted to 1.815 mln m³. In total 3.3 mln m³ of water were used (ibidem:16).

The total amount of freshwater used annually by the two uranium mines ranges between 4-5mln m³. At the same time, the other users in Erongo demand around 10 mln m³ of water, which numbers combined claimed to be unsustainable (MME, 2010:7-33). As a result, the third uranium mine previously expected to commence production in 2012 - Trekkopje was obliged to find an alternative water source. To meet the water requirements at the mine, Areva constructed a desalination plant on the coast, which is capable of producing 20 mln m³ of freshwater per year, out of which surplus of some 8 mln m³ will be available for other users in the Erongo region (Areva, 2013).

Taking into account all the possible developments in the region, it is hard to predict the exact amount of water needed in the future. At the same time, a more sustainable strategy presumes that mines should base their production only on the water recovered from the ocean. For these reasons, an additional desalination plant operated by NamWater is planned (GSN, 2012:33). To protect the scarce water resources from over-abstraction by the mining industry, a monitoring system on Khan and Swakop rivers was set up. Thanks to heavy rainfalls in 2011 the water levels in the observed boreholes rose on the average (ibidem:32). However, in two wells, located close to Rössing and Husab projects a noticeable decrease was reported (ibidem). Water quality and contamination are other important issues, which will be discussed at the output side of the uranium production system in Namibia.

4.3.1.4 Machinery, raw materials and chemicals

Uranium mining companies do not publish any data on machinery or raw materials and chemicals used in the process of production. Nevertheless, these are important inputs to the production system - the cost of reagents used in uranium processing is estimated to account for 30-40% of the total cost of uranium production (Gecko, 2013). Almost all primary products are imported from abroad, mainly from Far East (ibidem). The cargo arrives at the port of Walvis Bay, after which it is transported by trucks to the mines.

If most of the currently developed uranium projects would commence production in the upcoming years, the amount of imports would increase greatly, which could cause problems with congestion at the only industrial port of Namibia (MME, 2010:7-23). In order to avoid this problem and to benefit from the rising demand, a chemical processing complex is planned to be built by Gecko Minerals near Swakopmund (ibidem:4-19). It would produce some of the crucial products needed in uranium recovery including:

- sulphuric acid - produced at the rate of 3600 t/day
- soda ash - 150 000 t/year
- bicarbonate - 175 000 t/year
- caustic soda

Only sulphur and coal will be imported, the rest of the processed material is intended to be based on Namibian minerals (ibidem). Soda Ash plant would serve to supply other Southern African Development Community (SADC) countries, which currently also import these materials from overseas (ibidem).
4.3.2 Outputs from the uranium production system in Namibia.

4.3.2.1 Waste rock

Waste rock comprises all the rock removed from the ground, which is not used in further processing for uranium recovery. Usually it contains too little uranium to be of any interest. In Rössing, this is determined by scanning every truckload of the extracted rock (Rössing Uranium, 2013). There, it is decided if the rock is sent to the crushers, stocked as a low-grade ore for further potential use or transported to the waste rock dump.

There is a number of issues related to waste rock storage. Thorough geochemical studies of rock properties should be carried out prior to the disposal of waste rock to decide on the most appropriate method of storage, because dumping some types of rocks can lead to acid rock drainage or metal leaching (IAEA, 2009:17). Furthermore, waste rock still contains uranium and might produce radiation or emit radioactive materials to the environment. Therefore, in the most of the cases, the recommended waste rock management include:

- storage on impermeable pads to prevent from groundwater contamination
- application of cover systems to reduce risk of contaminated surface run-off or/and the amount of dust produced
- alternatively, waste rock can be disposed in an area with limited oxygen and water content, which would limit the risk of contamination (IAEA, 2010:17)

Finally, after mine closure, waste rock dump areas need to be cleared and rehabilitated.

Rössing currently produces about 40 mln tonnes of waste rock each year (Rössing Uranium, 2012:72). To present this number in a more comprehensible way - 1.27 tonne of waste rock is produced every second at the mine. The Environmental Impact Statement of Rössing Uranium (1991) describes the waste rock management method used in the mine. Waste rock is dumped directly into the gorges neighbouring with Khan River. No impermeable pads were planned to be used. Complete blockage of these gorges was envisaged. As a result, identified severe impacts include "increased noise and dust levels, loss of scenic diversity and loss of plant, animal and bird habitats" (ibidem:104). Moreover, in the table summarizing the impacts (ibidem:105), waste rock dumps are stated to affect groundwater to the same degree as noise levels or habitat loss. Radionuclide production and erosion status are another two variables identified as largely influenced by the waste rock dump system in Rössing (ibidem).

Langer Heinrich Sustainability Report (2012b) states that the relevant studies concerning geochemical properties of rocks and appropriate location for the waste rock dump were conducted prior to the beginning of operations. In the Financial Year 2012 at the mine over 18 mln tonnes of waste rock were produced (ibidem), which translates in a rate slightly higher than 500kg/sec. Waste rock dump area covered 152ha. Environmental Management Plan (Langer Heinrich, 2009) for the mine determines that waste rock will be used to progressively backfill the open-pit. Again, the waste rock dumps can result in this case in habitat loss and groundwater contamination as they are not placed on impermeable surface (ibidem). Furthermore, waste rock would be covered by topsoil only after backfilling the pit. Nothing is written about covering the dumps to prevent from water intrusion or dust emissions. The plan introduces a set of measures and controls to monitor the effects of the waste rock dumps on the environment. Nevertheless, the results of monitoring are not publicly reported.

4.3.2.2 Tailings

Tailings are commonly considered as the most hazardous aspect of uranium mining. They comprise all residues from milling and processing of uranium ore. Apart from heavy metals and chemical contaminants they contain around 85% of the radioactivity of the original mill feed (IAEA, 2010:17). Tailings at each mine should be subjected to geochemical and radioactive examination in order to apply an appropriate management method. Following concerns should be addressed during disposal:

- physical and chemical stability after mine closure
- optimization of tailings' density
- minimizing release of contaminants and radon gas into the environment (ibidem)

At Rössing, the tailings cover area of approximately 650ha (Ninham Shand, 2007). The liquid residues from the uranium production containing 50-58% solid material are pumped into the designated area, larger sediments are quickly deposited and the water is pumped back to reuse in processing (ibidem). After the material dries out it is
stored in another area within the dam. To prevent the finer material from being picked up by the wind, a special covering is used. The tailings dam at the mine was constructed with alluvium as base (Rössing Uranium, 1991). This is not an impermeable material and groundwater contamination was mentioned as one of the most serious impacts of the dam (ibidem). Furthermore, the walls of the dam are constructed from waste rock, which also cannot be considered as impermeable. Therefore, a number of seepage control measures have been set up. A plastic core surface water collector has been installed downstream, which in 2006 collected on average 6000 m³ per day (Ninham Shand, 2007). The whole system is claimed to recover in 2006 nearly 100% of the seepage to groundwater, eliminating any direct discharges into Khan river (ibidem). Other severe impacts of tailings dam were identified as habitat loss, dust production and changing aesthetic perception of the area (Rössing Uranium, 1991). With the planned expansion of the Rössing mine, the present capacity of tailings dam is not sufficient and new area is envisaged for further storage of expected tailings (ibidem).

Tailings cover currently (Paladin Energy, 2012b) 116ha and weight slightly over 1.5 million tonnes at the Langer Heinrich mine. Since they are situated on the top of uranium ore body with the progress of mining operations, the new Tailings Storage Facility will be located within the already exploited parts of the open pit (Herbert, 2011). This concept of temporary tailings dam received some criticism for not being adequately addressed from a technical perspective in Environmental Assessment prior to the start of mining operations (Schmidt, Diehl, 2005). The temporary tailings storage facility indeed turned out to be a source of pollution, which had a small range close to the source and did not spread beyond the borders of the mining licence area (Stobart, 2009). Future contamination is considered as possible and a set of measures including passive barriers, liners and seepage collection is recommended. However, the long-term effects of such management in a similar setting are not known (ibidem).

4.3.2.3 Non-mineral waste

Mining operations apart from the mineral waste described above produce also large amounts of other waste, some of which is contaminated. The category of 'special waste' produced by the mines in Namibia includes machinery, building rubble or scrap metal. Some of it is stored on the mining sites, some is reused or recycled by scrap metal processors, while the rest is stored on disposal sites in Walvis Bay and Swakopmund, which are estimated to be able to serve for 10-20 more years (MME, 2010:7-11). Weaker-controlled disposal sites, which also serve for this purpose, exist in smaller local towns of Arandis and Usakos, where waste is not segregated.

Uranium mining operations produce also relatively high quantities of hazardous waste. This category comprises radioactive materials, corrosive substances, explosives, oxidising, toxic and infectious substances, flammable liquids and solids, explosives and other substances such as tyres or batteries (ibidem). Some of that waste is recycled via suppliers or specialist recycling companies. However, a large part is stored on the sole hazardous waste disposal site in Erongo, which is located in Walvis Bay (ibidem).

Both currently operating uranium mines in Namibia have waste management plans in place. Rössing states that 70% of non-mineral waste generated on-site was recycled (2012). Hazardous and non-hazardous waste is handled by contractors. No numbers on the amount of waste produced are published. Moreover, 2012 is the first year when a target of waste reduction is set by the company (ibidem). Contrary to Rössing, Paladin Energy (2012b) claims to implement the "reduce, reuse, recycle" rule whenever possible. It also reports numbers on non-mineral waste, which are summarized in Table 7. Increases in some categories are declared to be caused by mine expansion (ibidem). Domestic waste in Langer Heinrich is delivered to recycling depots or municipal landfills. Liquid hazardous wastes are collected by a contractor, while other contaminated wastes are stored on-site (ibidem). According to the Langer Heinrich Environmental Management Plan from 2009 the latter should be collected by a contractor as well.

<table>
<thead>
<tr>
<th>Disposal Method</th>
<th>Recycling</th>
<th>Incineration</th>
<th>Reuse</th>
<th>Landfill</th>
<th>On-Site Storage</th>
<th>On-Site Treatment</th>
<th>Off-Site Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Type</td>
<td>Metal</td>
<td>Other</td>
<td>Medical Waste</td>
<td>Waste Hydrocarbons</td>
<td>General Waste</td>
<td>Tyres</td>
<td>Hazardous Waste</td>
</tr>
<tr>
<td>2011/12</td>
<td>95.5</td>
<td>22.1</td>
<td>0.04</td>
<td>4</td>
<td>207.8</td>
<td>ND</td>
<td>7.8</td>
</tr>
<tr>
<td>2010/11</td>
<td>22.9</td>
<td>6</td>
<td>0.02</td>
<td>5.6</td>
<td>84.9</td>
<td>ND</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Table 7. Non-mineral waste produced in Langer Heinrich mine (Paladin Energy, 2012b)
4.3.2.4 Emissions to air

Uranium mining results in a range of gaseous emissions from point sources, such as processing plants or vehicles. However, in the regional context the potential of dust diffusion from the mines, which can have adverse effects on health of mine workers, local population and the ecosystems is considered to be more relevant (MME, 2010:7-127). In the line with mine developments an increase in dust production is expected (ibidem). Measurements conducted so far have indicated that particularly during winter months at certain stations in Erongo dust levels exceeded the limits set by World Health Organization (GSN, 2012:38). More precise levels, sources and radioactivity of dust in Erongo have yet to be determined by currently undertaken studies (ibidem:33-45).

At the Rössing mine dust is produced along with blasting, crushing ore, loading trucks and transfer by conveyor. It can be also induced from the waste rock dumps and tailings dams by the wind and from roads by vehicles (Rössing Uranium, 2012:43). Between 2007 and 2011 the dust concentrations at the crushing plant amounted to 1-4mg/m³ (ibidem). Such levels exceed annual norms set by World Health Organisation (WHO) by 5000-20000% (2005:9). Nevertheless, all Rössing workers are equipped in dust masks, which are claimed to reduce personal exposure by a factor of 10 (Rössing Uranium, 2010:26). Still, in that case the norm of 20µg/m³ is exceeded by 500-2000%. During the same period, only 1 case of pneumoconiosis, which is an occupational disease attributable to dust exposure (Farlex Inc., 2013), was detected among the workers (Rössing Uranium, 2012:72). CO₂ emitted to the atmosphere by the mine amounts to approximately 200 000 - 250 000 tonnes each year (ibidem).

Paladin Energy does not report any numbers or plans on dust emissions. The company claims to have a whistle-blower policy, which addresses grievances concerning all types of mining impacts. Since there was no grievances concerning dust levels, this issue is not assessed in the Sustainability Report (2012b). Direct greenhouse gas emissions in FY2012 amounted to about 76 thousand tonnes of CO₂ equivalent. Adding to that 93 000 tonnes resulting from electricity consumption, the total emissions equalled 169000 tonnes (ibidem).

4.3.2.5 Radiation

Radiation is a type of energy, which travels in shape of subatomic particles or electromagnetic waves. People are constantly surrounded by different radiation sources such as computers, mobile phones or microwaves. This type of radiation is non-ionising, which means that it lacks energy to remove electrons from the shells of atoms. Such property characterises ionising radiation, which can induce molecular changes and impact living cells. This type of radiation origins from the universe, but is also emitted by soils, rocks and groundwater. Moreover, currently there are also some anthropogenic sources, which include x-rays, radioisotopes and radioactive tracers (MME, 2010:7-143).

In the Erongo region, the average naturally occurring terrestrial radiation of 0.7mSv²⁵/year is more than double the average terrestrial radiation for the Earth. Cosmic radiation is assumed to be equal to the global average of 0.38mSv/year (ibidem:7-145). Radiation from dust in Erongo exceeds the global average of 0.0058mSv by a factor of 10. (ibidem:7-146). Radon gas, created by radioactive decay of uranium, is another source of radiation especially associated with uranium mining. Nevertheless, in the study outsourced by Namibian Ministry of Mines and Energy, it turns out that radon gas in Erongo is responsible for over twice as low radiation dose²⁶ as in the other countries (ibidem:7-149). Final total result for the region is also lower than the global average. However, some results were assumed and the radon gas levels were described as likely to be too low (ibidem).

To understand better the negative potential effects of radioactivity it is important to distinguish between three most common types of ionising radiation: alpha, beta and gamma. Cosmic and terrestrial radiation consist of gamma rays (ibidem), which can penetrate the whole body from outside and might be stopped only by a thick layer of concentrated substance such as lead. Beta particles can be stopped by just few millimetres of aluminium, while alpha particles are halted by a sheet of paper or human skin (SOMO, WISE, 2011). Nevertheless, it is alpha radiation, which is considered to have the most adverse health effects on the human population worldwide. It is produced by one of the uranium decay products - radon gas, which inhaled can affect lung tissue. Radon gas

²⁵ Sievert - “The SI unit for the amount of ionizing radiation required to produce the same biological effect as one rad of high-penetration x-rays, equivalent to a gray for x-rays” (Farlex Inc., 2013).
²⁶ 0.46mSv/year as opposed to 1.095mSv/year.
is claimed to be the second identified cause of lung cancer globally, after smoking (WHO, 2009).

Open pit, waste rock dumps and tailings storage facilities are considered to release most of the mining-related radioactivity to the environment (MME, 2010:7-152,153). All three sources emit radon gas as well as radioactive dust to the atmosphere. Tailings dams are the most hazardous in terms of groundwater contamination with uranium and its radioactive decay products (ibidem). Therefore, there are few potential ways, in which radioactive sources originating from uranium mining can affect local population and wildlife. Firstly, they can be inhaled. Secondly, they can be ingested by drinking contaminated water. Thirdly, they can be ingested by consuming food, which had earlier absorbed some radioactive material. Another study was conducted to identify the groups, which might be the most affected by the current and planned uranium mining operations in the region. Local small-holding farmers living along the Swakop river, as well as a community of Arandis, located close to the Rössing mine and other planned projects turned out to be the most vulnerable. However, all the simulations led to the conclusion that the radioactivity dose they may obtain is well-below 1 mSv/year\(^{27}\) limit for the general public (MME, 2010:7-166). Finally, one more study concerning groundwater contamination with uranium and radon gas proved higher concentrations of uranium in groundwater close to the two existing mines, but denied such an occurrence pattern for radon (ibidem:7-167,168).

Mine workers are the group, which is directly exposed to the biggest radiation. The limit for them, which is set by International Commission on Radiological Protection, is also higher and equals 20 mSv per year. Results reported by Rössing Uranium shows exposure among mine personnel ranging from about 1 to 4 mSv per year depending on the position (Rössing mine, 2012:41). No information about radiation protection at the mine is reported by Paladin Energy.

4.3.2.6 Noise and vibration

Operations in the Namibian uranium mines are conducted 24 hours per day. A great amount of noise and vibration is produced by blasting, trucks and crushers. However, since there are no human settlements within 5 kilometres from the mines, noise and vibration originating in the uranium production operations are mostly concerning the mine personnel. Nevertheless, taking into account the rich biodiversity of central Namibia, these two factors can also have significant effects on the surrounding environment. At Rössing, it was observed that mining operations had led to a lower number of animals close to the mine (Rössing Uranium, 1991:116). Moreover, noise and vibration can disrupt migration paths of animals such as mountain zebras (Stobart, 2009:7-20).

\(^{27}\) not counting cosmic and terrestrial radioactivity, which is considered as a base
5. Stakeholder analysis

Every mining project is situated in a particular context. The systems analyses conducted above, aim to assess the links uranium mining in the Erongo region has with the elements of its context. Stakeholder analysis focuses on the groups or individuals "who can affect or are affected by the achievement of the organization's objectives" (Freeman, 2010). In the light of such a definition, the complexity of afore-described systems would impede an effective identification of all parties directly or indirectly involved in Namibian uranium mining. Therefore, just a number of stakeholders, which are considered crucial to the issue discussed is analysed here. Grouping them for the purpose of this thesis required significant simplifications and members of one group can belong also to another. Nevertheless, such an exercise allows to look beyond the traditionally dominating economic dimension of an industrial enterprise.

5.1 Stakeholder identification and division

Fourteen groups of stakeholders of uranium mining in Namibia were identified. They are presented on the Figure 23 with marked extent to which they affect and are affected by uranium mining operations. The results are based on an online survey sent to representatives of all categories with request to rate the level of influence of stakeholders on uranium mining in Namibia and vice versa according to the scale from 1 (none) to 7 (extreme).

Three categories of stakeholders were identified as having the biggest influence on the Namibian uranium industry. Other countries, including nuclear power utilities and state-owned uranium mining companies, are perceived as the most affecting party. Stockholders of uranium mining companies were recognized as the second decisive force, while the Government of Namibia has been given slightly lower rates. More parties are considered to be affected by uranium mining in Namibia. Surprisingly, the Government was recognized as the most affected stakeholder. Mine employees and stockholders were ranked second, with other countries almost 0.5 point behind. Three more stakeholders were given an average note of 5 or higher, which reflects general perception of being highly affected - procurement companies, environment and local residents. The stakeholders are discussed in a decreasing order starting from the ones recognized as having more influence on uranium mining than being affected by it.

Fig. 17 - Identified stakeholders and their relation to uranium mining in Namibia (the closer to the middle of the graph, the higher the score).
5.1.1 Other Countries

All the uranium produced in Erongo is for export purposes. Table 6 and figure 13 present the groups of major consumers for the Namibian uranium. Nuclear power plants in USA, Japan, China, South Korea and the European Union (EU) have been using it to produce energy. Information about the exact destinations of Namibian-origin uranium within the EU is confidential according to Euratom Supply Agency (2013b). However, the range of European utilities using Namibian-origin uranium widened during last years and currently accounts for about 1/3rd of all the utilities (ibidem). For example, Vattenfall, which operates nuclear reactors in Sweden, reports imports of uranium from Australia, Namibia and Russia (2013). As a result, in a very indirect way, anybody using electricity in Sweden can be considered as a stakeholder of the Rössing uranium mine.

A possibility of uranium diversion from the reported trade paths creates another dimension of other countries' involvement. As such, it is a critical issue to international security. Diverted uranium could serve in state-run nuclear weapons programmes or it could be used by less technically advanced terrorist organisations to create a so called 'dirty' bomb, causing large-scale radioactive contamination (ICNND, 2009). Iran, on which a number of international sanctions has been imposed for pursuing a nuclear weapon programme, through its Foreign Investment Company owns 15% of Rössing Uranium. Nevertheless, currently there are no publicly available materials, which could support any allegations concerning uranium diversion from Namibia to Iran. However, there is such documentation supporting earlier likely deliveries and use of Namibian-origin uranium in nuclear weapon programmes of Iran, Israel (through South Africa), South Africa, and United Kingdom (Hecht, 2012:145,148-149,155).

Apart from being responsible for all uranium purchases, other countries can influence significantly developments in uranium mining sector in Namibia, through shifting the global demand and supply, which are reflected in uranium prices. From the demand side, an example of a negative influence can be illustrated by the reactions of Japan and Germany after the Fukushima disaster. On the other hand, Chinese projected uranium requirements are pushing state-owned companies to secure uranium resources abroad, Zhonghe Resources and Swakop Uranium are examples of which. From the side of supply, Namibian uranium resources seem to be weakly competitive and a rapid expansion of uranium production in another country might keep the mineral price down, impeding developments of new mining projects. Kazakhstan, where a rapid increase of production in the recent years has taken place, provides such an example.

5.1.2 International Organisations

International Atomic Energy Agency (IAEA) is the international organisation, which have the biggest direct influence on uranium mining in Namibia. Under comprehensive safeguards agreement the agency conducts various on-site inspections and visits. Activities performed to verify compliance with the norms set by the IAEA can include:

- auditing the uranium mining company's operating and accounting records and comparing them with reports send to the agency by the Namibian Government
- verifying the uranium inventory and any changes from the declared state
- taking environmental samples
- applying surveillance and containment measures (GSN, 2012:74)


It is also important to take non-governmental international organisations into account. Associations of mining

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28 As Paladin Energy does not export uranium to the EU.
29 Uranium processing to weapons-grade is only within the reach of nuclear fuel cycle facilities, which are under a strict state and international (IAEA) supervision (ICNND, 2009).
30 before 1990
companies can be considered as such. Areva and Rio Tinto are in the International Council on Mining & Metals (ICMM) founded in 2001, which is a leading organisation setting performance standards. Its main initiative is the Sustainable Development Framework to which all the members have to adhere (Dashwood, 2013).

5.1.3 Stockholders

Stockholders (or shareholders) comprise all people or organisations holding shares of companies active in uranium production sector in Namibia. If a company makes profit in a given year, it is usually partially reinvested and the rest is redistributed among the shareholders in the form of dividends. Therefore, stockholders have an interest in good financial results of the company and can be seen as motivators for a better economical performance.

Rössing Uranium has stable shareholders including Rio Tinto (69%), Iran (15%), South Africa (10%), Namibia (3%) and 13 individuals (3%). Its main shareholder - Rio Tinto is listed on London Stock Exchange (LSE) and Australian Securities Exchange (ASX) (Rio Tinto, 2013a), which means that its stockholders can be affected positively by financial results of the company. They can also affect the management, because in some situations shares give a right to vote on shareholder meetings. Nevertheless, taking under consideration that Rio Tinto has over 75 various mining operations all over the World (ibidem), Rössing mine is just a small input to the overall results of the corporation.

Langer Heinrich mine is wholly-owned by Paladin Energy (2012a) - a company listed on Australian Securities Exchange. It is the first of two mines in operation managed by the company, so the results achieved by Langer Heinrich can affect the Paladin stockholders to a much bigger extent than in case of Rössing and Rio Tinto.

From the remaining companies, which are developing uranium projects in Erongo, only Bannerman Resources (2012) and Forsys Metals (2013) are financed primarily by shares issued on ASX and Toronto Stock Exchange respectively. French state controls indirectly 85% shares of Areva (2013). With almost 5%, the second owner is Kuwait Investment Authority, while only 4% of share is available for public. Two Chinese companies are also majority-owned by the state - China has indirectly 100% in Swakop Uranium (2012) and 58% in Zhonghe Resources (2011), where other 42% belong to Namibia-China Mineral Resources Investment and Development, which is claimed to be a private enterprise. Therefore, the latter three companies can be considered also as representatives of the ‘other countries’ category.

5.1.4 Media

Media have an important role of an observer of the uranium industry in Erongo. In a case of a strike or another issue, which could attract public attention to the uranium mining sector, journalists are likely to investigate and communicate the situation to the society. The Namibian, New Era or Namibian Sun are examples of national newspapers, where articles addressing the matters of uranium mining can be found. Sometimes, the issues connected with uranium mining in Namibia, cross national borders and can be described in international press or news services, usually of a specific character. The examples cited in this work include articles from Le Monde (Bezat, 2012), or World Nuclear News (2011).

A comprehensive study described in Strategic Environmental Management Plan (SEMP) for the Central Namib Uranium Rush 2011 Annual Report (GSN, 2012:77-80) examined all the articles published in 2011, which concerned uranium mining in Namibia. The total number of articles amounted to 387, out of which 283 were recognized as making any substantial comment on the issue. The study concluded that even though some critical voices on economic situation, Rössing Uranium links with Iran and security in the mines were raised, the overall picture over uranium mining in Namibia was not negative.

5.1.5 The Government of Namibia

The Government of Namibia is responsible for implementing the law concerning uranium mining in the country. Relevant ministries play a crucial role in the process of granting licences and controlling the mining operations. Also, the government adapts policies affecting the developments within the uranium industry (e.g. Minerals Policy or Nuclear Fuel Cycle Policy). It is responsible for prioritizing and pursuing different objectives of development, which is a broadly discussed issue in the context of supporting investments in mining.
The government is affected in a positive way by the taxes paid by uranium mining companies. However, as it was presented in the section 4.2.3.3, these are also highly vulnerable, since they depend on the financial results of the company, as well as on its stage of development. Additionally, by promoting mining developments, the government can boast with boosting economic development of the country and fighting unemployment. This can in result affect the way it is perceived domestically and externally. Finally, uranium mining companies in Namibia affect the government negatively by attracting the civil servants with better wages (Shindondola-Mote, 2009:20). This leaves the government and ministries understaffed, unable to effectively control all the aspects of uranium mining (ibidem).

5.1.6 NGOs

Some Non-Governmental Organisations in Namibia scrutinize uranium mining industry and through an interaction with the companies or publications might have some influence on improving mining practices. On a global scale, to some extent it was the NGO pressure, which pushed mining companies to start reporting on environmental and social impacts they cause in the mid-1990s (Dashwood, 2013:10). Usually, the NGOs are specialized in a specific issue. For example, Hilma Shindondo la-Mote, from Labour Research and Resource Institute in Windhoek, conducted a study (2009) of uranium mining industry in Namibia, whose main part was dedicated to mine workers. Bertchen Kohrs representing Earthlife Namibia also released a publication on the topic of uranium mining in Namibia (2008), which focuses on radiation and environmental hazards along with suggestions of different options to produce energy.

The relation between Non-Governmental Organisations and uranium industry can be reverse as well. In Namibia, the mining companies are associated in the Chamber of Mines of Namibia. In 2009, it created Uranium Institute, which aims at increasing healthcare, environment management and radiation safety in the country, while at the same time representing interests of uranium industry (Uranium Institute, 2013).

5.1.7 Local farmers

Since the climate in Erongo is very arid, agricultural activities occupy a small amount of land, concentrated mainly along the Swakop river (MME, 2010:5-7). Local farmers' influence on the uranium mining can be considered as negligible, mainly deriving from general perception of them as an affected party. On the other hand, they are dependent on groundwater quality and levels, so every contamination or over-abstraction resulting from mining operations can have an effect on their activity. Some farms in the Swakop river area were identified as places where the "Uranium Rush" will have the biggest impact on general public in terms of increased radiation (ibidem:7-165).

5.1.8 Schools and universities

Schools and universities affect uranium mining in Erongo primarily by training skilled professionals needed by the mining companies. This is recognized and stimulated by the industry as well. In 2011 Rössing provided bursaries for 45 students (2012:27). Moreover, Rössing Foundation financed the construction of English Language, Science and Mathematics Centres as well as libraries, which in 2011 provided services to almost 4000 local residents (ibidem:34) Paladin Energy provided bursaries for 6 students, which are going to be employed in the Langer Heinrich mine after graduation (2012b:27). Also, the company reports sponsoring of educational assistance organisation, providing textbooks for 12 grade pupils at the coast and offering courses on mining, manufacturing and engineering at the Namibian Institute of Mining Technology (ibidem:28). Predicted developments within uranium mining sector in Erongo can also negatively affect school capacities and the quality of education by a rapid influx of job seekers (MME, 2010:7-122,123). Therefore, it is recommended that all the new uranium mining companies make significant investments in the regional system of education (ibidem:7-124).

5.1.9 Environment

Environment means the physical context, in which something is situated and comprises all the living and non-living elements. It is obviously affected by uranium mining operations, but this relation can be reversed as well. Geological anomalies or rainfall can have a serious impact on the normal functioning of a uranium mine. For
example, Rössing Uranium puts the blame for its failure to achieve the production target in 2011 on excessive rain and industrial action (2012:20). Taking a global scale, an earthquake on the Japanese coast in 2011, apart from terrible damages and thousands of deaths, indirectly affected all the uranium industry, especially the planned developments in the Erongo region.

On the other hand, impacts of uranium mining on the environment are primarily local. Uranium mine construction permanently changes the physical features of a given area. It has also a great impact on local ecosystems, usually resulting in some habitat and biodiversity loss. During the operation phase a mine also affects greatly the environment by resource use and emissions. All these aspects have to be thoroughly assessed before applying for the mining licence in Namibia. The table below presents a summary of impacts identified in Environmental Impacts Assessment of uranium mining companies in Namibia. In the case of projects under development two scenarios are assumed:

- **managed** - if the company will mitigate negative impacts of the operation
- **not managed** - if the company will not take any actions to minimize the impacts

<table>
<thead>
<tr>
<th>Potential impact</th>
<th>Rössing Factual (1991)</th>
<th>Langer Heinrich expansion Managed</th>
<th>Trekkopje Managed</th>
<th>Husab Not managed</th>
<th>Zhonghe Managed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of soil resources due to pollution</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Loss of soil resources due to physical disturbance</td>
<td>Medium-Low</td>
<td>High</td>
<td>Medium-High</td>
<td>Medium</td>
<td>Medium-High</td>
</tr>
<tr>
<td>Biodiversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical destruction of biodiversity from construction</td>
<td>Medium-Low</td>
<td>High</td>
<td>Medium-High</td>
<td>High-Medium</td>
<td>High</td>
</tr>
<tr>
<td>Loss of biodiversity from the reduction of water resources</td>
<td>High</td>
<td>Medium-High</td>
<td>Medium-Low-Medium</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>General disturbance of biodiversity</td>
<td>Medium-High</td>
<td>High</td>
<td>Low</td>
<td>Medium-High</td>
<td></td>
</tr>
<tr>
<td>Radiological</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct exposure to radiation from on-site sources</td>
<td>Medium-Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium-Low</td>
<td>Low</td>
</tr>
<tr>
<td>Surface water</td>
<td></td>
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<tr>
<td>Pollution of surface water</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Medium-Low</td>
<td>Low</td>
</tr>
<tr>
<td>Ground water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water abstraction impacts</td>
<td>Medium-High</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Groundwater contamination</td>
<td>High</td>
<td>Medium-High</td>
<td>High-Medium</td>
<td>Medium-Low</td>
<td>Low</td>
</tr>
<tr>
<td>Air pollution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiological</td>
<td>Medium-Low</td>
<td>Low</td>
<td>Medium-Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Non-radiological</td>
<td>High</td>
<td>High</td>
<td>Medium-Low</td>
<td>Medium-High</td>
<td>High</td>
</tr>
</tbody>
</table>

*Table 8. Summary of Environmental Impact Assessments of the uranium mining projects in Namibia.*

5.1.10 Procurement companies

Procurement companies include all the enterprises delivering goods, services and infrastructure for the uranium mining industry. Without them, a proper functioning of any mine would hardly be possible. On the other hand, they also benefit greatly on uranium mining operations. In 2011, Rössing Uranium spend N$2.6bln on
procurement, which accounts for nearly 70% of total operating costs and 80% of all revenues (2012:55,66). The majority (63%) of Rössing procurement expenditures concerned Namibian companies and roughly 35% was made for companies registered in Erongo. Paladin Energy has even bigger share of regional procurement companies, which were responsible for 80% of all procurement transactions in the FY2012 (2012b:37). However, while in some instances the uranium mining companies are dependent in a certain area only on one company (e.g. NamPower), in other cases a great number of companies can be offering their services (e.g. consulting).

From the perspective of procurement companies, they are positively affected by the number and the scope of uranium mining operations. For example, Gecko chemical processing plants described in the section 4.3.1.4 would be profitable if another few mines were opened in the following years (MME, 2010:7-198). Therefore, the success of all the currently developing uranium mining projects can be generally considered as desirable by the relevant procurement businesses.

5.1.11 Tourism industry

Tourism is aside from mining and fishing, the third most important economic sector in the Erongo region (MME, 2010:5-9). With tourist arrivals approaching one million in 2006, in 2010 it provided roughly 3.7% of GDP and over 18 000 jobs for local residents (ibidem:7-57). Uranium mining affects the tourism industry by changes in the physical environment and restricting the access to certain areas. Other, more indirect concerns, are related to a potential loss of biodiversity, radiation emissions from uranium mines and deterioration of roads (ibidem:7-60). Two projects under development - Husab and Etango will have a visual impact changing the sense of place of Welwetschia Plains - a major regional tourist attraction (ibidem:7-62). Moreover, Etango is predicted to affect the internationally renowned "Moon Landscape" (ibidem).

On the other hand, uranium mining brings also some opportunities for tourism. Rössing Uranium offers a mine tour, which is attended by almost 3000 visitors each year (2012). A possibility of a mining site visit is offered also by Langer Heinrich. In the light of new projects being commissioned in the near future, the "Uranium Rush" Strategic Environmental Assessment recommended developing and enhancing synergies between uranium mining and tourism industry (MME, 2010:7-70).

5.1.12 Future Generations

Future generations can be identified as another stakeholder of uranium mining in Namibia. However, the relationship in this case is arguably the most unequal. They can not affect in any way the current mining activities, unless assuming that uranium mining companies are taking the notion of their existence under consideration. This is true to the extent that the companies are obliged to have an environmental management plan for the whole lifetime of mine, including decommissioning and post-closure monitoring phases. Also, certain legal documents like Environmental Management Act introduce some obligations towards future generations into the legal system of Namibia. In the Environmental Impact Assessments presented in the table above only Zhonghe Resources (2009) and UraMin31 (2008) mention future generations in their documents. The former does so in the context of legal system of Namibia, while only the latter integrates moral obligations towards future generations in the company's policy.

Future generations will be affected by the current uranium mining operations and any new developments within the industry. The state of environment, where uranium mines are located will never be the same as before. Taking into account the enormous amount of mineral and non-mineral waste produced by mines it is likely to largely deteriorate. Even if appropriate decommissioning and post-closure rehabilitation are conducted, the physical characteristics of the area or biodiversity will be different. Moreover, it is considered that new investments in uranium mining will be beneficial for the Namibian economy, as it will bring new direct jobs, increased procurement and service provision as well as additional tax revenues (MME, 2010). Nevertheless, such a situation will have its drawbacks, because Erongo region will become specialised in the primary sector and when the uranium resources are exploited or unprofitable to extract, it will be virtually impossible to change the structure of the economy in a short time, so Erongo might face high unemployment and poverty levels. Specialisation in mineral extraction is especially a hazardous choice due to the resource price volatility, which was demonstrated in section 4.2. Therefore, it was recommended to create a "Uranium Fund" following the

31 Named as subsidiary of Areva in this context - responsible for the Trekkopje project.
example of mineral-rich countries such as Norway, Canada or Botswana (MME, 2010:7-117). Nevertheless, this idea is currently not pursued by the government. Taking all these factors into consideration, it might not be the case that generations to come will be living in a rich and prosperous Erongo.

5.1.13 Residents of local towns

Towns in the Erongo region in a close proximity to the uranium mining projects include: located on the coast Walvis Bay and Swakopmund and inland Arandis and Usakos. They currently accommodate almost all of the workforce employed within the uranium industry (MME, 2010). They are also the base for many procurement companies.

Local residents are affected in many ways by the present and planned mining operations. Arandis, which is located 15 kilometres from the Rössing mine, as well as Husab and Valencia deposits, is the most exposed to dust emissions and radiation resulting from the mining operations. For all the towns, radiation and dust levels are likely to increase along with the projected opening of new mines. The current situation is still not precisely examined as the studies on dust and radiation for the Erongo region are currently taking place (GSN, 2012).

There are many risks associated to the possible development of new uranium projects. Waste from the mines along with the expected rise in the population will put the pressure on the disposal sites at the towns (MME, 2010:7-14). Waste management is still unadapted to possible impacts, with disposal sites not being audited, air and water quality not measured and not enough data to determine possible consequences (GSN, 2012:24-27). Moreover, with the influx of people a pressure on accommodation is expected, accompanied by negative consequences such as increase in crime, prostitution, as well as alcohol and drug use (MME, 2010:7-13).

However, some positive effects for the local population are also associated with the development of uranium mining industry in Erongo. Provision and quality of social services, such as health care is expected to increase (ibidem:7-12). Also, more residents will dispose with higher income, which would boost the local economy with new restaurants, shops and other services emerging in the region (ibidem). Moreover, spending on Corporate Social Responsibility purposes is likely to increase, as there will be more active companies. Currently, Rössing sponsors a few events for the local communities, examples of which are Rössing Marathon Championship or Rössing annual birdwatching event (2012:32). Moreover, it has a foundation, which provides support to the town of Arandis and the region by co-financing various projects, such as first petrol station in the town, construction of an open market or Erongo Micro Credit Initiative (ibidem:35).

5.1.14 Mine workers

In 2011 Rössing Uranium employed 1637 people (2012:72), while Langer Heinrich in FY 2012 reported 330 employees and 580 contractors (Paladin Energy 2012b:40). For all the uranium mining sector this number is estimated to reach between 3000 and 5000 in the following years depending on the developments (MME, 2010:4-24).

Mine workers are directly affected by the uranium mining. They receive salaries, which sustain their livelihoods and which are relatively elevated comparing to the national average (Shindondola-Mote, 2009:33). Also, they are working in the environment, which is considered as hazardous to their health, not only because of high radiation or dust levels, but also due to a significant risk of an accident. No fatalities were reported in 2011, but 11 people in Rössing were reported to suffer lost-time injuries32 (Rössing Uranium, 2012:36). In Langer Heinrich during FY 2012, the same concerned 5 people (Paladin Energy, 2012b:43). The companies have developed healthcare schemes and safety measures in place, but they still receive some criticism for intentionally not addressing certain issues in their medical checks and reports (Hecht, 2012; Shindondola-Mote, 2009).

Historically, a lot of effort was put on achieving safety measures, such as radiation limits, which in fact did not have any solid scientific justification (Hecht, 2012). After Namibia gained independence, two research programmes were conducted in Rössing to determine if working in the mine leads to genetic aberrations, which increase the risk of cancer. They brought contradictory results after which the matter was not investigated any more (ibidem:300-327). The IAEA, which also made a study of health impacts of uranium mining in Rössing stated that in the light of inexisting national health statistics no conclusions can be drawn (Shindondola-Mote, 2009:33).

32 That means, an injury due to which the employee was unable to perform his/her usual duties for one shift or more.
Miners can also influence the mining companies by collective bargaining and strikes in an extreme situation. On the collective level they are represented by Mineworkers Union of Namibia (MUN), which is the bargaining agent for all Rössing miners (ibidem:34). For example, between July and September 2011 a series of strikes in the mine took place, which were settled by reviewing the collective agreements in favour of employees (Rössing Uranium, 2012:24-25). As a result, salaries, housing allowance and retirement-bonus were increased (ibidem). In Langer Heinrich around 43% of workers belong to the MUN (Paladin Energy 2012b:32). However, no strikes exceeding one week were reported during FY 2012 (ibidem).

Nowadays, miners seem to hold a considerable potential to influence the uranium companies. However, this notion disappears confronted with the ruthless economic situation affecting the management decisions. Facing lower production and uranium prices than expected, on March 1, 2013, Rössing Uranium decided to dismiss 276 employees (2013b).
6. Discussion

6.1 Uranium and sustainability?

The systems and stakeholder analyses have shown that Namibia is confronted with a considerable trade-off regarding its natural resource management. It is thus vital to assess the relation between the uranium mining taking place in Namibia and sustainable development of this country. First, however, a broader theoretical perspective will be discussed. Uranium mining is a step in nuclear energy generation, which so far has not attracted a lot of attention in the public debate. Nevertheless, nuclear reactors and uranium mines are mutually dependent, so their effects should be considered jointly. Nuclear power is often presented as beneficial for sustainable development as it is virtually free of greenhouse gases production (OECD, 2000). Then, promoting nuclear energy production at the cost of fossil fuels would likely mitigate the effects of climate change. Moreover, thanks to a very low resource use and operating cost compared to fossil energy plants, it has lower general impact on the environment and constitutes an affordable source of electricity (ibidem). Also, from the perspective of energy security, it is a viable alternative for national development strategies as it can diminish dependence on resource imports and diversify energy mix. As long as these arguments can be valid on a global scale, they have a few shortcomings from a sustainable development perspective:

- the issue of nuclear waste management concerns a large number of generations to come;
- accidents involving nuclear power plants can cause enormous damage to people and the environment;
- dual-use potential of nuclear technologies and uranium present a nuclear weapons proliferation risk and a threat to international security;
- uranium is a finite resource;
- uranium is the heaviest and most radioactive element naturally occurring on earth - it decays very slowly and once extracted and exposed to the environment, it can represent a hazard to people and the environment;
- greenhouse gases are emitted during other phases of nuclear fuel cycle (mining, transportation, conversion, enrichment, fuel production, waste management) and life-cycle of a nuclear power plant (construction, decommissioning);
- uranium mining is concentrated in countries, which generally do not benefit from nuclear energy.

(Fig.12) Apart from transportation and processing costs between distant nuclear facilities (ibidem) uranium mining puts a pressure on local resources and the environment.

Production system analysis conducted in the chapter 4 revealed that to provide the required amount of energy to the new mines in Namibia, additional power plants will be needed, all of which will be run on fossil fuels. Increasing water demand from the industry in the face of scarce water resources in Erongo is going to be supplemented by energy-consuming seawater desalination. Taking all desired developments into consideration the energy required by uranium mines will increase from 1/4 to almost whole total current electricity production capacity of Namibia. The energy source, which is globally perceived as 'clean', locally will cause significant GHG emissions and air pollution. Also, the imports of necessary raw materials and machinery, which are likely to increase, have their impacts on the environment elsewhere.

Besides the high resource use, uranium mining results in a number of emissions to the environment. For example, besides the potential negative effect on groundwater levels caused by unsustainable abstraction, uranium mining can lead to radiological and heavy metal groundwater contamination. The studies conducted so far (MME, 2010; GSN, 2012) concluded that uranium mining in Erongo has not affected negatively water resources or quality in the region. Nevertheless, the figures provided in the documents might suggest something else. Groundwater levels in 2011 generally increased in comparison with 2010 due to exceptionally heavy rains earlier that year (GSN, 2012:30-32). Only one monitored borehole, which is close to Rössing, Husab and Valencia projects reported a groundwater levels decrease by over 20 meters (ibidem). Also, the map presenting spatial distribution of uranium in alluvial groundwater (MME, 2010:7-167) indicates a coincidence of very high uranium levels close to Rössing and Langer Heinrich mine. The EIA for the expansion of Langer Heinrich confirmed limited contamination of groundwater originating from temporary tailings storage facility as well as risks of future contaminations (Stobart, 2009).

33 Apart from Canada.
34 uranium mills → conversion plants → enrichment plants → fuel fabrication facilities → nuclear power plants
Although the above-described impacts are of limited range, they might present some threat to the local residents and the environment, since tailings and waste rock management in the two operating mines are not conducted in a complete accordance with global best practices (Rössing Uranium, 1991; Ninham Shand, 2007; Stobart, 2009; IAEA, 2009). Along with blasting, they are the main sources of radon gas and radioactive dust released to the environment. However, not much is known about the actual radiation and air pollution impacts resulting from the uranium mining in Erongo. The effects on the general public are assumed not to exceed limits (MME, 2010), but some factors like alpha and beta radiation from radioactive dust are undergoing further studies (GSN, 2012). The impacts on the mine workers are not clear either. Studies conducted in the Rössing mine brought contradictory results (Hecht, 2012). The company reports single cases of mine workers diagnosed with occupational diseases (2012), while some of employees claim that the situation is much more serious, suggesting deliberate concealing of medical information by the company (Shindondola-Mote, 2009). However, according to the director of Uranium Institute, with the recent introduction of new legal regulations, the uranium industry has to abide to strict healthcare standards and new programmes and initiatives are undertaken to improve the level of health monitoring and knowledge (Swiegers, 2013).

Similarly, the actual and long-term effects of uranium mining on the biodiversity in Erongo remain unknown. Dust originating from uranium mining might affect the environment by killing plants and lowering their productivity (MME, 2010:7-85). Moreover, it is assumed that the development of new uranium mining projects might pose a threat of extinction for many endemic invertebrates living on a relatively small areas (ibidem:7-84). Also, some vertebrate endemic species such as Husab Sand Lizard or Lappet-faced Vulture are considered as endangered by habitat loss and fragmentation resulting from the development of new mines (ibidem). Therefore, uranium mining might be directly responsible for the likely biodiversity loss, which is hardly compatible with the sustainable development approach claimed by the companies. Also, this can have an effect on tourism in Namibia, since the rich wildlife of this country attracts many foreign visitors. Still, "Since there is also no official policy on biodiversity offsets in Namibia as yet, operating mines are holding back on a firm commitment to offsets and partnerships" (GSN, 2012:63). This emphasises the importance of governance.

6.2 Governance and economy

In 2007, facing the influx of uranium mining companies attracted by the escalating price of the resource, the Government of Namibia issued a moratorium on granting new Exclusive Prospecting Licences to fill the gaps in the regulatory system and conduct a study in order to gain a better understanding of the possible cumulative impacts of increased uranium mining in the Erongo region. The same year, the Langer Heinrich mine commenced commercial production while the Rössing mine had been operating for 31 years. Late, but crucial legal documents followed - Environmental Management Act, passed also in 2007 and Radiation Protection and Waste Disposal Regulations in 2011. Strategic Environmental Assessment for the Central Namib Uranium Rush was released in January 2011 (MME, 2010). Determining indicators to monitor and report on annual basis the impacts of uranium mining in Erongo, the study can be perceived as a milestone and along with the two legal documents it has increased the institutional capacities of the Government of Namibia to efficiently manage new uranium mining developments in the country.

The first annual report assessing the progress in 2011 (GSN, 2012) has shown that despite the recent improvements, there are still many problems to overcome. Lack of capacity to conduct independent studies in order to measure certain indicators was reflected in incomplete results for the water quality, air quality/radiation, health, infrastructure, effects on tourism and ecological integrity categories. Moreover, within the ecological integrity, education, effects on tourism and air quality/radiation categories less than 50% of goals were met (ibidem). Especially in the cases of environment and tourism the report revealed serious conflicts of interests with the objective of increased uranium mining. It means that the coordination between ministries and government bodies relevant to these areas has to be improved. This situation can be best illustrated by the fact that Swakop Uranium was allowed to develop uranium mining project in an area marked with red flag for mining due to its biodiversity and touristic values (ibidem).

The survey conducted for the purpose of this study demonstrated that the Government of Namibia is the most affected stakeholder by the uranium mining in the country in the stakeholders' perception. Also, interestingly, the respondents valued higher the extent to which the government is affected than the level of its influence on the issue. This reflects undoubtedly the role uranium mining plays in the Namibian economy thanks to its tax contribution and the creation of jobs. In 2008, just taxes from uranium mining amounted to slightly over
$100\text{mln}$, which corresponded to approximately 1.2\% of national GDP. However, with the falling uranium prices and problems faced by the companies, the tax contribution of the uranium industry fell significantly to around 0.4\% of GDP in 2011 \cite{financial_reports_rossing_paladin_2008-2012, world_bank_2013}.

The role of uranium mining in the Namibian economy is not limited to its tax contribution to the state budget. In this developing country, which is still facing high unemployment and poverty levels, the provision of jobs is extremely important. In 2011 the two uranium mines employed directly almost 2000 people, out of whom 98\% were Namibian citizens \cite{rossing_paladin_2012}. Additionally, Langer Heinrich had 580 contractors who worked on the mine expansion. Moreover, the industry expenditure on the procurement is few times higher than its tax contribution. Between 2010 and 2012\footnote{It is not possible to give the exact number due to different reporting periods for the 2 operating mining companies.} it amounted to approximately $550-650\text{mln}$ per year, out of which $400-450\text{mln}$ went to Namibian-registered suppliers \cite{ibidem}. Employment and procurement stimulate further the local economy by raising disposable income. Taking all those factors into consideration, the governmental policies aimed to pursue investment in uranium mining are completely understandable. However, in a globalised world the economical sustainability of such a development path is precarious.

### 6.3 Forces behind the developments in uranium mining

Both systems and stakeholder analyses demonstrated a high dependency of uranium mining developments in Namibia on external factors. Global trade in uranium is shaped by rapidly changing perceptions of predicted demand and supply, which is reflected in uranium prices. A random event like the Fukushima disaster can highly influence political decisions concerning nuclear power worldwide, therefore posing a serious impediment to development of new uranium mining projects. In May 2013, amounting to $105/\text{kgU}$, the spot market uranium price is at the lowest level since 2006 \cite{cameco_2013a}. Massive investments in nuclear power by China, India, Russia and other smaller countries might eventually elevate the uranium price, but currently, the nuclear stand-by of Japan along with the political trends of moving away from nuclear power in Germany and France still seem to have a strong effect on uranium trade. In such a situation, the cost of resource production might be decisive in the developments of new uranium mines. The assessment made by the OECD and the IAEA \cite{oece_iaea_2012} indicates that Namibian uranium resources are relatively uncompetitive in economic terms. At the same time, the report presents Namibia as a country with the highest predicted increase of uranium production until 2020. The risk of not fulfilling this forecast is therefore quite high.

The participants in the stakeholder survey valued 'Other countries' the highest in affecting the uranium mining in Namibia. It is understandable considering that all uranium produced in Namibia is exported, as well as taking into account the influence of the uranium price shaped by the mechanisms described above. Stockholders of the companies involved were chosen as the second decisive force. The money Paladin Energy gained on the Australian stock market allowed the company to finance investments in Africa. Also, substantial shareholders have certain influence on the management of the firm. It is worth noting that a large part of Paladin Energy shares belong to the directors \cite{paladin_2012a}. In case of Rössing Uranium, the link with Rio Tinto is obvious. To what extent the South African or Iranian shareholders can influence the policy of the company is less clear. However, in the light of international pressure on Iran related to its nuclear weapons programme, the rights of its delegates in Rössing Uranium management were suspended. The Government of Namibia, discussed in the previous section, is perceived as the third most powerful stakeholder in uranium mining in its own country. However, the difference in the perceived influence level of the three parties was very small. Environment and international organisations were recognized as next in the order, but with a significantly lower capacity to impact uranium mining.
6.4 The way forward

A desired development of Namibia until 2030 is described in the document Vision 2030 (GRN, 2004:162). It presents goals related to non-renewable resources in the following way:

"Namibia's mineral resources are strategically exploited and optimally beneficiated, providing equitable opportunities for all Namibians to participate in the industry, while ensuring that environmental impacts are minimised, and investments resulting from mining are made to develop other, sustainable industries and human capital for long term national development".

At the same time the document embraces sustainable development as the central concept (ibidem:34). Mining is therefore seen as a sustainable driving force of the Namibian economy. It will likely bring financial benefits to a large part of Namibian society, uplifting many people from poverty. At the same time, there are some risks and disadvantages involved in such a strategy. Uranium mining is characterised by resource price volatility, which might turn some currently developed projects unprofitable. It can be illustrated by the example of Trekkopje mine, which is kept on hold by Areva until the market conditions improve. If the uranium price remains low for a long time, some projects might be abandoned without an appropriate rehabilitation. Also, the extent to which Namibia benefits on its mineral resources could be improved. Currently, taxes constitute only a small percentage of uranium sales. The state-owned Epangelo Mining company, which will be granted all new Exclusive Prospecting Licences for uranium, represents a promising way of improving the situation. However, currently it is not clear when the company is going to develop its own projects.

The structure of economy is another issue of concern. As presented in the Vision 2030, the investments in mining should serve to stimulate the other sectors of Namibian economy. Otherwise, when the mineral extraction becomes unprofitable, the country will be left with mining infrastructure and specialized workers lacking a viable, quick alternative, which would cause a number of economic and social problems. The Strategic Environmental Assessment for the Uranium Rush (MME, 2010) recommended creating a special uranium fund for investments in the future diversification of economy and in human capital. So far, no such plans were found and questions about it to the Government representatives were left without answer. Another recommendation, which could bring more benefits for Namibians would be to increase direct CSR expenditures on education by the uranium industry (ibidem). This would facilitate creation of a more adaptive and productive human capital, which would offset the negative potential of economic inertia. However, in case of Rössing Uranium (2012b) all CSR expenditures currently oscillate around 1% of the total annual turnover, which is still relatively high compared to less than 0.2% reported by Paladin Energy (2012a, 2012b) in Namibia. Not only are these numbers relatively low, but this type of spendings is also largely invested in the initiatives aiming at providing training to prospective employees. Therefore, increasing such expenditures would need to be accompanied by broadening their scope.

Some effects on the environment associated with uranium mining activities (e.g. the land use change or biodiversity loss) are irreversible. Moreover, after mine closure, waste rock and tailings containing uranium residues and processing chemicals will be left within the mine area. Contact with the environment is planned to be minimized and groundwater monitored, but still the original characteristics of the place will not be restored and the remains will pose contamination hazards. It is therefore important to implement a comprehensive monitoring system and prevention measures, which would mitigate any negative effects the planned uranium mine developments could cause. Moreover, obligations to offset the negative effects of uranium mines on biodiversity could be imposed on the mining companies. In the face of no alternative to uranium mining, the positive trend of recent years in increasing regulatory capacities to manage uranium mining in Namibia needs to be continued.
7. Conclusion

Mining companies tend to present uranium production as a sustainable strategy for development. Although it brings some benefits in the form of employment, taxes and stimulation of local economies, in the light of systems and stakeholder analyses conducted in this thesis, sustainability of these advantages is debatable.

Taking into account the high poverty and unemployment rates in Namibia, direct and indirect employment creation is essential for economic development as well as social and political stability. Indeed, uranium industry - with over 2000 employees - is one of the major job providers in the Erongo region. At the same time, due to the great dependence on external factors, future developments within this sector are uncertain. So far, the high expectations related to uranium mining developments and job creation (MME, 2010) have not been met. In fact, the falling resource price has had an adverse effect - the Rössing mine management conducted a massive lay-off in the beginning of 2013, while the Trekkopje mine suspended the commencement of commercial production. In this context, the growing amount of resources invested from public and private sources to specialise in the mining sector can be considered as a high-risk choice.

This issue is also connected to the tax contribution of uranium mining industry, which remains an important source of income for the government. One problem is that it is not clear, what the taxes are spent on. Creation of a special 'uranium fund', which would be used for mitigating negative impacts for future generations and stimulation of other sectors of economy in Erongo could contribute to increased sustainability. Another issue is related to the tax system based primarily on the corporate income tax, which - depending on financial results of the companies - does not generate stable profits. Further studies on an optimal mining tax system in the Namibian context as well as on the viability and functioning of a resource fund would be necessary to increase sustainability of such a development path. Also, the initiative of creating a state-owned mining company can bring positive results, but the pace of its development so far indicates the existence of significant barriers in an efficient entry into the uranium market. Identifying and analysing these obstacles could contribute to improving the development strategy, which would empower Namibia to gain more benefits from its own natural resources. Similarly, both uranium mining corporations declare that the majority of their procurement spending goes to Namibian companies (Rössing Uranium 2012, Paladin Energy, 2012b). Nevertheless, the statistics concern firms registered in Namibia and it is not known how much of them are in fact owned by Namibian citizens.

Apart from the above discussed benefits, uranium mining results in a number of impacts, which are hardly compatible with the idea of sustainability. It puts a great pressure on local resources and regional energy systems resulting in higher emissions to the environment. This situation directly affects the local population and threatens biodiversity. An initiative to assess the potential cumulative effects of the 'uranium rush' had been undertaken with a satisfying result (MME, 2010). However, monitoring of the actual impacts should be improved, while policies aimed to ensure compensation and mitigation of negative consequences of uranium mining operations should be introduced. Also, some crucial questions concerning casual relationship between radiation/air pollution and health of mine workers/local population require an independent and thorough study.

The link between uranium mining and its peaceful use remains even more complicated. The Iranian presence among the shareholders of Rössing raises suspicions of supplying a clandestine nuclear weapon programme. As far as there is some evidence indicating such a possibility in the period before the independence of Namibia (Hecht, 2012:145-155), current regulatory system is claimed to exclude such an option (Swiegers, 2013). Still, more research in needed to verify if there are no shortcomings in the nuclear security and non-proliferation measures in place.

All in all, uranium mining does not appear to stimulate sustainable development of Namibia. On the political level, regulatory capacities are increasing, but cooperation between different actors and management of benefits need to be improved. Although uranium mining constitutes an important part of the national economy, there are many uncertainties resulting from external factors. Also, foreign stakeholders are recognised as having the highest perceived level of power on the issue discussed, while local stakeholders appear to be more affected than influential. Uranium mining in Namibia does not necessarily benefit its citizens in the first place. Meeting needs of future generations might require looking for alternatives.
8. Acknowledgements

This study would not be possible to complete without help of many people.

I would like to thank my supervisor - Mikael Höök - for directing my way with his expert comments.

I was extremely lucky to have Timothée Parrique as my opponent. He contributed greatly with a comprehensive review of my thesis. His constructive suggestions helped me to implement important corrections and improve the overall quality of the paper.

My parents deserve a special appreciation for the continuous support they provided. I owe especially much to my brother and my dear friend, who helped me with additional comments and assistance during the whole process of writing.

I would also like to express my gratitude to Bertchen Kohrs from Earthlife Namibia as well as to Dr Wotan Swiegers from the Uranium Institute for their comprehensive and fascinating answers to my questions, as well as help in finding useful references for the study.

Thanks to all the other people that helped me through providing meaningful responses to my mails. This master thesis owes credit especially to all the respondents, who took part in my online stakeholder survey.
9. References


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Forsys Metals, 2013. *Corporate Presentation - February 2013.* Available at: http://forsysmetals.com/wp-


Swiegers W., 2013. E-mail correspondence.


Appendix A - Online stakeholders survey and the results

1. How much is uranium mining in Namibia affected by the following parties?

<table>
<thead>
<tr>
<th>Party</th>
<th>1 - Not at all</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 Extremely</th>
<th>-Rating Average</th>
<th>Rating Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockholders of uranium mining companies</td>
<td>0.0% (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22.2%</td>
<td>55.6% (5)</td>
<td>5.89</td>
</tr>
<tr>
<td>Other countries (including nuclear power utilities and state-owned</td>
<td>0.0% (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.1%</td>
<td>22.2%</td>
<td>4.44</td>
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<tr>
<td>uranium mining companies)</td>
<td></td>
<td></td>
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<td>11.1%</td>
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<tr>
<td>Government of Namibia (including relevant ministries)</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td>0.0%</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Procurement companies</td>
<td>11.1% (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.1%</td>
<td>11.1%</td>
<td>2.78</td>
</tr>
<tr>
<td>Residents of local towns</td>
<td>11.1% (1)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>11.1%</td>
<td>11.1%</td>
<td>2.78</td>
</tr>
<tr>
<td>Uranium mines employees</td>
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<td></td>
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<td></td>
<td></td>
<td>22.2%</td>
<td>22.2%</td>
<td>2.22</td>
</tr>
<tr>
<td>Local farmers</td>
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<td></td>
<td></td>
<td>11.1%</td>
<td>22.2%</td>
<td>2.22</td>
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<tr>
<td>Tourism industry</td>
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<td></td>
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<td>11.1%</td>
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</tr>
<tr>
<td>Media</td>
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<td></td>
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<td>22.2%</td>
<td>22.2%</td>
<td>2.22</td>
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<tr>
<td>Non-Governmental organisations</td>
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<td>33.3%</td>
<td>55.6%</td>
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<tr>
<td>Schools and universities</td>
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<td></td>
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<td>22.2%</td>
<td>22.2%</td>
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<tr>
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</tr>
<tr>
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<td></td>
<td></td>
<td>11.1%</td>
<td>11.1%</td>
<td>2.22</td>
</tr>
<tr>
<td>Other parties (please specify and rate)</td>
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<td></td>
<td></td>
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<td></td>
<td>11.1%</td>
<td>11.1%</td>
<td>2.22</td>
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</table>

2. To what extent does uranium mining in Namibia affect the following parties?

<table>
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<tr>
<th>Party</th>
<th>1 - Not at all</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 Extremely</th>
<th>-Rating Average</th>
<th>Rating Count</th>
</tr>
</thead>
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<td>Stockholders of uranium mining companies</td>
<td>0.0% (0)</td>
<td></td>
<td></td>
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<td></td>
<td>22.2%</td>
<td>55.6% (5)</td>
<td>5.89</td>
</tr>
<tr>
<td>Other countries (including nuclear power utilities and state-owned</td>
<td>0.0% (0)</td>
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<td></td>
<td>22.2%</td>
<td>44.4% (4)</td>
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<td>11.1%</td>
<td>11.1%</td>
<td>2.78</td>
</tr>
<tr>
<td>Government of Namibia (including relevant ministries)</td>
<td>0.0% (0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0%</td>
<td>0.0%</td>
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50
2. To what extent does uranium mining in Namibia affect the following parties?

<table>
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<th>12.5%</th>
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<th>25.0%</th>
<th>25.0%</th>
<th>25.0%</th>
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<td>25.0%</td>
<td>25.0%</td>
<td>25.0%</td>
<td>5.13</td>
<td>8</td>
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<tr>
<td>Residents of local towns</td>
<td>0.0% (0)</td>
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<td>11.1%</td>
<td>22.2%</td>
<td>44.4%</td>
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<td>11.1%</td>
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<td>2.89</td>
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<td>22.2%</td>
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<td>11.1%</td>
<td>11.1%</td>
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<tr>
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<td>22.2%</td>
<td>22.2%</td>
<td>4.78</td>
<td>9</td>
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<tr>
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<td>11.1%</td>
<td>22.2%</td>
<td>11.1%</td>
<td>11.1%</td>
<td>11.1%</td>
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</tr>
<tr>
<td>Other parties (please specify and rate)</td>
<td>11.1% (1)</td>
<td>33.3%</td>
<td>0.0%</td>
<td>11.1%</td>
<td>22.2%</td>
<td>11.1%</td>
<td>11.1%</td>
<td>11.1%</td>
<td>3.78</td>
<td>9</td>
</tr>
</tbody>
</table>

Participants:
- Stockholder
- Other countries representative
- Government member
- Local resident
- Mine employee
- Journalist
- NGO director
- Environmental NGO member
- Young student (future generations)

No representatives of:
- Procurement companies
- Farmers
- Tourism
- Schools and Universities

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