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The security level and its impact on the effectivity and efficiency of Official Development Assistance in DRC

Diploma thesis

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Abstract

The diploma thesis deals with the analysis of the security level in the Democratic Republic of the Congo and the state of road infrastructure. It examines the influence of the security cooperation and the Official Development Assistance on the transport infrastructure development. In the descriptive part of the thesis the terms connected with regional security cooperation, Official Development Assistance, and the transport indicators are defined. The analytical part provides an analysis of the transport infrastructure in DRC; the evaluation of road system and the analysis of the transport infrastructure are included as well. This is followed by the evaluation of the influence of the Official Development assistance and regional cooperation on the development and quality of transport network. The author proposes recommendations to improve current situation in the conclusion.

Keywords

Regional security cooperation, transport network, infrastructure, Official Development Assistance, DRC

Abstrakt

Diplomová práce se zabývá analýzou stupně bezpečnosti v Demokratické republice Kongo a stavem silniční sítě. Zkoumá vliv bezpečnostní spolupráce a oficiální rozvojové pomoci na rozvoj infrastruktury v dopravním sektoru. V popisné části práce jsou definovány pojmy týkající se regionální bezpečnostní spolupráce, poskytování oficiální rozvojové pomoci a způsoby hodnocení dopravní sítě. V analytické části je provedena analýza bezpečnostní spolupráce DRC, hodnocení silniční sítě a dále pak analýza dopravní infrastruktury. Následuje zhodnocení vlivu poskytované rozvojové pomoci a regionální spolupráce na rozvoj a kvalitu dopravní sítě. V závěru jsou navržena autorova doporučení, která by vedla ke zlepšení stávající situace.

Klíčová slova

Regionální bezpečnostní spolupráce, dopravní síť, infrastruktura, oficiální rozvojová pomoc, DRC

List of abbreviations

ACP	African, Caribbean, and Pacific Group of States
AfDB	African Development Bank
ASEAN	Association of South East Asian Nations
ARF	ASEAN Regional Forum
ASF	African Standby Force
AU	African Union
CEPGL	Economic Community of the Great Lakes Countries
CFMK	Chemin de Fer Matadi-Kinshasa
COMESA	Common Market for Eastern and Southern Africa
CPI	Corruption Perceptions Index
DRC	Democratic Republic of the Congo
EAC	Eastern African Community
EC	European Commission
ECGLC	Economic Community of the Great Lakes countries
ECOWAS	Economic Community of West African States
EITI	Extractive Industries Transparency Initiative
EU	European Union
FAO	Food and Agriculture Organization
GII	Gender Inequality Index
HDI	Human Development Index
IBRD	International Bank for Reconstruction and Development
ICAO	International Civil Aviation Organization

ICC	International Criminal Court
IDA	International Development Assistance
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
INTERPOL	International Criminal Police Organization
IPU	Inter-Parliamentary Union
ISPS	International Ship and Port Facility Security
ITUC	International Trade Union Confederation
LCA	Logistic Capacity Assessment
LPI	Logistic Performance Index
MDG	Millennium Development Goals
MIGA	Multilateral Investment Guarantee Agency
NAM	Non-Aligned Movement
NATO	North Atlantic Treaty Organization
NEPAD	New Partnership for Africa´s Development
NGO	Non-governmental Organization
OAS	Organization of American States
ODA	Official Development Assistance
OEEC	Organization for European Economic Co-operation
ONATRA	Office National des Transports
OPCW	Organization for the Prohibition of Chemical Weapons

OSCE	Organization for Security and Co-operation in Europe
PSC	Peace and Security Council
RVA	Régie des Voies Aérienne
RSC	Regional Security Complex
SADC	Southern African Development Community
SADCC	Southern African Development Coordination Conference
SNCC	Société Nationale des Chemins de Fer du Congo
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations Refugee Agency
UNJLC	United Nations Joint Logistic Centre
UNWTO	United Nations World Tourism Organization
WB	World Bank
WCO	World Customs Organization
WFTU	World Federation of Trade Unions
WHO	World Health Organization
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

Table of Content

1 Introduction and aim

Development cooperation emerged after the Second World War as a consequence of Marshall Plan´s success in the Europe post war re-building. At those times the development aid was seen very simply. The development should come quickly only through providing capital, technical know-how and other resources but the reality proved far more complex and uncompromising. After the WWII only a small number of institutions and organizations provided financial aid. After fifty years the financial system is composed of the International Monetary Fund (IMF), the World Bank (WB), more than 20 regional and sub-regional development banks, over 40 bilateral development agencies, the United Nations (UN) and thousands of small Non-governmental organizations (NGOs), and private foundations. (Sagasti, 2006)

Ideas, how to support and accelerate development and how to organize the cooperation are constantly changing and evolving. After the expansion of development cooperation it was based on the huge investments mainly into human capital to initiate economic growth. Recently the national poverty strategies, macroeconomic policies, public expenditure management and Millennium Development Goals (MDGs) are created to support the development efficiently. Official Development Assistance (ODA) practices have been heavily influenced by the development ideas predominant at a particular time. (Sagasti, 2006)

A lot of debates regarding the impact of ODA on the growth and sustainable development have been held. Critics argue that aid only discourages developing country initiatives, supports bureaucracies, as well as the assistance and help is ineffective, wasteful and should be reformed and eliminated. On the other hand supporters oppose, that despite the aid failure and the need to reform the ODA, it has helped millions of people to fight with poverty and to improve their social conditions and even enhance economic performance in a lot of developing countries. It is clear that impact of the development aid varies according to the type of the assistance, to the policies of the donor countries, and the capacities of the target country. (Sagasti, 2006)

In the thesis the author concerns with the ODA provided by the member states of Organization for the Economic Cooperation and Development (OECD). The ODA provided to the Democratic Republic of Congo is analyzed. Despite the ODA, the road infrastructure and network is examined.

The aim of the diploma thesis is to analyze the transport infrastructure and the development of the transport infrastructure capacity and quality in the connection with the Official Development Assistance provided. The evaluation of the road network is done using the accessibility, connectivity and circuitry indicators. Based on the results from analysis and the author´s calculations the recommendations how to improve the situation are suggested.

2 Methodology

To fulfil the aims of the thesis literature review is used in the first part. This part is based on the current knowledge about the thesis topic. The review uses secondary sources and do not report new or original experimental work. The literature review gives a theoretical base for the research and thus helps the author to work on the practical part of the diploma thesis.

Second, practical, part uses quantitative research defined by Aliaga and Gunderson (2003) as *"explaining phenomena by collecting numerical data that are analysed using mathematically based methods (in particular statistics)"*. To analyze the relationship between Official Development Assistance and the transport infrastructure the statistical method of correlation analysis is used. Moreover indicators such as connectivity, accessibility and deviatility are calculated to evaluate the current state of road network in the DRC using the Google Earth tool. Analytical part is supplemented by graphs, tables and cartographic maps that have been generated by author based on the data analysis. To the analysis mainly the data from World Bank (WB) database has been used. Used methods are further described in sub-chapter Types of communication sites and their evaluation.

Final part provides suggestions and conclusions. Author of the thesis provides solutions and recommendations based on the quantitative research done in analytical part.

3 Literature review

The literature review provides an overview of the regional security development in the world; it deals with the regional security cooperation and the cooperation models. Further the OECD is analyzed. This part discusses the ODA and its influence on infrastructure; it analyzes how the transport influences development of the country; and finally the types of communication sites and the evaluation are described.

3.1 Regional Security

In the regional level the states are closely linked together thus their securities cannot be treated as separate units. In this level the national and global security interplay and the most actions occurs here. It can be said that each Regional Security Complex (RSC) is made from the fears and aspirations of the separate units. (Buzan & Waever, 2003)

The modern history of regional security complexes (RSCs) according to Buzan and Waever (2003) can be divided into three stages: *the modern era* (1500-1945); *the Cold War and decolonisation* (1945-1989); and *the post-Cold War period* (since 1990). Before 1500 security dynamics were unfolded in relatively separate systems. The systems cannot be seen as regional because the global level was not strong enough to create global world system. Therefore the separate systems cannot be the regions but worlds in fact. In the period from 1500 to 1945 the global system was build. The European national states built empires in all parts of globe. The overseas extensions of European powers were created. In Africa, the Middle East and Asia the Europeans occupied the existing social and international systems and thus suppressed the native regional security dynamics. The regional security in this era is defined more by global rivalries among the European powers than by security interdependence among the states. According to the neorealists this period is one of unbroken multipolarity. Globalists see the era as the time during which a lot of foundations have been established for the high-intensity global system after 1945. Buzan and Waever (2003) in their work Regions and Powers mentioned that for the European imperial powers the "*world was their region*".

The era from 1945 to 1989 influenced the regional security contradictorily. The imperial power was rolled back during decolonization, thus the new states could be created. The regional cooperation started in those new independent states in Africa, the Middle East,

the South and Southeast Asia. On the other hand the rivalry between the United States and the Soviet Union developed. During the Cold War many of RSCs in the Middle East, Asia, and Africa formed but they were influenced and organized by those two superpowers: the United States and the Soviet Union. According to neorealists this era is seen as a shift from multipolarity to bipolarity. Globalists more focus on the intensification of the global economy despite the obstructions connected with the Cold War. (Buzan & Waever, 2003)

According to Buzan and Waever (2003) the ending of the Cold War had three main impacts on the forming of regional security:

1. The superpower was lifted overlay from Europe. After the collapse of Soviet Union, fifteen new states were established; therefore new RSCs came into game.

2. The RSCs in the third world got more freedom and autonomy against this more differences between core and periphery occurred.

3. Non-military issues and actors were included into security agenda.

Buzan and Waever (2003) claim there exist four levels of the analysis of regional security complexes that together constitute the security constellation. The four levels are:

1. Domestically in the states of the region,

2. State to state relations, these generate the region as such,

3. The region´s interaction with neighbouring regions,

4. The role of global powers in the region.

This theory will be further applied on DRC in the analytical part of this work.

3.1.1 Regional Security Cooperation

The regionalism and the regional cooperation have been growing features of the world politics since the end of the World War II, especially since the 1990s. The Cold War and decolonization resulted in the establishment of multilateral regional organizations, including for example the North Atlantic Treaty Organization (NATO), the predecessors of the European Union (EU) and the African Union (AU), the Arab

League and the Association of South East Asian Nations (ASEAN). After the end of the Cold War so-called new regionalism has appeared. The number of regional cooperation frameworks has been established; and the efforts to strengthen existing regional institution have been developed. (Bailes & Cottey, 2006)

The security cooperation is the considerable part of this phenomenon. Some institutions such as NATO, ASEAN Regional Forum (ARF), and the Organization for Security and Co-operation in Europe (OSCE), are primarily security organizations. Most of the regional organizations such as the AU have significant security dimensions as do other smaller regional organizations such as the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS). (Bailes & Cottey, 2006)

Many regional organizations link the traditional definitions of security with its wider concepts involving human rights, democracy, environmental and economic issues. Even those organizations primarily designed to promote economic and social growth have the policies to promote stability and security in the given region. (Bailes & Cottey, 2006)

3.1.2 Regional security cooperation models

According to the Bailes and Cottey (2006) we can divide the regional security cooperation into at least four models, i.e. alliances, collective security, security regimes and security communities.

Alliances could be considered to be the one of the oldest forms of international cooperation. They were designed for both defence and attack against common threat and opponent. The practical impact of the alliances on the international security is often negative: even defensive alliance can heighten the threat consciousness of its members; it may worsen tensions, and may take part in competitive arms acquisition. Even the concentrating on internal enemies such as religious or ethnic groups can also radicalize them and encourage them to seek external supporters. The alliances have positive impact as well by reducing the likelihood of war, by promoting confidence, and tightening cooperation in other non-security areas. The typical example of the alliance could be ASEAN and NATO. (Bailes & Cottey, 2006)

In the 20th century the concept of collective security appeared. The collective security is a strategy in which the member nations agree not to attack each other and to defend

each other against the attacks. The main principal is that an attack against one nation is an attack against all of them. (Conflict research consortium, 1998)

In other words a collective security system tends to prevent war by assuring a response to any act of aggression to peace among its members. The examples of such system are globally United Nations; and regionally the African Union, the Organization of American States (OAS), and the Organization for Security and Co-operation in Europe (OSCE). Experiences from last years show that this system works well when there is a consensus among the major powers, on the other hand it fails when these major powers come into conflict or some big dangers appear. (Bailes & Cottey, 2006)

Security regimes are common in non-security dimensions of international relations, e.g. in the regulation of international trade and transport. The regimes define norms for state´s behaviour and provide ways to implement and verify these norms. The regimes may for example exactly regulate certain types and uses of weapons, or they can cover broad prescripts for behaviour such as the non-use of force, or respecting the current state borders. As security regime some regional organizations such as OSCE and some Latin American initiatives can be considered. (Bailes & Cottey, 2006)

The fourth type of the security cooperation according to Bailes and Cottey (2006) is security community. Karl Deutsch defined the security community as a group of states among which there is a "real assurance that the members of that community will not fight each other physically, but will settle their disputes in some other way". The concept of security community was developed in 1950s by Karl Deutsch. A security community have more intense, comprehensive and sustained interactions than the other mentioned models. It starts with removing the risk of conflict within the group. For the example the European Union has eliminated the conflict between the states but not within them (Northern Ireland, Basque region). Ambitions of building such community have been in also in several non-European regions but it remains poorly understood.

3.2 Organisation for Economic Co-operation and Development

The OECD is the follower of the Organization for European Economic Co-operation (OEEC) which was established in 1948 to manage American and Canadian aid under the Marshall Plan that was design to reconstruct Europe after World War II.

The OECD was established by twenty states in 1961 to avoid mistakes done after the World War I and to ensure lasting peace by encouraging co-operation and reconstruction rather than punishing and defeating. The Convention entered into force on 30 September 1961. The organization has been created as an economical counterpart to NATO to achieve sustainable development, higher employment and increase living standards. The OECD should take part on economic expansion and growth in member states as well as in those countries going through the process of economic growth. The world trade should be supported by the organization on non-discriminatory base. (OECD 1, 2007)

The OECD tends to promote policies that should improve the economic and social well-being in the world. It is a forum in which governments of the 34 member states work together, share experiences, and seek some solutions to the current problems. The work of the OECD is to measure productivity and flows of the global trade and investment. It aims to understand what drives economic, environmental and social change. The analyzing data and predicting future trends is another part of the OECD´s work. The international standards on wide range of areas are set by the organization. It looks at the aspects that affect everyday life of the citizens as well, e.g. how much are the taxes paid, the quality of life, and communication with civil society organizations. (OECD 2, 2015)

The work of the organization is based on monitoring of events in member countries as well as in the outside area. The policy is done after the discussion according to the data collected and analyzed. Thereafter the governments implement the recommendations. (OECD 3, 2015)

The main goal of the OECD is to contribute to the development by promoting economic growth and maintaining financial stability at one time, increasing employment and quality of life. The main tool how to reach these goals is to cooperate on the economic policy among the member states. The equally significant goal is to facilitate the world

trade by the non-discriminatory trade policies. The main idea how to reach this goal is to reduce the trade barriers. However the OECD does not have any authority to enforce rules so the agreements are not binding which tends to lower the effectiveness of the organization on the trade issues. (IFI Transparency Resource, 2014)

OECD is funded by the member states. Contributions are based on the size of the national economics. The United States is the largest contributor, provides nearly 22% of the budget. The USA is followed by Japan. The voluntary contribution to support the OECD´s work could be done as well. The size of the budget and the OECD´s programme of work are determined on a two-year basis by member countries. (OECD 4, 2015)

3.2.1 Organization structure of the OECD

1) Council

Decision making is vested in the OECD Council. The Council is made up of one representative from all member states plus a representative of the European Commission (EC). At the level of permanent representatives the Council meets regularly and the decisions are taken by consensus. The OECD Secretary-General chairs these meetings. The ministerial level meetings are done once a year to discuss key issues and set priorities for the work. The work mandated by the Council is carried out by the OECD Secretariat. (OECD 5, 2015)

The Council is responsible for collective foreign policy issues including the relations with non-member countries. At the ministerial level the ministers from member countries ser priorities that would best support their common policy-making needs. (UNESCO, 2014)

2) Committees

Specialised committees consisting from representatives of all member countries advance ideas and review progress in specific policy areas e.g. economics, trade, employment, education, and science. About 250 committees, expert and working groups exist in OECD. Some 40,000 senior officials from national administrations go to the meetings each year to request and contribute to work executed by the OECD

Secretariat. Meetings at ministerial level of these specialised committees are also held occasionally. The decisions are usually taken by consensus. (OECD 5, 2015)

3) Secretariat

The OECD Secretariat is headed by Angel Gurría (current secretary general) and is assisted by more Deputy Secretaries-General. Angel Gurría also chairs the Council a thus provides the link between national delegations and the Secretariat. The Secretariat is located in Paris and is made up of about 2,500 staff that supports the activities of committees. The secretariat carries out the work in response to priorities decided by the Council. The economists, lawyers, scientists and others are employed to manage work in Secretariat. Most of them are based in Paris but some work at centres in other countries. (OECD 5, 2015)

3.3 Official Development Assistance

Official Development Assistance (ODA), commonly expressed as Foreign Aid, has remained a major tool for transferring both technical knowledge and capital from developed to developing countries. In a number of countries ODA persists a major source of development finance. In present years there is a realization that resources flowing from ODA have to be utilized in a more efficient and effective way. (Acharya, 2003)

The body responsible for defining what types of expenditures belongs to the Official Development Assistance is called OECD Development Assistance Committee (DAC). The basic definition has not changed significantly since 1972. The ODA refers to financial flows: "*to countries on the DAC list of ODA recipients and to multilateral development institutions which are provided by official agencies, including state and local governments or by their executive agencies; and each transaction of which is administered with the promotion of the economic development and welfare of developing countries as its main objective; and is concessional in character and conveys a grant element of at least 25 per cent.*" (OECD 6, 2008)

The OECD defined a number of limits on ODA reporting to avoid some subjective interpretations of the definition. These are for example:

1. Military aid may not be reported as ODA while expenditures incurred on the cost of using donor military forces to deliver humanitarian aid may be reported.

2. Using donor police services to control civil disobedience cannot be defined as ODA but civil police training is reportable.

3. Assistance to refugees in developing countries is considered to be ODA as well the temporary assistance to refugees from developing countries arriving in donor countries and the cost associated. (International Development Committe, 2009)

3.3.1 Official Development Assistance and infrastructure

The transport is crucial to socio-economic development of a country therefore the investment for transport infrastructure is one of the principal items of public investment plan. The domestic financial resources are usually insufficient to finance capital-intensive transport infrastructure projects. That is why these projects need to be

financed through ODA financial resources. Critics often argue that the investment into hardware infrastructure is a waste of resources. These critics are receiving more attention as donors are now giving more priority in such goals as poverty reduction through direct intervention in social sectors such as education and health. (Acharya, 2003)

It may be true that not all transport projects financed by ODA are meeting the expected objectives but still the creation of an adequate infrastructure is necessary to support sustainable growth, development, and reduction of poverty in developing world. According to Addison and Anand (2012) nowhere is infrastructure of such importance as in Africa. The region is characterized by extensive and longstanding infrastructure deficiencies. A lot of MDGs are related to infrastructure services. The reduction of poverty, creating likelihood, reducing unemployment, delivering shifts into high-value added agriculture, these all require investment into infrastructure.

Compared to the past reliance on conventional Official Development Assistance from OECD-DAC members, in present the range of financial options now available for infrastructure investment is much wider. Infrastructure is now seen as a desirable investment area. The infrastructure development has changed significantly with a rising number of international and bilateral donors, both international and regional development banks, governments and others. (Addison & Anand, 2012)

Provision of basic access is essential for any kind of social or economic activities. Subsequently the transport should be a core of development strategy. Transport plays a central role in generating growth by facilitating domestic as well as international trade, and by having a greater access to the social infrastructures such as schools, hospitals, etc. According to the studies done the transport investment has potential to increase social return to private capital and contributes to decrease of cost of production. A lot of developing countries realize the strong connection between transport and socio-economic development and thus place emphasis on transport infrastructure. (Acharya, 2003)

According to the researcher Surya Raj Acharya (2003) the problem of inadequate capital resources to launch infrastructure investment projects was behind the early ODA initiatives. ODA strategies were primarily based on the two-gap models of Harrod Domar tradition and transport infrastructure was a candidate to justify ODA financing.

There was an expectation that such investments will generate growth in many areas and the economies will achieve take-off. After the success of Marshall Plan, the ODA initiatives were attempted to replicate the results in the developing countries with main focus on capital intensive investment projects including transport infrastructure. Unfortunately ODA was not very successful in these projects. The poverty and underdevelopment in a lot of countries receiving aid were not weakened. New developmental problems such as growing regional disparity, environmental degradation and others were confronted. The economic growth remained stagnant and developing countries had to rely more on development aid. The donor communities frequently changed their ODA strategies to achieve time-bound targets for poverty reduction and other social development objectives. The high priority is given to education, health and other social sectors with an assumption that the investment in these fields will bring success in fulfilment of MDGs. (Acharya, 2003)
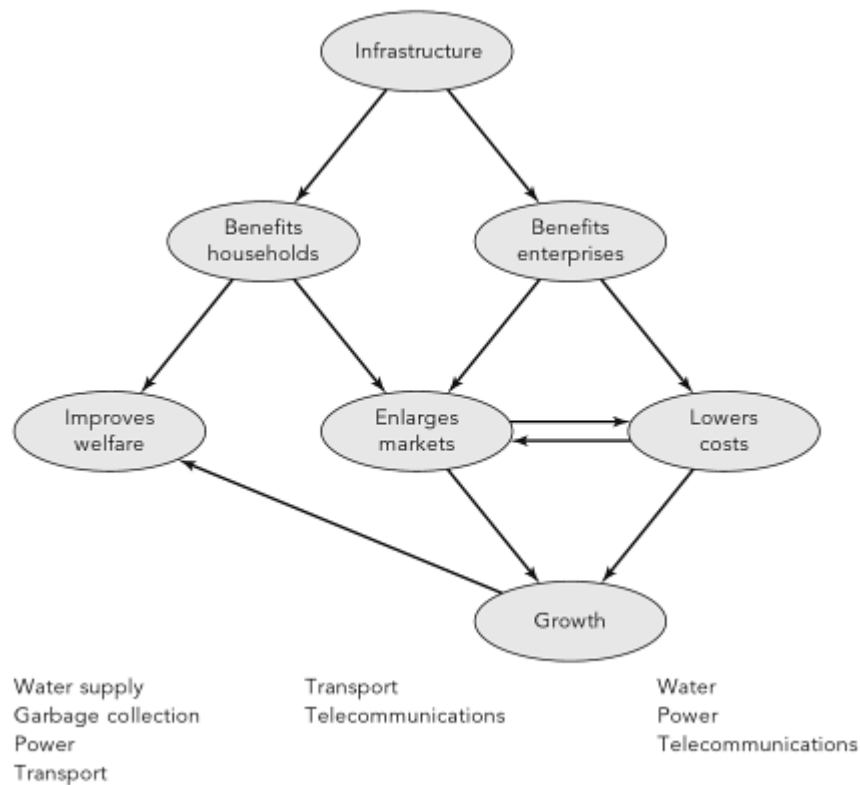
3.4 Transport and development

Since the beginning of human civilization transport has affected economic development. The first cities grew up on rivers and lakes, on bays and ports where the transport was easily available. The early transport systems have been defined by proximity to oceans, seas, waterways, plains and mountains. (IBRD, 2015)

It has been assumed that high quality of transport infrastructure contribute to the economic growth and development. David Hilling (1996) mentions in his book the work of Owen (1987). According to Owen a lot of factors contribute to the economic and social growth, and the mobility is especially important. The food, health, education, and employment are available only if there are adequate means of moving people, as well as goods and ideas. It could be easily demonstrated that there are huge differences in the availability of transport at the global level. Large parts of developing countries are immobile; the infrastructure is inadequate for present needs without the complication of growth of demand in the future. This is caused mainly by the lack of skills and resources necessary to upgrade the transport.

Efficient transport is fundamental component of economic development, globally as well as nationally. Transport availability can be a boost or barrier to economic growth. Transport contributes to economic development by reducing cost and time for existing passengers; improving time performance and reducing loss and damage, thus reducing economic drag. Thanks to better transport availability there is a wider access to markets, possibility of higher production, distribution, and consumption, thereby increasing economic growth; and the transport increases productivity thanks to the access to more diverse base of inputs such as raw materials, energy and labour. (IBRD, 2015)

According to Rémy Prud˙homme (2005) the infrastructure is a space shrinker; it increases markets, and lowers trade barriers. In urban areas infrastructure contributes to enlarging the effective size of labour market and of the goods and ideas markets and thus increasing productivity and output.

Figure 1: How infrastructure contributes to development

(Source: Prud´homme, 2005)

As depicted in the Figure 1 from the adequate infrastructure both households and enterprises benefit. Water supply and sanitation, power supply and transportation improve living conditions especially in cities. According to Prud´homme (2005) the welfare improvements do not contribute much to GDP but it could be argued that they improve the quality of labour force and thus its productivity. Many economists consider improving welfare as part of development however it does not directly contribute to growth. Infrastructure supply lowers the cost of some inputs used by enterprises. Lower inputs mean lower total costs which causes the reduction of total costs. The most important mechanism of the infrastructure development relationship is market enlargement. This applies to goods markets, capital markets, as well as to labour markets.

S.D.Ellis (1997) in the report called Key issues in rural transport in developing countries deals with the transport as a basic need. Poor accessibility in the rural areas perpetuates the deprivation trap by denying access to human basic needs. Isolation through poor accessibility slows down the diffusion of new technologies, increases

marketing and production costs and limits access to education and health facilities. In the past the major transport interventions were into the new road building because the rural people´s transport need were not fully recognized and understood. Doubts, whether new road building necessarily stimulates economic growth and if it does not deepen the differences between poor and rich population, occurred. As a result the priority is given to providing access to basic social and economic goods and services.

In order to plan accessibility to respond people´s need Howe (1983) defined six core needs as: *1) Health, 2) Education, 3) Markets, 4) Water, 5) Firewood, 6) Other subsistence tasks (principally farming).* (Elis, 1997)

Most rural transport is on an informal path and track network which connects villages, farms and sources of water. The highest burden is laid on women with regard to collection of water and firewood. Limited access to markets, schools and health facilities is caused by poor accessibility as well. Thereby the people´s productive potential is limited. (Elis, 1997)

3.5 Types of communication sites and their evaluation

In the diploma thesis the road network is evaluated by following four morphological sings: Deviatility, accessibility, density, and connectivity.

3.5.1 Deviatility

It is common that communications do not have linear direction but more or less deviate from it, consequently the connection among various transportation hubs is frequently not linear. This sinuosity of transportation networks is called *deviatility* (from Latin deviare, i.e. turn off). Deviatility could be expressed as ratio between the length of communication among chosen transportation hub (l_k) and length of direct connection among them (l_p). The deviatility (d_s) is expressed by following formula (Brinke, 1999):

$$d_s = \frac{l_k}{l_p}$$

If $l_k = l_p$ then $d_s = 1$, therefore the deviatility could be equal to 1 or it could be higher than one $d_s \geq 1$. It means that the deviatility is higher the more it deviates from 1.

According to Brinke (1999) deviatility of communication network is influenced by many factors. The first one is size or attractiveness of the hubs. The most important and biggest cities are connected with communications that have the most possible linear shape in order to provide the shortest and thus the most economic transport connection. On the other hand small and less attractive municipalities lack the transport connection. The second factor influencing the deviatility is the relief. The terrain obstacles such as mountains, big rivers, deserts and marshes do not allow the linear communications and thus the deviatility is higher in mountainous terrain than in the lowlands. The third factor is socio-economic. The division and ownership of land can negatively influence the deviatility. At less important roads it could be observed that are at some points deviated from linear shape because the owner of land did not sell the land to build there a communication.

3.5.2 Accessibility and hierarchy

Accessibility is another structurally-morphological factor, according to Brinke (1999) the most important one that influence spatial organization and structure of the cultivated landscape.

Accessibility is closely related to hierarchy of communications. If the road or rail network is observed more deeply it will be found out that some communications are more important than the others. Those usually connect more important and bigger municipalities and commonly have lower deviatility. In case of road network the roads of 1st grade have lower deviatility than the roads of 2nd grade connecting less important places. The same situation could be observed on hubs. Some of them have higher amount of connections and more communications pass through them. It is obvious that in communication network some meaning-grading system of communication and hubs exists – this is the hierarchy of connections and hubs. (Brinke, 1999)

The hubs with high accessibility have suitable conditions for location of various services and institutions. These hubs are consequently centres of high movement of people, goods and resources. (Brinke, 1999)

By increasing accessibility of communication hubs we can coordinate their economic and social development. As an example Birke compared two cities with almost the same number of citizens. In given period of time the cities started to develop in different manner. The first city gone through fast population and economic growth, while the second city stagnated. The reason for this different development was the railway network in the surroundings of the first city. On the other hand hubs with high accessibility can regulate location of another communications. (Brinke,1999)

3.5.3 Connectivity

Connectivity is significant factor of communication network from economic point of view. Connectivity indicates the level of connection among communication hubs. Generally it could be said that the higher the connectivity, the higher amount of connections among the hubs, therefore the traffic is more efficient and faster. The level of connectivity is influenced by the level of economic development in the given area. In developed countries it is demanded to build linear connections among the transportation hubs due to frequent movement of goods. (Brinke, 1999)

The Figure 2 below gives an example of four transportation hubs A, B, C, D with different level of connectivity. The first case (a) illustrates minimal connectivity, while the last case (d) shows maximal level of connectivity.
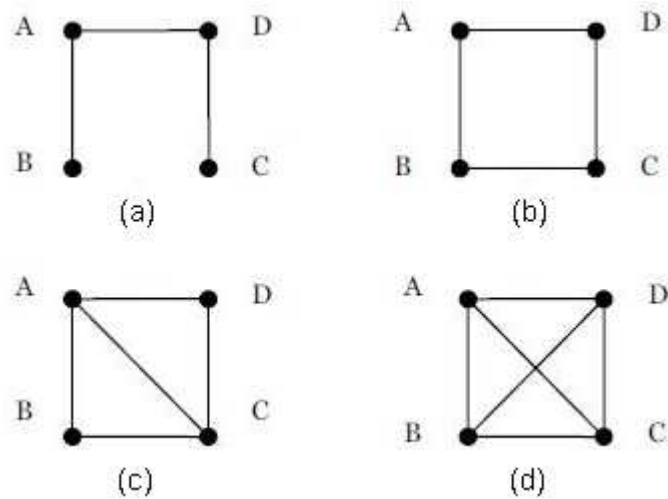
Figure 2: Connectivity of network illustrated on four hubs

(Source: Brinke, 1999)

The connectivity could be expressed as ratio of real number of connectors among transportation hubs (S_d) to maximal number of connectors among transportation hubs (S_{max}):

$$K = \frac{S_d}{S_{max}}$$

Minimal and maximal number of connections among hubs (S) is dependent on the number of hubs (u). The minimal number of connections is always lower by one that the real amount of hubs, i.e. $S_{min} = u - 1$; maximal number of connections is then $S_{max} = \frac{1}{2} \times u \times (u - 1)$. Maximal connectivity is equal to one. (Brinke, 1999)

Increase of connectivity is dependent on the development of economy in given area. The more developed country, the higher requirements on linear connections, reciprocally the better the connectivity the better the further economic development of given area. (Brinke,1999)

3.6 Correlation analysis

In the diploma thesis the correlation analysis is used to assess the extent to which the Official Development Assistance provided affect the development in the transport network of the Democratic Republic of the Congo.

To assess the extent of the linear dependence of the two components of a continuous random vector, Pearson´s correlation coefficient ρ has been introduced. (Litschmannová, 2011).

$$\rho = \rho(X,Y) = \begin{cases} \dfrac{cov\,(X,Y)}{\sqrt{DX \cdot DY}} & DX, DY \neq 0 \\ 0 \end{cases}$$

Below some of the coefficient characteristics are listed (Litschmanová, 2011):

1. $-1 \leq \rho \geq 1$, the equality is reached only if there is the linear dependence between the random variables X and Y.

2. If X, Y are independent random variables, then $\rho = 0$.

3. If $\rho = 0$, then X, Y are uncorrelated random variables.

4. If $\rho > 0$, then X, Y are positively correlated (if X increases, then Y increases).

5. If $\rho < 0$, then X, Y are negatively correlated (If X increases, then Y decreases).

It is obvious that Pearson correlation coefficient is an appropriate measure of linear dependence of random variables.

4 Analytical part

Analytical part provides an overview of current situation in DRC as well as it analyzes briefly the country´s history. Based on the literature review the security cooperation in DRC is examined; the state of transport infrastructure is discussed as well. Moreover the ODA is analyzed and its impact on the infrastructure development is measured using the correlation analysis.

4.1 Democratic Republic of the Congo

DRC lies in the Central Africa. The republic is the eleventh biggest in the world with total area of 2,344,858 sq kilometres and 77,433,744 citizens. The population growth rate is 2.5% according to the 2014 estimates. The capital city is Kinshasa. (CIA, 2015)

According to the latest estimates of National Statistics Institute nearly 40% live in urban areas, while the rest 60% create rural population. There is a huge potential for DRC to become one of the richest countries in Africa. About 80 million hectares of arable land and over 1,100 minerals and precious metal contributes to the wealth of the country. (World Bank 1, 2015)

The population of DRC consist of over 200 African ethnic groups of which the majority are Bantu. The four largest tribes are Mongo, Luba, Congo, and Mangbetu-Azande. Mongo, Luba, and Congo are all Bantu while Mangbetu-Azande is the Hamitic ethnic group. These four tribes make up about 45% of the population. The official language is French; the most spoken languages are Lingala, Kingwana, Kikongo, and Tshiluba. The most practiced religion is Roman Catholic with the share of 50%, the second largest group are Protestants with 20%, followed by Kimbanguist with 10%, and Muslim 10%. The rest 10% covers other religions as well as the syncretic sects and indigenous beliefs. The life expectancy for total population is 56.54 years which ranks the country to the 203rd place from 223 countries compared. (CIA, 2015)

4.1.1 Background

The country has been established as a Belgian colony in 1908. The Republic of Congo gained independence in 1960. The early years were affected by social and political instability. In November 1965 Joseph Mobutu declare himself president and changed his name to Mobutu Sese Seko. The country name was changed as well to Zaire.

Mobutu had stayed in his position for 32 years using a brutal force and false elections. During the fighting in Rwanda and Burundi in 1994 there was a massive inflow of refugees into the country. Rebellions backed by Rwanda and Uganda fronted by Laurent Kabila overthrew the Mobutu regime. Kabila renamed the country the Democratic Republic of the Congo. Even his regime was challenged by the rebellions again backed by Rwanda and Uganda. Kabila was supported by troops from Angola, Chad, Sudan, Namibia, and Zimbabwe. In 2001 Kabila was assassinated. As the successor Kabila´s son Joseph Kabila, was named the head of state. In October 2002 the president negotiated the withdrawal of Rwandan forces, followed by signing of Pretoria Accord guaranteeing the end of fighting. The government of national unity was established. In 2003 the transitional government was created; successful constitutional referendum was held in 2005; and elections for presidency took place in 2006. In 2009 the conflict was restored. It led to displacement of large number of people and the basic human rights were abused. Despite the peace talks between Congolese government and opposition were held, the DRC continues to experience violence by other armed groups. In the elections in 2011 Kabila was re-elected to the presidency. (CIA, 2015)

In Annex 2 the groups that operated in DRC in 2011 mainly in provinces Sud-Kivu and Nord-Kivu could be observed.

4.1.2 Development issues

The DRC has high potential to be a top African contributor to the economic growth thanks to the country size, potential and geo-political importance. The DRC is endowed by natural resource wealth including cobalt, copper, gold, tantalum, tin, petroleum, and diamonds. The DRC controls around 50 % of the world´s cobalt production. The country has sufficient water resources for consumption, agriculture, environmental protection as well as enough to power all of Africa. (USAID 1, 2014)

The DRC suffers from violence against women and children, chronic conflicts, disease, famine, high corruption, and extreme poverty. According to the International Food Policy Research Institute´s Worldwide Hunger Index the DRC is the hungriest country in the world, with only 10% of its agriculture potential exploited. (USAID 1, 2014)

The Human Development Index (HDI) value for 2012 was 0.304 in DRC, it ranks the country at 186 out of the 187 countries and territories. The average annual increase is

around 0.2%. The Gender Inequality Index (GII) for DRC is 0.681, which places the country at 144 out of 148 countries in 2012. (UNDP, 2013)

The DRC is among the top five contributors to child mortality and out-of-school children. This fact makes the success on achieving key MDGs almost not possible. In the country, the second largest number of extreme poor citizens from whole Africa lives. Due to the current trend the country could easily become the home to the second largest number of extreme poor in the world after Nigeria. (USAID 1, 2014)

The country struggles from repeating political crises, mismanagement of natural resources, entrenched corruption, and poor governance. According to the president Kabila declaration the country is supposed to fight the corruption, but there is neither political will, nor evidence of progress in establishment of legal framework. The anti-corruption policies are often manipulated for political reasons. In 2013 the country ranked 154th of the 177 countries assessed by Transparency International´s Corruption Perceptions Index (CPI) with score 22 on a scale of 0 to 100, where 0 is highly corrupted and 100 is highly clean. (Transparency International, 2013)

4.1.3 Economic performance

Apart the aforementioned problems DRC deals with high unemployment as well. According to the data reported by Banque Centrale du Congo the unemployment rate decreased to 46.10% in 2013 from 49.10% on 2012. Despite the decrease the average unemployment rate since 1999 until 2013 has been 52.07% reaching even 66.90% in 2000. (Trading economics, 2015)

After a slowdown in 2009 to 2.8% caused by global financial crisis the economy of the country is slowly recovering. The DRC registered a growth rate of 8.5% in 2013. Public investment and favourable trends in commodity prices have helped to this growth. Thanks to the prudent fiscal and monetary policies the inflation fell to 1% in 2013 from 53% in 2009. The economic growth around 7-8% is expected in future years, as well as the increased investment, growth in the extractive industries, and increased contribution to the civil engineering and service sector. (World Bank 1, 2015)

Table 1: GDP per capita, 2005-2013 (US$)

(Source: World Bank 2,edited by author)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
GDP per capita	221,45	257,17	286,14	326,53	301,93	346,70	404,11	446,03	484,21

The Table 1 above depicts the GDP per capita in DRC in years 2005 – 2013. It is obvious the economic situation is improving year by year except of the fall in 2009 caused by the economical crisis. The Graph 1 shows the improvement graphically.
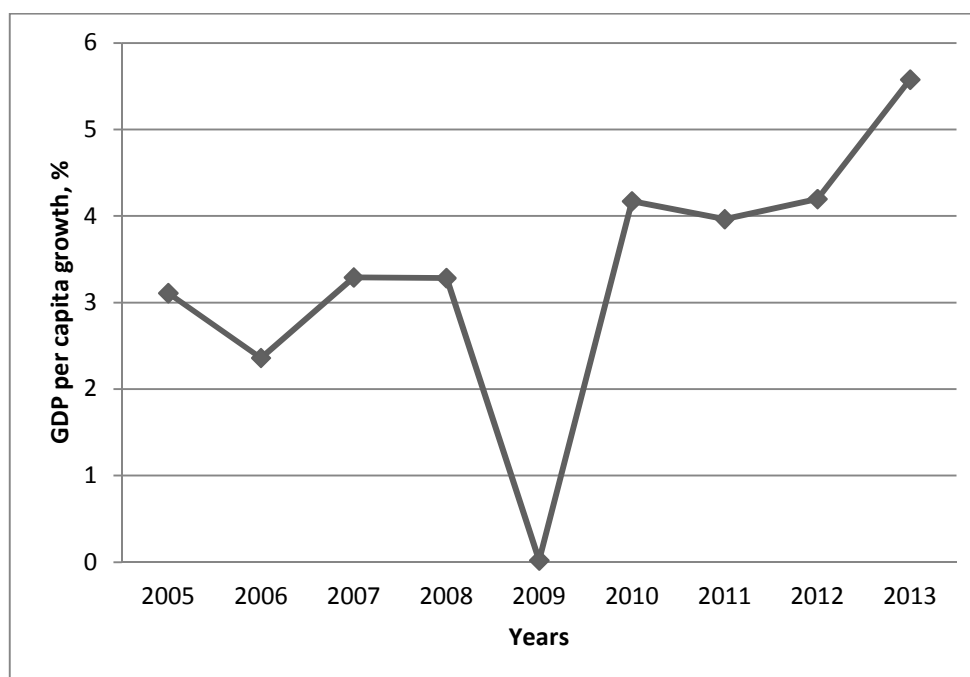
Graph 1: Annual GDP per capita growth, 2005-2013 (%)

(Source: World Bank 2, edited by author)

The GDP of the country is composed of agriculture with share of 44.3%, by services 34%, and by industry 21.7%. (CIA, 2015) The agricultural sector in DRC employs 62% of men and 84% of women. For the last four year the country has been ranked first on the Global Hunger Index, while the production has fallen 40% since 1990. The main agriculture products are coffee, sugar, palm oil, tea, cotton, cassava, and fruits. (USAID 2, 2015)

Main industries in DRC are mining (mainly copper, cobalt, gold, diamonds, coltan, and zinc), mineral processing, consumer products (textiles, footwear, cigarettes), and processed foods and beverages. Diamonds, copper, gold, and cobalt belongs among the most exported commodities; while foodstuffs, transport equipment and fuels belong among those frequently imported. Main export destinations are China where 54.3% of

export flows, followed by Zambia with 22.6% and Belgium with 5.7%. On the other hand the biggest import partners are South Africa with 22.3% of import, China with 15.3%, and Belgium with 8%, followed by Zambia, Zimbabwe, France, and Kenya. (CIA, 2015)

4.2 Security cooperation in the Democratic Republic of the Congo

Based on the theoretical approach described in the literature overview of the thesis, the author has done the analysis of security cooperation of DRC on four levels.

4.2.1 Domestic level

Since the end of the Belgian colonial rule in 1960 the country has been plagued by violence. The conflict which considerably influenced the security of the country was Second Congo War (also known as War of Africa). In the war different armed forces participated as well as the proxy groups from Rwanda and Uganda operated on Congolese territory. (Castellano da Silva, 2012)

The Congolese government supported the foreign groups to fight against aggressor troops. However the conflict formally ended in July 2003 by the Transitional Government of the Democratic Republic of the Congo taking power, the hostilities are continuing. Foreign armed groups use the territory of DRC to extract the resources. Raping and act of terror against local population are still present in the country, therefore the investment into military and security measures is needed.

Government of DRC spends millions of US dollars to military. As obvious in the Graph 2 the expenditures reached the maximum in 2013 when the government spent US$428.07 million, this is 1.31% of the country´s GDP.
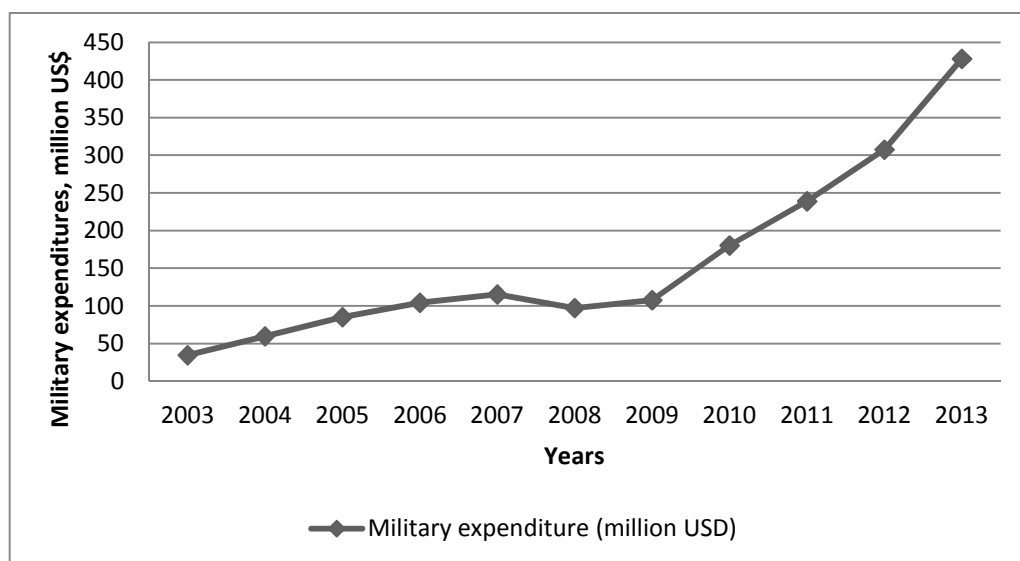
Graph 2: Military expenditures, 2003-2013 (million US$)

(Source: World Bank 2, edited by author)
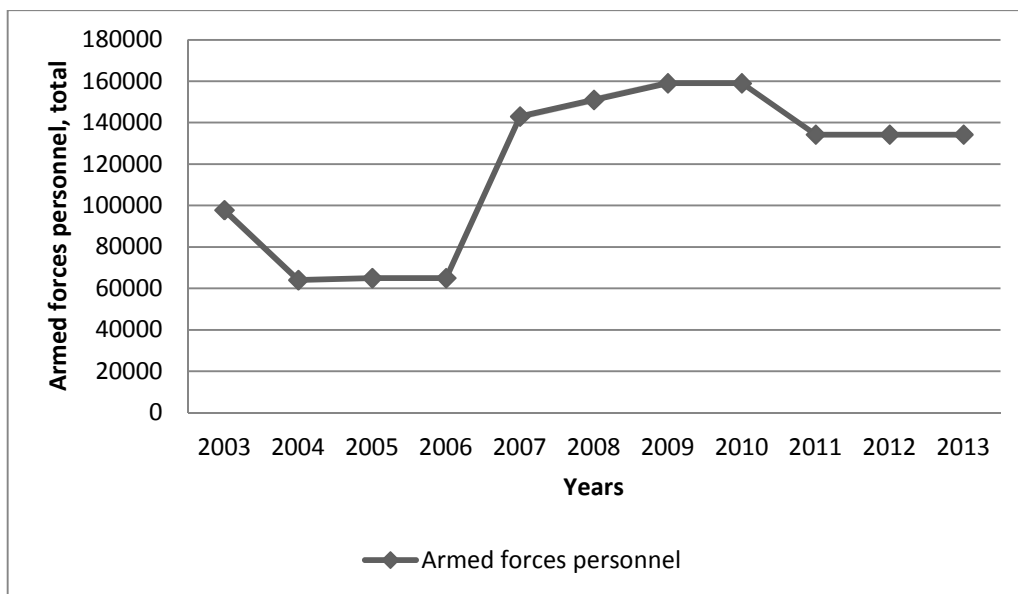
Graph 3: Armed forces personnel, 2003-2013 (total)

(Source: World Bank 2, edited by author)

In the Graph 3 the number of persons employed in army in years 2003-2013 can be seen. There are no available data for 2006 therefore the data from 2005 were used to design the graph. As obvious number of armed personnel in 2011 slightly decrease and it stayed the same until 2013 – the end of the observed period.

4.2.2 State-to-state level

Since the decolonization it was hard to see any coherent state level regional security. It is important to mention again that in the conflict in DRC were involved seven countries from southern Africa as well. Rwanda, Burundi and Uganda belong among aggressors, while Angola, Namibia, Zimbabwe, and DRC were in the conflict defenders. Zambia and South Africa actively participated in peace negotiations.

In February 2013 step further to achieve and keep the peace in DRC and the region as a whole was the adoption of the Peace, Security and Cooperation Framework for the Democratic Republic of the Congo and the region. The framework has been signed by Angola, Burundi, Central African Republic, DRC, the Republic of Congo, Rwanda, South Africa, South Sudan, Uganda, and Tanzania. The commitments at the national, regional, and international levels to establish conditions for peace have been made.

On the national level DRC should continue and deepen security sector reform; it should consolidate state authority especially in east part of the country; the republic should support economic and infrastructure development. (UN, 2013)

On the regional level the signatory countries should not interfere in the internal affairs of neighbouring countries; armed groups should not be supported; the sovereignty and territorial integrity of neighbouring countries should be respected; and the countries should work on strengthening of the regional cooperation. (UN, 2013)

On the international level the communities should support long-term stability of the Great Lakes region, they should work towards the revitalization of the Economic Community of the Great Lakes Countries (CEPGL), and they should support the governments of the countries to address the security challenges. (UN, 2013)

4.2.3 Interregional level

The DRC became part of several organizations working on interregional level in past years. One of them is African Union established in 2001 and launched in 2002 replacing the Organisation of African Unity. It consists of 54 member states, only one African state – Morocco is not a member of the African Union. The main objectives of AU are beside other to coordinate and intensify cooperation for development, to safeguard member states territorial integrity, and to promote international cooperation. (African Union 1, 2015)

In terms of security the most important organ of African Union is the Peace and Security Council (PSC). The main responsibility of PSC is to promote peace, stability and security in Africa; to maintain the peace and to engage preventive diplomacy; and to manage catastrophes and humanitarian actions. (African Union 2, 2015)

DRC is also part of Southern African Development Community (SADC). The community was established in 1992 as a follower of Southern African Development Coordination Conference (SADCC). The main objective of SADC is to achieve development, economic growth, peace and security, and thus to alleviate poverty, enhance the standard of living, and support the socially disadvantaged through regional integration. (SADC 1, 2012)

According to the theory and experience it is proved that interregional cooperation can positively contribute to capacity and economic development and to infrastructure across countries and regions.

SADC closely cooperate on the interregional level with African Union and New Partnership for Africa´s Development (NEPAD). The aims and objectives of these three structures are closely aligned therefore they coordinate their work to allow combined and complimentary efforts. As a result of cooperation of SADC and AU in the area of regional peacekeeping, African Standby Force (ASF) has been established. (SADC 2, 2012)

ASF is based on arrangements of PSC with Africa´s five sub-regions (see Annex 3). The ASF has right to intervene in member states circumstances in case of war crimes, genocide and crimes against humanity. (African Union 3, 2015)

Furthermore SADC is part of so called Tripartite cooperation among SADC, Common Market for Eastern and Southern Africa (COMESA), and the Eastern African Community (EAC). In 2011 Free Trade Area among these organizations was established. The cooperation should ensure market integration, infrastructure and industrial development. (SADC 3, 2012)

4.2.4 Global level

The DRC is member of several international organizations, e.g. United Nations, International Monetary Fund, World Bank, and World Trade Organization.

According to the information provided on the websites of European External Action Service (2015) the DRC on the global level cooperates with European Union. The primary objective of the Commission of EU is to support reconstruction of the country. The main interest is focused on transport infrastructure development and strengthening of good governance. Priorities of relations between EU and DRC are peace, security and stabilisation. Member states of the EU, Commission and the rest of International Community make efforts to restore peace and stability in the eastern part of the DRC. Moreover the Commission is one of the most important donors in the country.

The DRC established relations with Unites States after its independence from Belgium. Foreign policy of US in DRC focuses on the building of democracy and stability, securing the peace, and providing basic needs of the citizens. The United States is the

largest donor in the case of United Nation stabilization mission in DRC. The US provides assistance to the DRC; it aims to, inter alia, support security and governance structures necessary for improvement of social and economic conditions; to protect civilians; to strengthen the rule of law; and increase food security. The two countries have signed a bilateral investment treaty, moreover US has signed a trade and investment framework agreement with COMESA, of which the DRC is a member. The DRC participates in the exchange programs through the United States International Visitor Leadership Program. (U.S. Department of State, 2013)

China, as the great power, plays significant role in DR Congo as well. The Chinese invest into the booming mining sector and infrastructure. In 2008 consortium of Chinese companies and DRC made a contract about investment into infrastructure. The investment has been provided by Sino-Congolese joint venture, Sicomines, in exchange for access to concessions of copper and cobalt. It means that DRC have received US$6 billion, from which it is possible to build 3,200 km of railway from Katanga to Matadi. The package includes the construction of 4,000 km roads, two hydroelectric dams, airports, hospitals and schools. In return, rights to extract the natural resources have been provided. China has currently positioned itself as a prominent actor in the country. As a result of Chinese presence in DRC, the country has increased its export into China. (Edinger & Jansson, 2008)
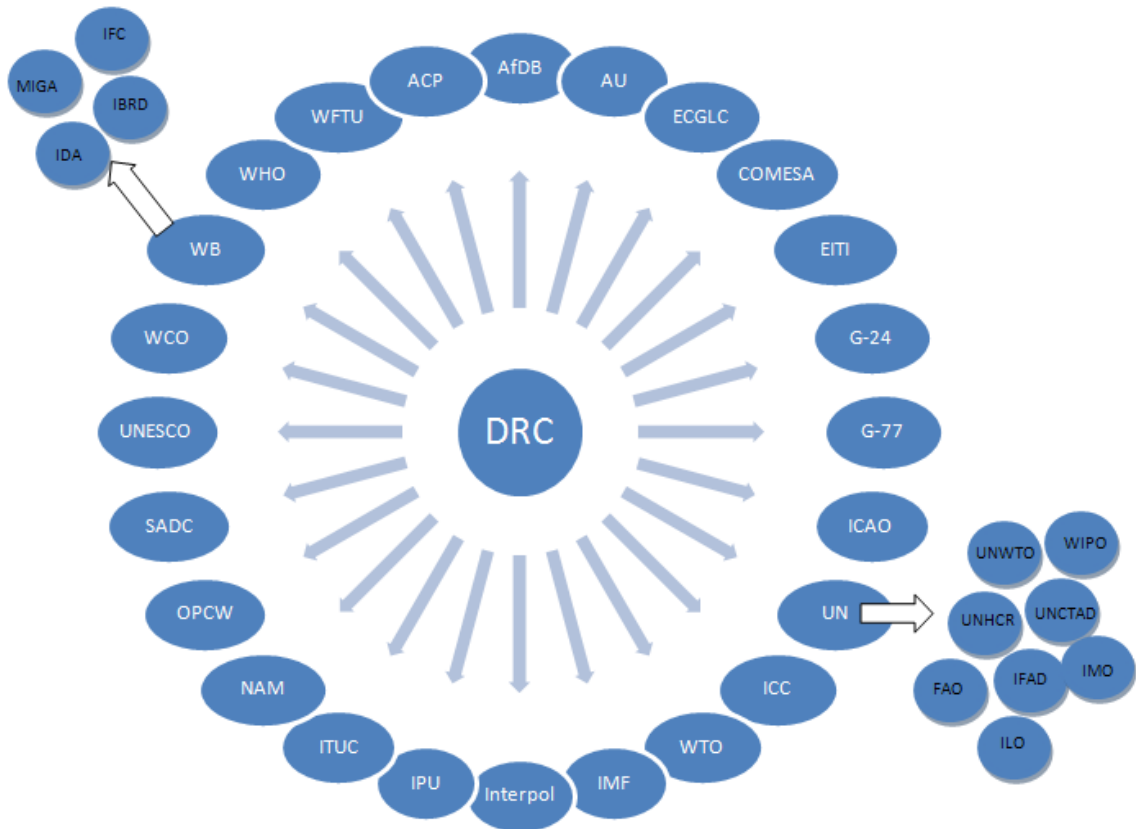
Figure 3: DRC in chosen international organizations

(Source: Author´s own work)

The Democratic Republic of the Congo is on the international level part of many organizations. Twenty five of them connected mainly to social, economic, cultural development are illustrated in the Figure 3 above. Beside the participation in United Nations DRC takes part in its agencies and programmes such as International Labour Organization (ILO), International Fund for Agricultural Development (IFAD), Food and Agriculture Organization (FAO) and others depicted in the Figure 3.

4.3 Official Development Assistance in the Democratic Republic of the Congo

DRC is highly dependent on the Official Development Assistance. The aid is necessary mainly to functioning of basic social services. Many bilateral and multilateral donors returned back to DRC after the end of the Second Congo War in 2003 and before DRC´s first democratic elections in 2006.

The Democratic Republic of the Congo has been among the top 10 recipients of humanitarian assistance in nine of the last ten years (2002-2012). In 2006 the ODA received was equivalent to 52% of GNI.

According to OECD statistics ODA reached US$2,389.05 million in 2009. Over half of the money came from the WB, China, the EC, and the UK. As obvious from the Graph 4 the net ODA increased to US$4,249.27 million in 2011. Since that the amount of ODA has been decreasing in observed period of time.
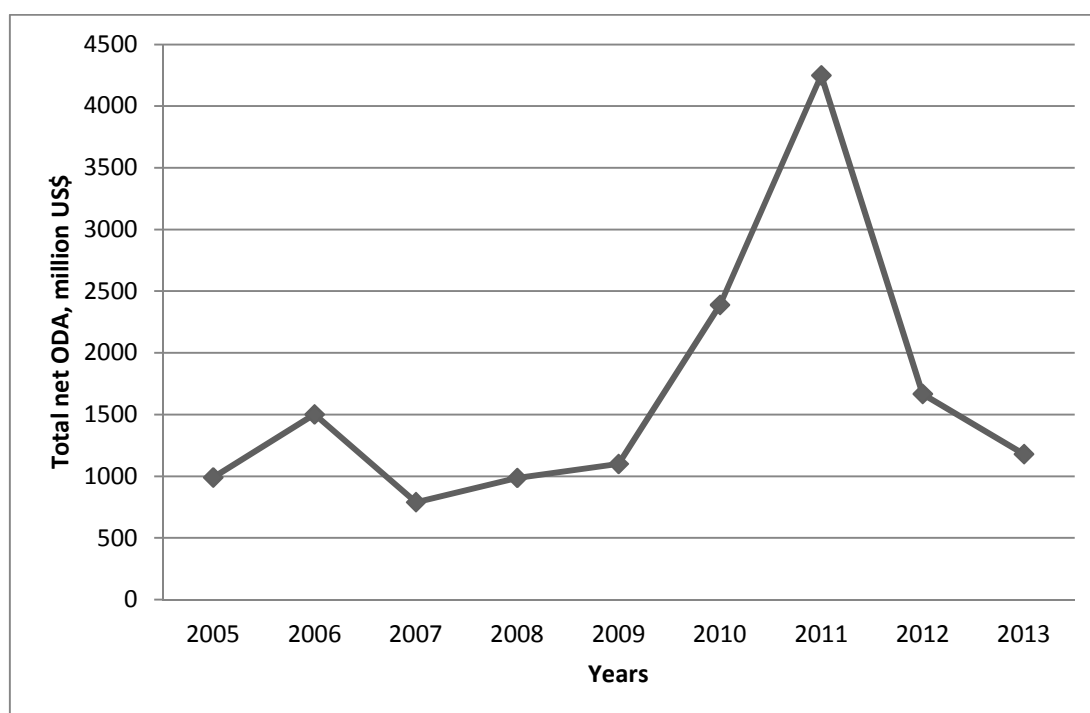
Graph 4: Total net ODA in DRC, 2005-2013 (million US$)
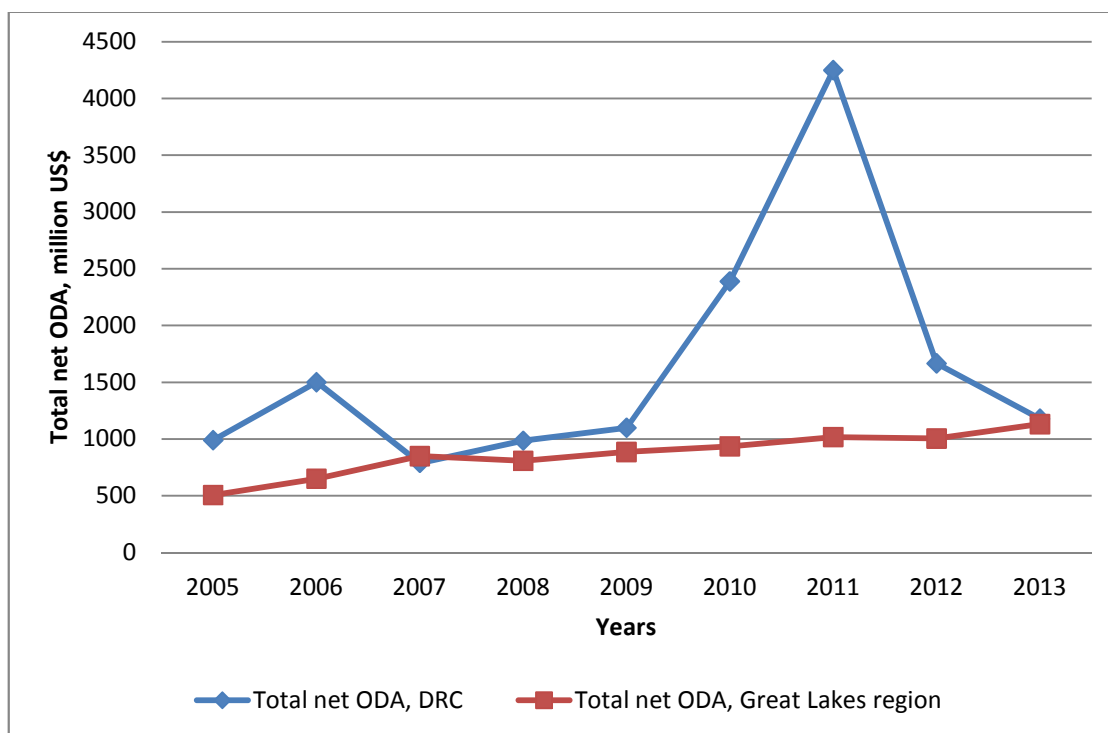(Source: OECD/DAC 1, edited by author)

To compare the DRC with other African countries the net ODA per capita is frequently used. The net ODA per capita for DRC is shown in the Graph 5. For the comparison author has chosen remaining 5 countries from the Great Lakes region, namely Burundi, Kenya, Rwanda, Tanzania, Uganda and calculated their average. Obviously the Democratic Republic of Congo is below the average of other countries from the region in majority of observed years except of 2010 and 2011.
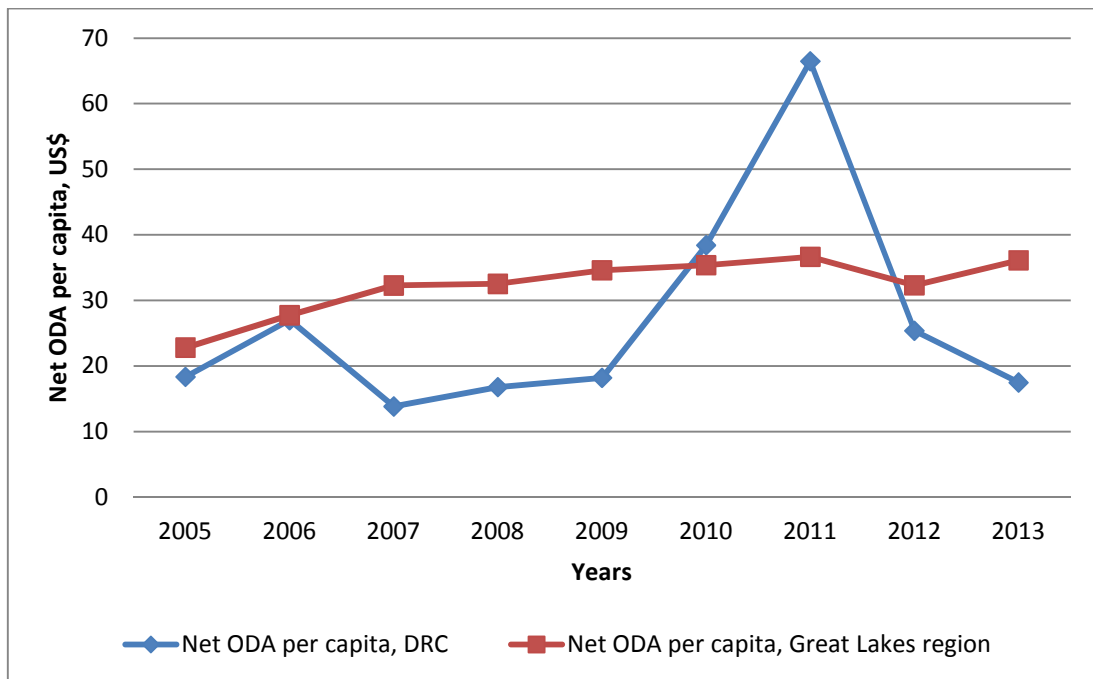
Graph 5: Net ODA per capita, 2005-2013 (US$)
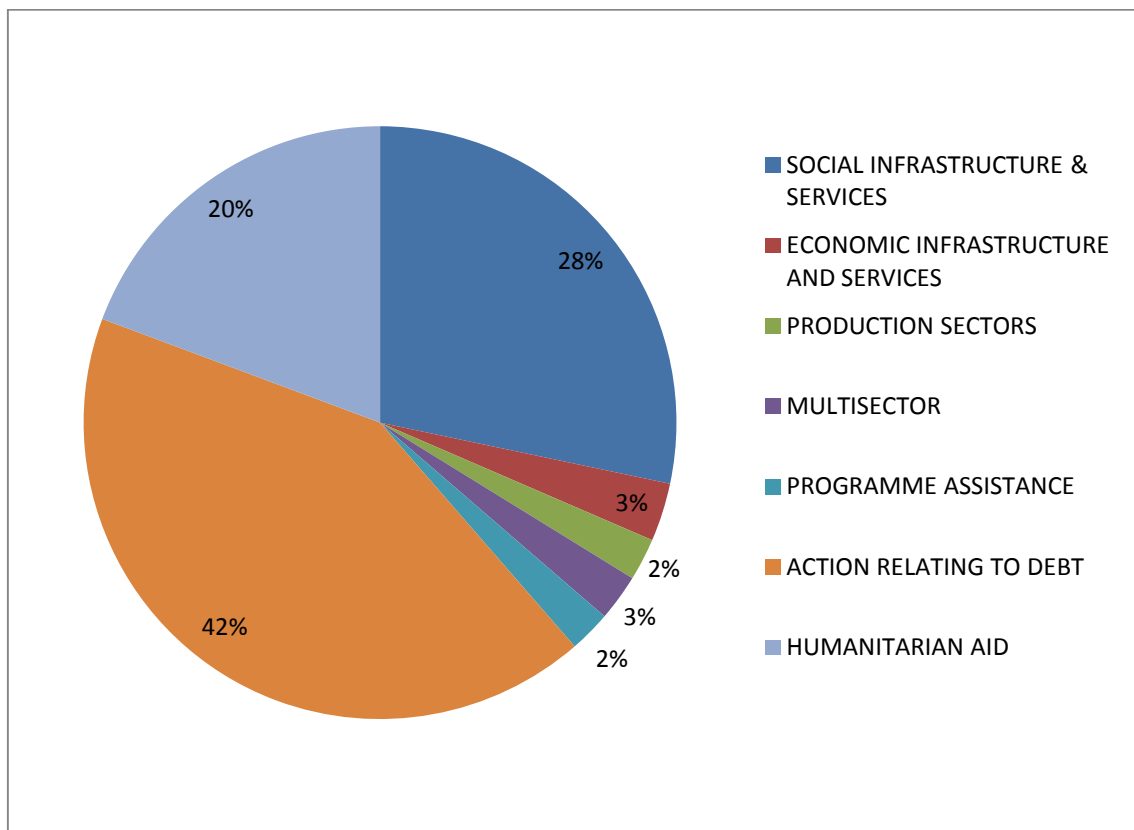(Source: OECD/DAC 1, edited by author)

When the total net ODA in DRC is compared to other countries in region it is above the average, see Graph 6. This difference between total net ODA and net ODA per capita could be caused by the two times higher number of citizens than is the average number of citizens in compared Great Lakes countries.

Graph 6: Total net ODA, 2005-2013 (million US$)

(Source: OECD/DAC 1, edited by author)

According to the survey in OECD statistics done by author, the most of Official Development Assistance financial sources in DAC flows into the actions relating to the debt 42%, followed by social infrastructure and services 28% where the education; water supply and sanitation belongs to (see Graph 7). The third largest sector where ODA flows is humanitarian aid with 20%. The transport and communication belongs together with energy into the economic infrastructure and services. In the frame of the economic infrastructure and services into the transportation and communication flows only 5%. The small portion of ODA assigned into transportation in DRC could be caused by the pervasive conflicts and thus by the unsatisfactory social conditions. Therefore there is considerable need of the government to invest into other sectors than is the transportation. The input data for the Graph 7 could be seen in Annex 4.

Graph 7: ODA in sectors, 2005-2013 (%)
(Source: OECD/DAC 2, edited by author)

Table 2 shows the distribution of Official Development Assistance in the transportation sector. It is obvious that the amount of money provided increases year by year. The biggest portion of money is flowing into the road transport. The government of the DRC realizes the necessity of the developed road network in order to achieve stable development of the country. Several projects to improve the infrastructure are supported and funded by donors, mainly by the World Bank, European Union and China. The water transportation is very common in DRC; it is a cheap mean of transport therefore small portion of ODA is flowing to this sector to improve the standards. The rail and air transportation sector received only small portion of ODA. It could be caused by the necessity to invest into the road sector because of the poor condition of the roads.

Table 2: ODA in transportation sector, 2005-2013 (milion US$)

(Source: OECD/DAC 2, edited by author)

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Transport and Storage, total	5,53	8,63	8,37	12,02	30,56	42,56	44,43	52,89	44,82
Transport policy and administration	2,08	4,04	3,64	0,31	0,13	0,01	NA	1,19	0,11
Road transport	3,45	4,55	4,69	11,67	29,93	39,5	37,92	50,64	44,52
Rail transport	NA	NA	NA	0,04	0,31	2,6	6,42	0,21	0,02
Water transport	NA	NA	0,02	0,01	0,04	0,31	0,07	0,02	0,01
Air transport	NA	NA	0,02	NA	0,15	0,03	0,02	0,83	0,16

The top donor in DRC in the period of 2012-2013 was International Development Assistance (IDA). It provided around US$461.6 million to DRC, followed by Germany and European Union institutions. Top ten donors and the amount of ODA provided in 2012-2013 could be seen in the Table 3.

Table 3: Top ten donors in DRC, 2012-2013 (million US$)

(Source: OECD/DAC 3, edited by author)

1.	IDA	461,6
2.	Germany	343,8
3.	EU institutions	310,4
4.	US	277,2
5.	UK	242,1
6.	Global Fund	160,8
7.	Belgium	138
8.	AfDB	116,8
9.	Japan	98,8
10.	AfDF	82,8

## 4.4 Transportation and infrastructure in DRC

The infrastructure in the Democratic Republic of the Congo is probably the most challenging in the Africa and even in the world. The transportation has always been difficult due to vast geography, low population density, a lot of forests, and big amount of rivers crossing the country. As a result of conflicts roads and railways are obliterated. On the other hand there are thousands of kilometres of waterways. Traditionally the water transportation has been the dominant way of moving around the country´s two-thirds. The Annex 5 shows the waterways graphically. The waterways can provide low-cost transport, with relatively modest investment to improvement of the current state. The need to invest into the infrastructure is according to World Bank one of the highest in Africa. (PWC, 2013)

Since 2003 when the peace was established, some progress has been made in terms of infrastructure. Thanks to the privately funded GSM network the two-thirds of population has a mobile telephone signals. External funding provided a possibility to rebuild the country´s road network as well as the air transportation has grown. In these days about half of existing infrastructure assets is in need of reconstruction. (Foster & Benitez, 2011)

According to the World Bank to rebuild the country and get to the same level as has the rest of developing world, the DRC needs to spend US$5.3 billion a year over the decade, which is 75% of its 2006 GDP.

The World Bank created the Logistic Performance Index (LPI) to help countries identify challenges they face in the performance on trade logistics. The LPI is based on the survey of operators on the ground. The LPI consists of six dimensions, these are *1) efficiency of the clearance processes* where belongs speed, simplicity and predictability of formalities, *2) quality of trade and transport related infrastructure* e.g. ports, railroads, roads, information technology, *3) ease of arranging competitively priced shipments, 4) competence and quality of logistic services,* this includes for example transport operators, and customs brokers, *5) ability to track and trace consignments, 6) timeliness of shipments in reaching destination within the scheduled or expected delivery time.* Performance is measured on the scale from 1 (the lowest performance) to 6 (the highest performance). (World Bank 3, 2015)

It is obvious from the Graph 8 that the performance of DRC has decreased since 2012. This could be caused by the lower amount of money provided by Official Development Assistance. In 2015 was DRC on 159th place from 160 countries observed, while in 2012 it ranked 143 from 155 countries.
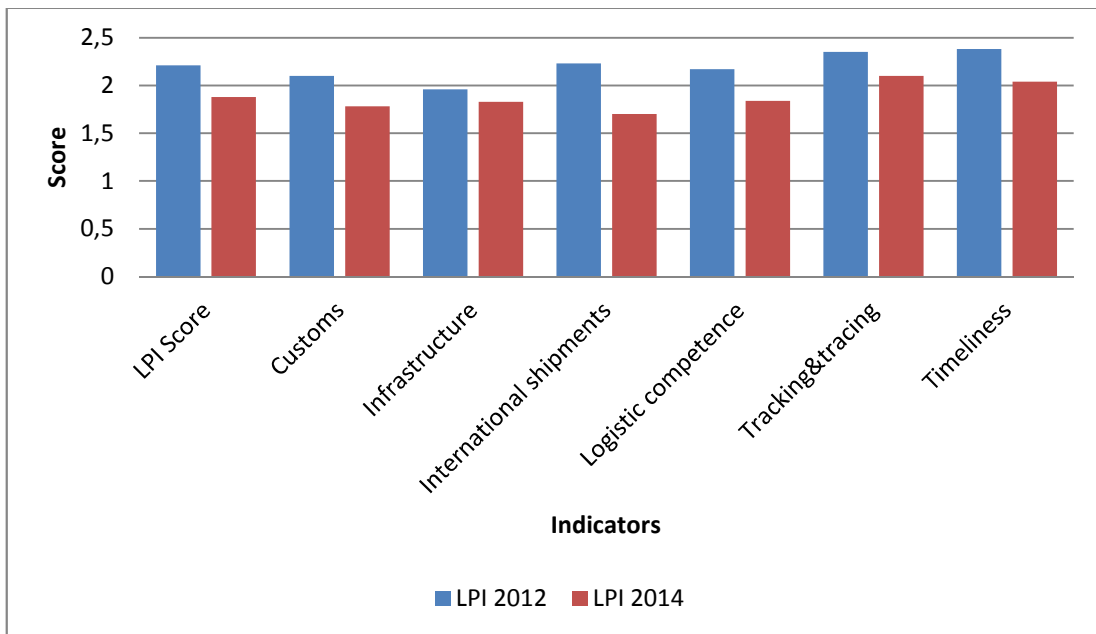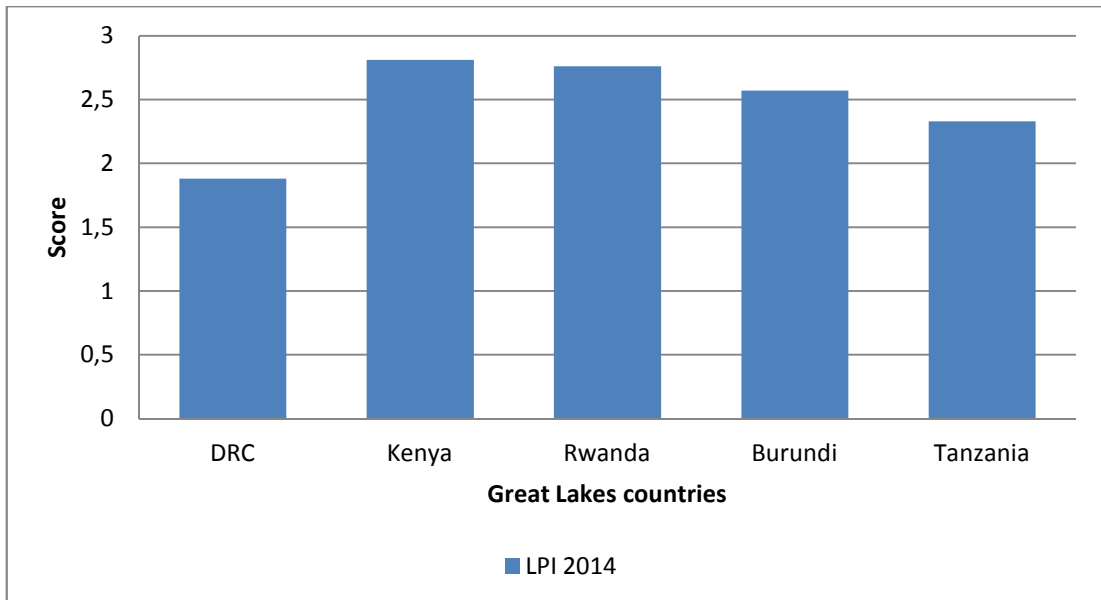

Graph 8: Logistic Performance Index and its subcategories for DRC, 2012 and 2014

(Source: World Bank 4, edited by author)

In the Graph 9 the comparison of LPI of the Great Lakes countries can be observed. DRC had in 2014 the lowest score of LPI. It could be assumed that this is caused by the poor infrastructure in all fields of transportation as well as by poor services provided. The best score from the region reached Kenya ranking 74th place from 160 countries observed. Rwanda ranked 80th place, Burundi 107th, and 138th place in 2014.

Graph 9: Logistic Performance Index for Great Lakes countries, 2014

(Source: World Bank 4, edited by author)

4.4.1 Road transport

Lack of adequate roads is a major problem influencing the development of the almost all area of DRC. The roads since colonial time and continuing into 1970 have been subordinated to the waterways. Just a few roads remain in good condition. Thanks to the progress in mobilizing external resources the road network has been reconstructed in some areas. Since the end of the conflict, reconstructing the road network has been a top priority. A lot of multilateral and bilateral donors, as well as China support the road development. The money from donators covers a lot of major corridors linking Kinshasa and Lubumbashi. (Foster & Benitez, 2011)

Many parts of the DRC are not accessible by road. From ten provincial principal towns only two (Matadi, Bandundu) are connected with the capital city Kinshasa by a road. Two of them are accessible by water (Kinsangani, Mbandaka) and the remaining six (Kananga, Mbuji Mayi, Lubumbashi, Kindu, Goma, Bukavu, and Kisangani) by air. (Logistic Capacity Assessment 1, 2014)

The road network in DRC consists of 58,358 km of national road; 86,615 of rural roads; and 7,400 km of urban road. According to estimates, around 5% of the national roads are sealed. (Logistic Capacity Assessment 1, 2014)

As per the official classification the road network could be divided into four main official categories. These are *1) national roads, 2) priority regional roads, 3) secondary regional roads,* and *4) local roads*. Since the most of the roads are damaged or inexistent this subdivision remains theoretical. The Observatorie National des Transports claims that the entire national road network in the Democratic Republic of the Congo was in 2011 about 152,400 km long, with 21,136 km of national roads; 20,124 km of priority regional roads; and 17,245 km of secondary regional roads. (Observatorie National Des Transport, 2011)

The Table 4 provides information about the length of the national roads, priority regional and secondary regional roads in the eleventh provinces of DRC.

Table 4: Roads length in DRC by province, 2011 (km)

(Source: Observatorie National Des Transport)

Province	National roads	Priority regional roads	Secondary regional roads	Total km
Bas-Congo	1370	891	869	**3130**
Bandundu	2215	3566	3160	**8941**
Équateur	2970	2781	3158	**8909**
Orientale	3699	3484	3075	**10258**
Sud-Kivu	1037	873	0	**1910**
Nord-Kivu	833	524	389	**1746**
Maniema	1071	1183	1543	**3797**
Katanga	4258	4054	2958	**11270**
Kasaï Occidental	1985	1141	859	**3985**
Kasaï Oriental	1446	1627	1234	**4307**
Kinshasa	252	NA	NA	**252**
Total	**21136**	**20124**	**17245**	**58505**

The National roads has been managed by Office des Routes (Roads authority of DRC) since 1972. Local roads are controlled by the Direction des Voies de Desserte Agricole (DVDA). All urban roads are under the management of Office des Voiries et Drainage. (Logistic Capacity Assessment 1, 2014)

Major role for road rehabilitation play several world organizations. Majority of the infrastructure projects are controlled by the European Union and the World Bank. The main goal is to rehabilitate three main corridors of DRC to unlock the country and thus support the development. (UNJLC, 2015)

Extensive number of bridges and ferries exist to cross the rivers in the country, unfortunately their condition is poor; however they are major bottleneck for road transportation. Around 20,000 bridges and 325 ferries occur in the country; majority of them have not been replaced or reconstructed at all. Under the responsibility of the Office des Routes the road network was comprised of 1,886 bridges in 2011. Over 90% of these bridges are in poor condition. In the Table 5 the distribution of the bridges by province and type in 2011 can be seen. (Logistic Capacity Assessment 1, 2014)

Table 5: Number of bridges by province and material, 2011

(Logistic Capacity Assessment 1, edited by author)

| Province	Wooden	Metallic	Reinforced concrete	Total
Bas-Congo	144	129	84	357
Bandundu	157	82	59	298
Équateur	7	109	7	123
Orientale	112	123	95	330
Sud-Kivu	77	47	20	144
Katanga	17	110	81	208
Kasaï Oriental	8	57	13	78
Kasaï Occidental	23	40	13	76
Kinshasa	0	2	12	14
Nord-Kivu	81	18	25	124
Maniema	65	33	36	134
Total	691	750	445	1886

There is only little reliable detailed information on road infrastructure however it is known that the large portion of the roads is in poor condition. In the Table 6 the condition of national roads could be observed. The term "National roads" covers in this table the National roads, Priority regional roads, and the Secondary regional roads. (Logistic Capacity Assessment 1, 2014)

Table 6: State of national roads by province, 2013 (km)

(Logistic Capacity Assessment 1, edited by author)

Province	National roads	Good	Fair	Poor	Unknown
Bas-Congo	2592,3	842,5	326	418,5	1005,3
Bandundu	8286,25	1380,2	606	1510,5	4789
Equater	8407,2	639,7	470,3	2602,2	4695
Kasaï Occidental	3842,5	233,6	340	1765	1504
Kasaï Oriental	3833,3	368,8	354,7	1768,3	1341,5
Katanga	10851,4	1917	1193,4	2173,5	5567,5
Kinshasa	367	341,7	18,1	7,2	NA
Maniema	3365,5	285	288,1	927	1865,4
Nord-Kivu	1526,6	668,3	476	289,5	92,8
Orientale	10973,4	1326	897	2398	6352,4
Sud-Kivu	2715	558,7	461,4	464,2	1230,7

However no reliable data on the length of the roads in DRC exists, it can be assumed from the fuel consumption that the road network is used more frequently in DRC. The consumption of both gasoline and diesel increases since 2005. The Graph 10 indicates the consumption of gasoline fuel and diesel fuel in years 2005-2011.
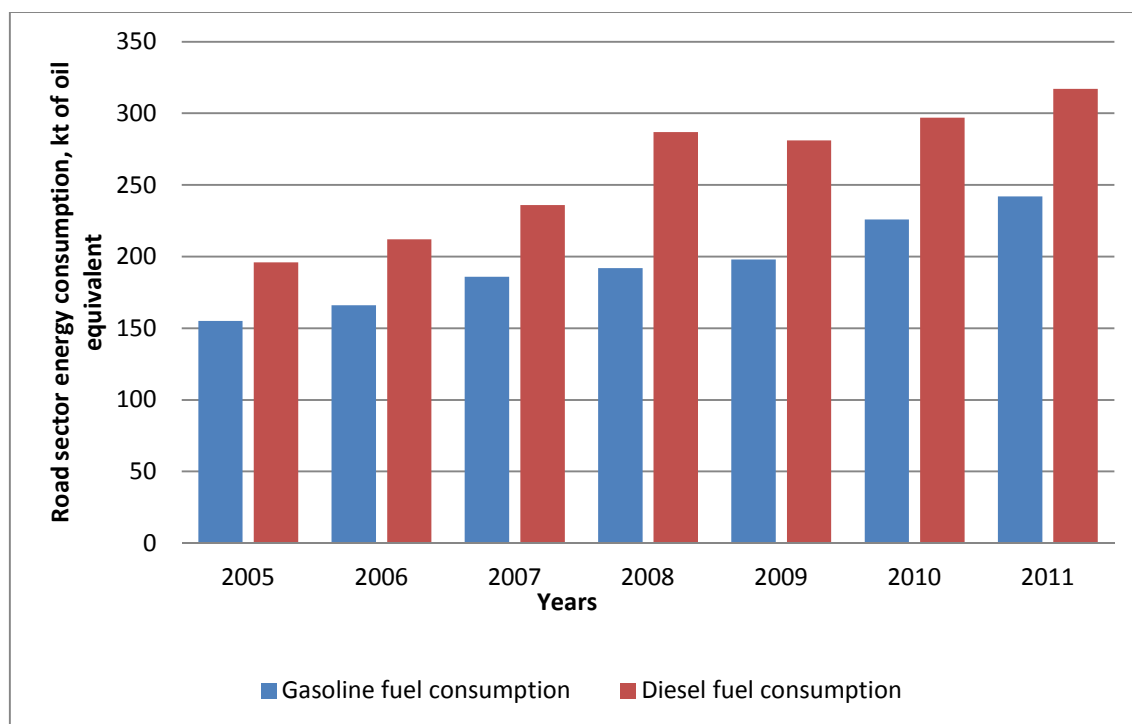
Graph 10: Gasoline fuel and diesel fuel consumption, 2005-2011 (kt of oil equivalent)

(Source: World Bank 2, by author)

4.4.2 Railway transport

The DRC has two main rail systems which have strategic significance for the country. These are Chemin de Fer Matadi-Kinshasa (CFMK) run by Office National des Transports (ONATRA) and the Société Nationale des Chemins de Fer du Congo (SNCC). The railway network consists of 5,033 km non-interconnected railway lines. The condition is poor and some of them are not currently in use. (Logistic Capacity Assessment 2, 2014)

ONATRA operates rail link from Kinshasa to the port of Matadi which is 366 km long. The track is 30 years old and therefore in acceptable condition. The single-track is electrified and there is road access at four major junctions. The network serves for timber exports and other bulk traffic that is not time sensitive; this includes imports to the city of Kinshasa. (AICD, 2010)

SNCC operates railway network centred in the south-east of the country. The most important part of this rail is the connection of Kolwezi on the Zambian border with the Katanga region as well as with Ilebo on the west. The network is in poor condition so the speed limit is set to 10-35 km per hour. The network is widely used for export of copper leaving the DRC for the port of Durban. After the end of reconstruction of the Benguela Railway it will offer the opportunity to export copper through Lobito in Angola (AICD, 2010)

According to Logistic Capacity Assessment the SNCC manages multimodal transport system which consists of interconnected rail network 3,641 km long; 858 km is electrified; network on the Lake Tanganyika which is 1,425 km long and connects DRC to Zambia, Tanzania, and Burundi; a network on the Lake Kivu that links Bukavu to Goma (106 km), and Kalundu-Bukavu road network 128 km long; and a river system of the medium Reach from Kindu to Ubundu 310 km long, and the upper reach from Kongolo to Malemba-Nkulu which is 390 km long. (Logistic Capacity Assessment 2, 2014)

The Les Chemins de fer des Uélé controls the network that connects Bumba in Bondo however this line is not used. (Logistic Capacity Assessment 2, 2014)

Two main international railway lines can be found in the Democratic Republic of Congo. The Tanzania-Zambia Railway Authority (TAZARA) connects the Southern African regional transport network to East Africa and the rest of the world through the seaport Dar-es-Salaam in Tanzania. The rail line runs from Dar-es-Salaam to the Town of Kapiri Mposhi in Zambia. There it connects the Zambia Railways system and the Congolese railways SNCC. (Logistic Capacity Assessment 2, 2014)

Second important international railway is from Dar-es-Salaam to Kigoma in Tanzania which is 1,254 km long. The railway serves parts of Nord-Kivu, Sud-Kivu and Katanga provinces in DRC. The goods arriving from Dar-es-Salaam to Kigoma by rail are then transported by boat to Bujumura and Kalemie in DRC and thereafter there are transported inside the DRC. (Logistic Capacity Assessment 2, 2014)

Both Congolese rail networks are faced with the traffic decline. This is caused by decrease in quality of services and strong intermodal competition. This mean of transportation plays no more its historical roles. The DRC´s road network undergoes

extensive rehabilitation therefore it is used more frequently than the railways. Due to the imperfections in services as well as the discriminatory pricing of Congolese copper by the Zambian rail operator the majority of copper is transported by roads. As a result the railways do not play the crucial role in Congolese economy. (AICD, 2010)

The Graphs 11 and 12 show the decline in amount of goods as well as passengers transported in years 2005-2012.
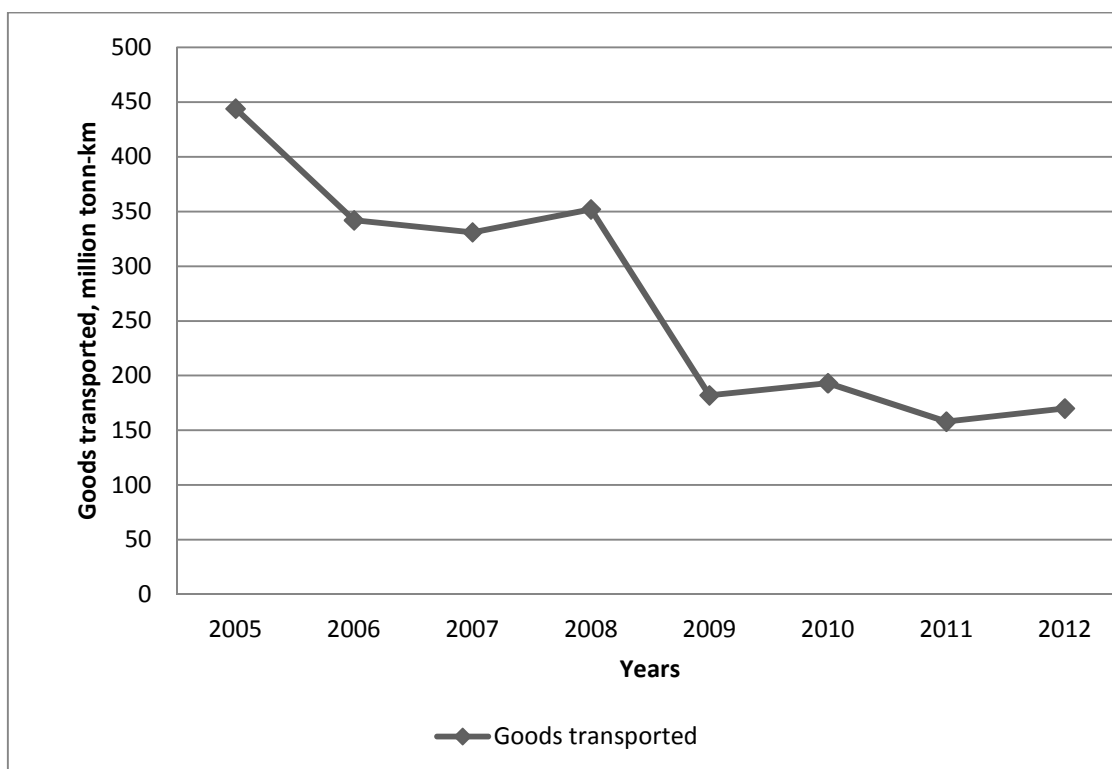
Graph 11: Railway transport: transported goods, 2005-2012 (million tonn-km)

(Source: World Bank 2, edited by author)

In addition the networks suffer from high tariffs and very poor efficiency. Compared to Angola, Cameroon, Congo, and Gabon the efficiency parameters of Democratic Republic of Congo are only a fraction. Freight tariffs at US$0.13 – 14 per tonne-km are almost three times higher than elsewhere in southern Africa. Railway traffic density is therefore less than half of those found in other states in region. (AICD, 2010)
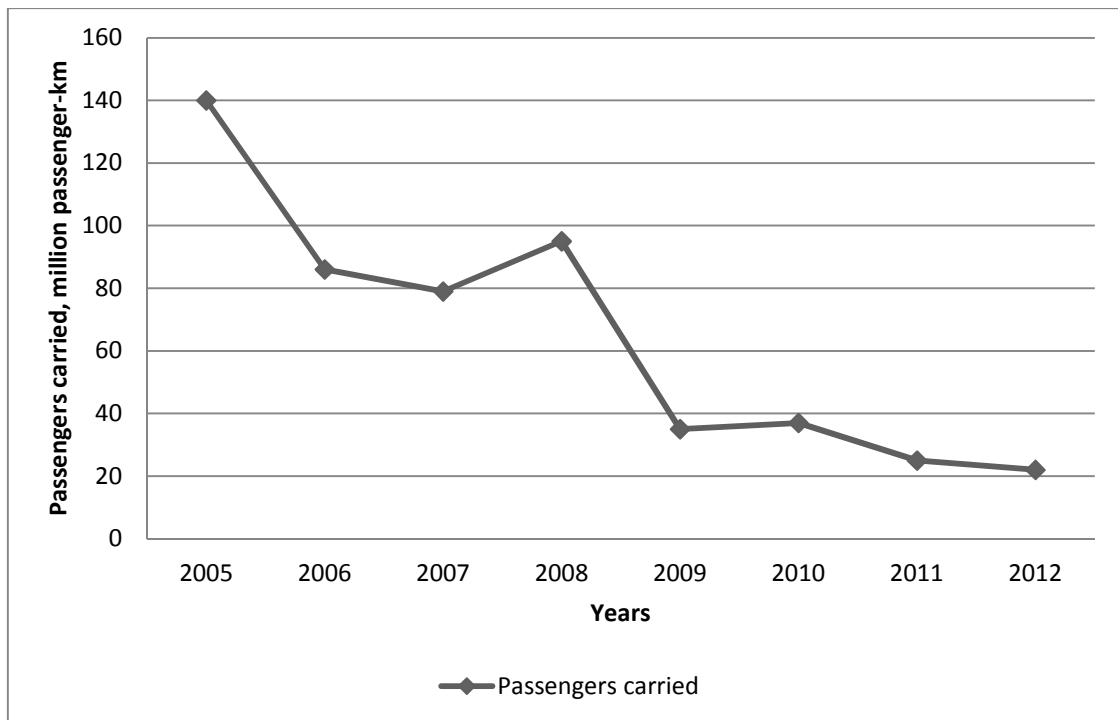
Graph 12: Railway transport: passengers carried, 2005-2012 (million passenger-km)

(Source: World Bank 2, edited by author)

Main attention in terms of reconstruction of railway lines is paid to the area where copper is being mined. In 2013 representatives from Chinese manufacturer CNR, the Bank of Congo, and a Chinese export consortium signed a contract for eighteen diesel-electric locomotives. These will serve the customers of Société Nationale des Chemins de fer Congolais (SNCC). The order is part of the National multimodal transport project under the World Bank. (Railways Africa, 2014)

The project does not focus only at the railways but on the transport infrastructure as a whole. The three objectives of the project are 1) *to improve transport connectivity and thus support national economic integration*, 2) *to restore Societe nationale des chemins de fer du Congo financial and operational viability*, and 3) *to implement sector wide governance plan and strengthen transport Stated Owned Enterprises operational performance*. The project complies with the goals of the Government of DRC, these are to promote macroeconomic stability and economic growth through the rehabilitation of key transport infrastructure and improve governance and consequently improve the provision of social services and reduce the level of poverty. (World Bank 5, 2013)

4.4.3 Air transport

Due to the vast area of DRC, poor road and railway infrastructure, natural obstacles such as rivers and rugged topography, the country is strongly dependent on air transportation. According to information from Master Nation the DRC was in 2013 endowed with 189 airports, only 26 of them had paved runways. Nevertheless the airport infrastructure is in poor condition and shortage of air navigation equipment occurs. Consequently the air transportation is not able to fulfil its functions appropriately. (Nation Master, 2013)

Airports in the country has been build since approximately 1920 and they have never been rehabilitated thus the condition of the runways is in insufficient condition. According to LCA the airports and services provided do not comply with international standards; for example a lot of control towers do not provide 360° panoramic view as internationally demanded. It could be said that the air transportation in DRC is risky due to outdated or missing navigation equipment, depending on airports. LCA claims that air infrastructure suffers from the lack of legal and regulatory framework and resources that would ensure the air security. The consequences of inappropriate services and air transport conditions are severe. There is extensive number of incidents, more than 50% of plane crashes on the African continent. In DRC on average 22 accidents per year take place. Due to the very poor condition the airlines registered in DRC are on the blacklist of European Union, and furthermore the airports are under the sustained threat of closure. (Logistic Capacity Assessment 3, 2014)

According to World Bank the number of domestic air transport routes has significantly increased and the aircraft fleet has gone under the renewal. In 2011 eight airports and 14 airlines had scheduled advertised services. (Foster & Benitez, 2011)

The International Civil Aviation Organization (ICAO) realizes the urgent need of rehabilitation of airports as well as the necessity to build air navigation control and supervision capacity. Correspondingly the government of DRC prepared extensive programme to develop airport infrastructure and equipment over the 2010-2015 period. The programme has been prepared through the Régie des Voies Aérienne (RVA) that is responsible for managing airports and air navigation safety. During the programme around US$642 million will be invested. (Logistic Capacity Assessment 3, 2014)

The Régie des Voies Aériennes (RVA) was established on 21 February 1972 as a technical and commercial corporation owned by state. The RVA was created to maintain, develop and operate the airports, to manage airspace and ensure the safety of air navigation. As well the organization is responsible for the commercial exploitation of airport equipment and facilities, and training of the staff. The airports controlled by RVA are divided into three classes: *1) International airports* are further divided into Senior international airports and First class international airports. Into this category belong 6 of the airports managed by RVA; 14 airports are classified as *2) national airports*; and finally 34 airports are *3) airfields.* (Logistic Capacity Assessment 3, 2014)

The overview of selected airports:

- Kinshasa N´Djili International Airport

The airport is classified as senior international airport (see the classification above) and is the largest of the six international airports in DRC. It is placed in the capital city Kinshasa. However the airport has great importance and is the most senior from the airports controlled by RVA it does not correspond with the international standards and there is small place to growth. In the current period the rehabilitation of runways takes place. In the Table 7 the statistics of total aircraft movements and total passengers carried in 2012 are illustrated. (Logistic Capacity Assessment 4, 2014)

**Table 7: Kinshasa N´Djili International Airport, 2012**

(Source: Logistic Capacity Assessment 4, edited by author)

	Domestic	International	Total
Passengers	320406	406679	727085
Movements	11688	6966	18654

- Goma First Class International Airport

The international airport lies in the city Goma, province Nord-Kivu. The airport is in poor condition due to the eruption of volcano Nyirangongo in 2002. The stream of fluid lava flowed on the runway and in the city and since that event the airport has not undergone the reconstruction. The 2 km long destroyed runway is used by the population living around the airport as a shorter route to both sides. (Logistic Capacity Assessment 5, 2014)

The rest of airports do not have adequate infrastructure nor offer good services. Lot of the airports lack the terminal buildings, separate freight/passenger facilities and do not poses any inspection.
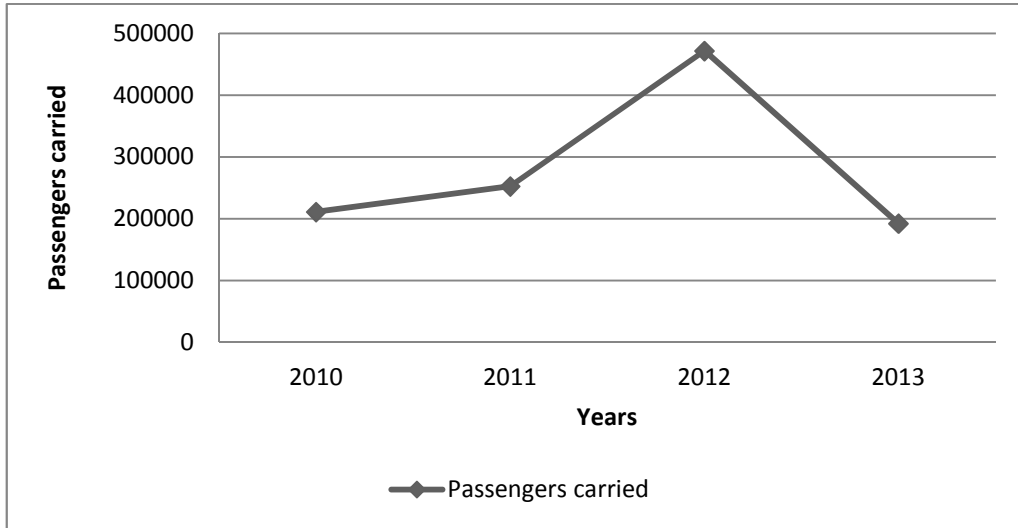
Graph 13: Air transport: Passengers carried, 2010-2013

(Source: World Bank 2, edited by author)

The Graph 13 illustrates number of passengers carried in 2010-2013, Graph 14 then the registered carrier departures. It is assumed that due to great decrease in ODA provided to Democratic Republic of Congo and due to continuing violence specifically in North and Sud-Kivu where the important airports such as Goma, Bukavu and other small airports are located, the amount of passengers carried and departures decreased significantly.
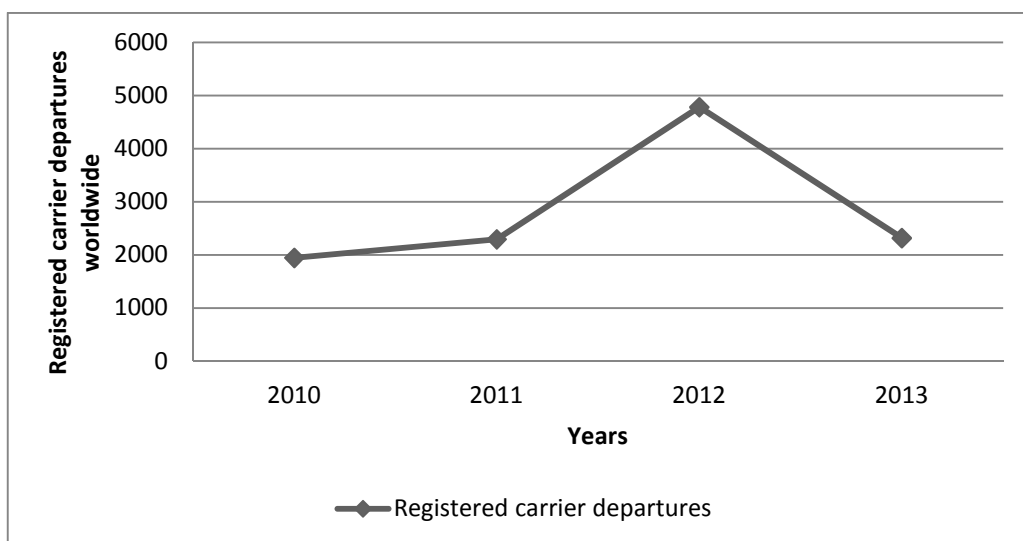
Graph 14: Air transport: Registered carrier departures worldwide, 2010-2013

(Source: World Bank 2, edited by author)

4.4.4 Water transport

Water transportation plays in the Democratic Republic of the Congo significant role. Around 15,000 km of the Congo River and its major lakes are navigable. The Congo River is the second largest river in Africa after the Nile River. It has homogenous distribution of the tributaries therefore it enables the river to have the best river rate of flow in Africa.

The river network is divided into four sections called navigable reach. The reach is often connected by rail. The four navigable reaches in DRC are: *1) the lower reach* of the Congo River in the west, it is 140 km long form Banana to the port of Matadi; *2) the middle reach* in the north and in the centre of the Congo River Basin composed of two axes Kisangani-Kwamouth and Illebo-Kwamouth; *3) the upper reach* in the east composed from two axes as well, these are Ubundu-Kindu and Kongolo-Bukama; *4) the chain of lakes* including Mweru, Tanganyika, Kivu, Edward, and Albert. (Logistic Capacity Assessment 6, 2014)

During the colonization barges were widely used as mean of transport. In these days the river is used for export of timber products to Kinshasa, from there the goods continue by road and rail to Matadi. Costs per kilometre on waterways are only a fraction of the costs per kilometre of road. Unfortunately during the dry season, around four months, long parts of the rivers are not navigable. Another obstacle to efficient water transportation is deficiency of investment in navigation aids and port facilities. The majority of river transport is provided by private operators. (World Bank 6, 2010)

It can be said that DRC is predominantly landlocked and have poor connections to the sea. As well the port infrastructure and connections to the ports are poor due to the vast area of the country. There are two main ports in the republic, Boma and Matadi. Both ports have low capacity and low draught therefore they are unable to fill the needs of western part of DRC. (PWC, 2013)

The overview of selected ports:

- Port of Matadi

Matadi is the most important maritime port in DRC with 90% maritime traffic, it has a handling capacity of 2.5 million metric tons of cargo per year. The port of Matadi is a feeder port serving Kinshasa and the southwest area of DRC. The port has started to upgrade its installation according to International Ship and Port Facility Security (ISPS) Code. With Kinshasa the port is connected by railroad. (Logistic Capacity Assessment 7, 2014)

- Port of Boma

The port was established in 1889, since the inception the port was intended to transport the agriculture and forestry products in the Mayombe region. It is the second largest maritime port in DRC after the port of Matadi. The official draft is limited and thus the access of small vessels fully loaded and big vessels partially loaded is limited as well. (Logistic Capacity Assessment 8, 2014)

- Port of Banana

The Banana port is located in Muanda region. Thanks to the presence of oil exploitation in the region the port acts as an interface between the onshore and offshore, and also coordinates the inter-harbor and inter-bank traffic. The port plans in the future to install video surveillance according to the ISPS, and to improve current state of the port. (Logistic Capacity Assessment 9, 2014)

In the Table 8 the performance of above described ports in 2012 can be observed.

Table 8: Ports of Matadi, Boma, Banana, 2012

(Source: Logistic Capacity Assessment 7,8,9, edited by author)

	Matadi	Boma	Banana
Vessel Calls	504	144	48
Container Traffic (TEUs)	2652983	39563	20223
Bulk	2211025	39563	28645
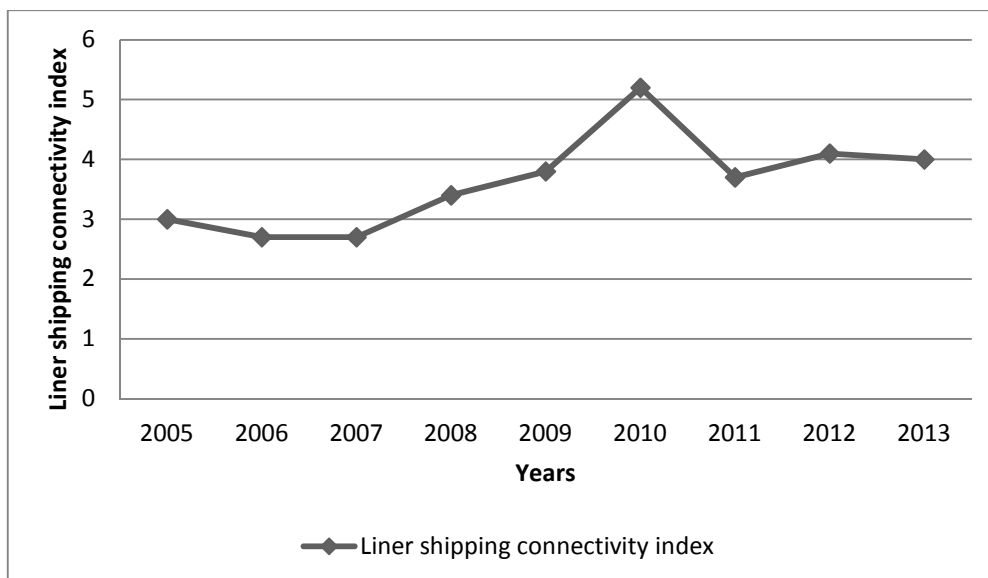
Graph 15: Water transport: Liner shipping connectivity index, 2005-2013

(Source: World Bank 2, edited by author)

In the Graph 15 the Liner shipping connectivity index for DRC is depicted. The index is computed by the United Nations Conference on Trade and Development (UNCTAD) and captures how well countries are connected to global shipping networks. The index is based on five components, these are: *1) number of ships, 2) container-carrying capacity, 3) maximum vessel size, 4) number of services,* and *5) number of companies that deploy container ships in a country´s ports.* The liner shipping connectivity index is measured on the scale from 0 (the worst) to 100 (the best). In 2013 DRC reached 4.0 which place the country among the worst in the world.

4.5 Road network evaluation

The chapter deals with the analysis of road infrastructure quality based on morphological factors chosen for the diploma thesis. Those factors are accessibility, deviatility, connectivity and density.

The factors were used to examine nine of eleven regions in the Democratic Republic of the Congo. Kinshasa region was excluded from the examination due to the fact this region composes only of the capital city Kinshasa. Second excluded region is Equater. Through the Equater region river Congo flows, and thus almost none connection that would be based only road network exists. To reach the biggest cities in northern and southern part of the province it is needed to use water or air transport. These reasons led to the decision to exclude the regions from analysis.

In each province five biggest cities were chosen. To analyze the road condition few conditions had to be fulfilled. First, the most used National (N) and Regional (R) roads were chosen to avoid unpaved roads as most as possible. However as analysed in the previous chapter in some cases it is not feasible. Second, the road from one city to another could pass through neighbouring province in case it was the shortest possible network.

4.5.1 Deviatility

To calculate deviatility of the Democratic Republic of the Congo as a whole, it is needed to calculate deviatility of each region; consequently the results have to be averaged.

Bandundu province has been chosen to demonstrate the calculation of the shortest road distances and direct distances among five biggest cities in the region. Deviatility is then calculated as the shortest road distance divided by the direct distance among the cities.

Table 9 provides an overview of road network distances among chosen cities in Bandundu province and their sum.

Table 9: Road network distance among chosen cities of Bandundu province (km)

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum
Bandundu	Xxx	393	545	313	439	
Kikwit	393	xxx	155	86,1	267	
Idiofa	545	155	xxx	238	419	
Bulungu	313	86,1	238	xxx	242	
Kenge	439	267	419	242	xxx	
Sum of length	1690	901,1	1357	879,1	1367	6194,2

Table 10 illustrates direct distances among chosen cities and their sum as well as the deviatility of each city. The average deviatility was then used to calculate average deviatility of DRC.

Table 10: Direct distance among chosen cities of Bandundu province (km), deviatility

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Average
Bandundu	Xxx	246	305	192	166	
Kikwit	246	xxx	86	59	198	
Idiofa	305	86	xxx	119	283	
Bulungu	192	59	119	xxx	175	
Kenge	166	198	283	175	xxx	
Sum of length	909	589	793	545	822	3658
Deviatility	1,86	1,53	1,71	1,61	1,66	1,68

The Table 11 provides overview of values of deviatility for all analysed regions. The values were calculated in the same way as the values for Bandundu region.

From the calculated data it is obvious that the highest deviatility reached Maniema province with 3.16. It is caused by the insufficient road connection. The roads have been destroyed during the long lasting turmoil in eastern part of the country. Moreover Maniema is the most isolated province in the country. The connection among its cities as well as with other provinces is very poor. The second worst province is Sud-Kivu neighbouring to Maniema with deviatility 2.32. The province is characterized with low road density in respect to its area and by greater number of hills.

On the other hand the province with lowest deviatility 1.37 is mineral rich province Katanga. This number is caused by the location of cities and good roads density. However the deviatility reached the best value from DRC, the roads are in poor condition.

Table 11: Deviatility for all regions and average value of DRC

(Source: Google Earth, edited by author)

	Deviatility
Bandundu	1,68
Bas-Congo	1,44
Kasai-Occidental	1,56
Kasai-Oriental	1,43
Katanga	1,37
Maniema	3,16
Nord-Kivu	1,38
Orientale	1,88
Sud-Kivu	2,32
DRC	**1,80**

4.5.2 Accessibility

Accessibility as one of the most important indicators measures how easy is to reach the hubs in the road network or on the other hand how many obstacles are on the route. To measure the accessibility the distance among the cities is used. Results are expressed in kilometres.

In the Table 12 the overview of shortest road network distance among the hubs is measured, the values are summarized, followed by the calculation of accessibility expressed in kilometres.

Table 12: Road network distance among chosen cities of Bandundu province, accessibility (km)

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Average
Bandundu	xxx	393	545	313	439	
Kikwit	393	xxx	155	86,1	267	
Idiofa	545	155	xxx	238	419	
Bulungu	313	86,1	238	xxx	242	
Kenge	439	267	419	242	xxx	
Sum of length	1690	901,1	1357	879,1	1367	
Accessibility	338	180,22	271,4	175,82	273,4	247,77

The calculation of accessibility is illustrated on the Bandundu province. At first, the shortest possible road distances among five biggest hubs in the province were measured and summed up for each city, consequently divided by the number of analysed hubs in the road network, i.e. five.

Accessibility for the province has been calculated as an average value of accessibilities for the cities. As obvious from the Table 13, the accessibilities vary significantly from region to region. This result is caused by great differences in area of the provinces and their shapes. Considerable role plays also the percentage of mountains, rivers, natural parks and forests.

The worst accessibility reached Orientale province mainly because of its large area, moreover it lies on southeast which is affected by the continuous crimes and fights thus the connection among cities is poor. Despite the prolonged shape of Kasai-Oriental province, the accessibility is the lowest from the nine analysed provinces. This is caused by the cumulation of the most significant hubs in a very small area in the south. The connection between southern and northern part is via less important roads and by air transportation to the city Lodja in the southern part of the province. The Nord-Kivu is province with second lowest accessibility, due to its small area and concentration of the hubs in eastern part of province.

Table 13: Accessibility for all regions and average value of DRC (km)

(Source: Google Earth, edited by author)

	Accessibility
Bandundu	247,77
Bas-Congo	192,99
Kasai-Occidental	202,38
Kasai-Oriental	95,05
Katanga	244,59
Maniema	410,82
Nord-Kivu	140,02
Orientale	615,68
Sud-Kivu	266,62
DRC	**268,44**

4.5.3 Hierarchy

Hierarchy indicator is closely connected to the accessibility of the road network. Three ways of assessing hierarchy in the provinces were used in the thesis. The first used is the hierarchy according to the number of direct connections among the hubs, hierarchy according to the sum of connections of the hubs with the remaining hubs of given road network, and finally the hierarchy according to the sum of the distances from one hub to the others.

Table 14 shows the hierarchical level of hubs according to the direct connections among the hubs again in Bandundu province. It is valid that the more the direct connections among the hubs the higher the hierarchical level. To evaluate the hierarchical level values from 1 to 5 were used, where 1 is the lowest and 5 is the highest hierarchical level.

Table 14: Direct connections among the hubs in Bandundu province, hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	1	0	1	1	3	**2.**
Kikwit	1	xxx	1	1	1	4	**3.**
Idiofa	0	1	xxx	0	0	1	**1.**
Bulungu	1	1	0	xxx	1	3	**2.**
Kenge	1	1	0	1	xxx	3	**2.**

Table 15 provides an overview of the sum of connections among the hubs in Bandundu province again. The same rule of evaluation of the level is imposed. However in this case the bigger the sum of connections is the lower the hierarchical level is.

Table 15: Sum of connections among the hubs in Bandundu province, hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	1	2	1	1	5	**2.**
Kikwit	1	xxx	1	1	1	4	**3.**
Idiofa	2	1	xxx	2	2	7	**1.**
Bulungu	1	1	2	xxx	1	5	**2.**
Kenge	1	1	2	1	xxx	5	**2.**

The Table 16 shows the level of hierarchy according to the sum of the road distances among the hubs in Bandundu province. The hierarchical level is the lowest when there are the greatest distances among the cities.

Table 16: Sum of the road distances among the hubs in Bandundu province (km), hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	393	545	313	439	1690	**1.**
Kikwit	393	xxx	155	86,1	267	901,1	**4.**
Idiofa	545	155	xxx	238	419	1357	**3.**
Bulungu	313	86,1	238	xxx	242	879,1	**5.**
Kenge	439	267	419	242	xxx	1367	**2.**

From the tables it is apparent that the city with the highest hierarchical level is Kikwit in two ways of measurement. It is the largest city of Bandundu province. It is important administrative and commercial centre; it has its own airport; the city is connected to the capital city Kinshasa by a new road as well as by the river transportation.

4.5.4 Connectivity

Connectivity has been used as other indicator of the DRC road network efficiency. It indicates the level of connection among communication hubs. Generally, the connectivity is calculated as ratio of real number of connectors among transportation hubs to maximal number of connectors among transportation hubs. As an input the maximal number of hubs has been calculated using the formula: $S_{max} = \frac{1}{2} \times u \times (u - 1)$, where u is number of transportation hubs. In case of the thesis the number of hubs is equal to 5 for all provinces. The maximal value of connectivity is 1. It means that the closer the connectivity is to 1 the better the efficiency of road network in analysed area.

Table 17: Connectivity for all regions and the average value for DRC

(Source: Google Earth, edited by author)

	Sd	Smax	Connectivity
Bandundu	7	10	0,7
Bas-Congo	4	10	0,4
Kasai-Occidental	6	10	0,6
Kasai-Oriental	6	10	0,6
Katanga	5	10	0,5
Maniema	4	10	0,4
Nord-Kivu	4	10	0,4
Orientale	7	10	0,7
Sud-Kivu	6	10	0,6
DRC			0,5

From Table 17 it is obvious that the average connectivity is 0.5. It can be observed that the best connectivity has Bandundu province and Orientale province. There is high density of the national and regional roads in surrounding of the most significant transportation hubs; to observe only national and regional roads was set as an input condition to the measuring of connectivity. On the other hand through the Maniema province only one National road passes as well as it passed through the Nord-Kivu province. However the density of roads in Bas-Congo is relatively good, the roads either did not fulfilled the conditions or they connect the hubs that were not analysed.

4.6 Correlation of ODA and transport network indicators

To calculate the relationship among Official Development Assistance and the indicators related to the transport infrastructure the data from World Bank database have been used.

The correlation coefficient ranges between -1 and +1. If the value of correlation is +1 it means perfect positive correlation, i.e. as one variable move, either up or down, the other variable moves in the same direction. Conversely, value -1 means perfect negative correlation, i.e. as one variable move in either direction, the second variable moves in opposite direction. If the value is 0, there is no relationship between variables.

The overview of analysed correlation is illustrated in the Table 18 below.

Table 18: Correlation of ODA and transport infrastructure indicators

(Source: Author´s own work)

	ODA
Railway transport	
Passengers carried	-0,479
Goods transported	-0,4
Air transport	
Passengers carried	0,942
Registered carrier departures	0,988
Water transport	
Liner shipping connectivity index	0,617
Road transport	
Energy consumption	0,894

As the level of transport infrastructure in DRC is very poor and almost no current data exists, the most suitable indicators were used to set the relationship among them and the Official Development Assistance. Strong relationship can be observed in case of air transport. It can be seen that as the ODA has been increasing till 2012, the number of passengers carried and number of goods transported has been increasing as well. On the other hand in 2013 the decrease in ODA came and consequently the number of passengers and goods declined as well. The decrease in ODA provided could be caused by the fighting between the March 23 Movement and the government in Nord-Kivu province. In 2012 the M23[1] rebels took control of Goma where the national airport is

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[1] The March 23 Movement (French: *Mouvement du 23-Mars*), also known as the Congolese Revolutionary Army, is a rebel military group based in eastern areas of the DRC

located. Thus the level of air safety is worsening and naturally there is a decrease in number of carried passengers. Strong positive relationship occurs between the road energy consumption and ODA provided to the road sector. It is in accordance with government plans to invest into the road sector and rehabilitate the road infrastructure. The government also relies, inter alia, on the loans that could be secured by Chinese banks.

On the other hand negative relationship not very strong could be seen in case of railway infrastructure. The transportation via rails is more expensive then when the road is used; moreover the ODA provided into this sector is insufficient.

5 Recommendations

Based on the analysis done in the thesis it is obvious that the transport infrastructure of the Democratic Republic of the Congo is in critical condition. Continuous conflict damaged most of the railway and road networks and the air transport suffers from poor security. However some progress since the official return of peace in 2003 has been made, the situation mainly in eastern part of the country remains critical.

5.1 Security

To improve the transport infrastructure it is necessary for the country to increase the level of security.

At first higher attention should be paid to the protection of the civilians in DRC. It is common that the police and security forces have been on the site of the violence rather than to be helpful to the citizens. To secure its citizens it is recommended to the national parliament and the parliament provinces as well to improve the oversight of the security sector. Frequently the army is not paid due to the corruption and thus there is no need for the members to protect the civilians. Contrary the soldiers are involved in the raping of local women; they use the civilians as a source of income. It is highly recommended to the government of DRC to reform the Congolese army, to develop effective plan of financing the army so that it becomes a source of security rather than the threat. By making the army stronger the neighbouring countries would be demotivated to invade the country and to exploit the minerals. Consequently the government should remove the commanders violating human rights from their positions.

Secondly, there should be zero tolerance to the corruption. In 2013 the country ranked 154th of the 177 countries assessed by Transparency International´s Corruption Perceptions Index (CPI) with score 22 on a scale of 0 to 100, where 0 is highly corrupted and 100 is highly clean. There is very low transparency for the high government positions. These facts further undermine already weak governance and thus the security situation is even worsening. Due to the high corruption the policies have low outcome as funds are deflected, the political institutions are seen as a source of wealth rather than a public service. Therefore it is recommended to combat corruption at all levels of government, because the efforts only at the local levels are not sufficient enough.

Thirdly, the government should be more accountable and should develop efforts to be able to investigate, and imprisons the persons who are responsible for crimes against humanity.

Further, the mining should be delinked from the war financing. The country has a lot of minerals which have served as a curse rather than to be the source of wealth of the country and high living standard for the citizens. The minerals have been one of the major sources of the war in the region. The author of this thesis recommends to companies operating within mining industry to identify the origin of the minerals, there should be implemented system ensuring the transparently paid taxes to the Congolese government. To reach the transparent trade not only the government should be involved, but the companies and consumers as well. Moreover efficient policies and bodies regulating mining industry and trading with minerals should be implemented. Strict observance of such policies should be required, the violation should be punished.

Finally, the DRC and the signatory countries should more intensively work on improvement of implementation of the Peace, Security and Cooperation Framework for the Democratic Republic of the Congo and the region. The observance of PSC framework should lead, inter alia, to the political stability of the country and the region, to economic development, and the peace building and peacekeeping.

5.2 Road transport

Road network in the Democratic Republic of the Congo remains challenging due to low population density and extensive river network. Moreover the vast area is covered by tropical forests, rivers are crisscrossed, thus the road construction is complicated and high amount of bridges is needed. Due to the vast area DRC have to spend huge amount of money only to keep the infrastructure in usable condition.

As it was mentioned previously in the text without ensuring peace in the country the development of the road infrastructure is almost impossible or at least very difficult. Continuously after the stabilizing the country the efficient plan for financing the road network reconstruction and maintenance should be devised. The roads damaged during the conflicts should be rebuilt to restore the connections among hubs and thus ensure the basic needs for the citizens.

According to several sources dealing with African infrastructure the price for goods transportation is very high in DRC. The improvement of the road conditions, decrease in deviatility and better accessibility should theoretically lower the prices of road transportation. Additionally, improvements in governing the trucking industry should be done and precise rules should be set.

High level of corruption limits the effective use and allocation of funds and Official Development Assistance. It is highly recommended to combat the corruption, set the monitoring mechanisms, and the use of money from loans, funds and donors should be transparent to all.

Because of the crisscrossing rivers the road transportation is problematic. Very often the roads end at the river bank because the bridges either do not exist or are in unusable condition. Therefore it is recommended to focus the projects on the reconstruction of bridges and to build new ones in crucial places. Further the road network should be more frequently combined with water transportation in terms of ferry use. The river is major obstacle mainly in the Équateur where the Northern and Southern parts of the province are divided by Congo.

Finally, the road infrastructure development the law and regulatory conditions could be analyzed and the private sector could be involved into the financing.

5.3 Railway transport

The railway networks are facing the decline in use in last years due to decrease in quality of services and strong competition. Thanks to the rehabilitation programmes the condition of roads is getting improved so there is not so big necessity to use the railways as it was in history. Another obstacle in railway use is high transportation costs.

Despite these facts railways remain crucial mean of transportation in parts of the country where the minerals are exploited. Due to large cargos volume it is not possible to transport it by roads thus the government and private investors should implement programmes oriented on the railways reconstruction. The transportation of larger freight via rail could be seen as advantage because it would prevent the road damages. Furthermore the rehabilitation of railways could decrease the price of transportation.

Finally, the rules for the freight transport should be set to avoid tremendous differences in prices and services provided.

5.4 Water transport

River transportation plays valuable role in the DRC economy. Congo River links two main cities Kinshasa and Kisangani and has innumerable tributaries that crisscross the country. It is therefore logical to use the river to freight move despite it is very slow mean of transportation. Another indisputable advantage is the low costs of shipping. The costs per kilometre of navigable waterway are only a fraction of those of road or rail. The author would recommend to connect the river banks with the roads and rails, and thus support the river transport.

As the country is almost landlocked there are only two main ports, Boma and Matadi. Both ports have low draught during the year and low capacity so they are not able to ensure the needs neither of the country nor the western part of DRC. Moreover the quality of services is very poor and the port-handling charges for cargo are high in comparison to other African ports. To improve port performance both the institutional and management reform would be needed. Furthermore in order to the whole country could benefit from the ports it is needed to improve the road and rail infrastructure. The recommendations to these topics have been done in previous subchapters.

5.5 Air transport

Due to the vast area air transport has significant role in the domestic transportation. The major obstacle in air transportation is the poor security. The safety records of domestic air transport should be addressed in the nearest future. The poor record is caused mainly by the lax oversight of airline companies and consequently by human errors. The decline in use of the domestic airlines could be caused in the eastern part of the country by the occurrence of rebellion groups in the neighbourhood of Goma airport.

The author would recommend to the airlines to make greater efforts in the management of their companies; to renew the aircrafts; as well as to focus more on the flight crew in terms of regular controls of their health condition; and develop the programmes aiming to improvement of facilities necessary for the secure flights.

As mentioned in the previous subchapters the crucial condition for improving all means of transportation remains the security in the country.

5.6 Official Development Assistance

The Democratic Republic of Congo has been among the top ten recipients of Official Development Assistance in last years, the country is highly dependent on the aid. The financial resources are by the highest share used to the actions related to the debt, and social services to provide basic services to the citizens of DRC. As a consequence the resources flowing into the transportation sector are not sufficient enough, however the amount is increasing. The biggest share of ODA in terms of transport is allocated to the road transport. The government realizes the necessity of improvement the condition of roads destroyed by the continuous wars in order to achieve stable development.

Because there is strong relationship between the security and the development of infrastructure it is highly recommended to improve the security levels and restore the peace as mentioned in previous subchapter. There is as well strong interdependency among the different kinds of the transportation. The government and donors should realize the necessity of implementation such projects interconnecting all kinds of transportation. Further the cooperation among government, donors, and private subject should be developed and coordinated.

It is very important to ensure the positive socio-economic impact of the realized projects and their sustainability. Moreover the environmental impacts of the project should be analyzed before the implementation.

Further the author would recommend allocating more resources among the rail and air transport. Because of the vast area of the country the domestic air transportation is integral part of travelling around the DRC. As mentioned before the security of this kind of transport remains very poor, as well as the facilities are in bad condition. The railways are the most important mean of transport mainly in such parts of country where the minerals are exploited.

To attract the donors the government of DRC should develop effective and consistent legislation. Further it should work on improvement of the country profile. It is recommended to create strict rules when fighting the corruption because it negatively influences the amount of ODA and the money are not reaching the target projects. Finally the ODA should aim to impact the poorest 20% of people living in developing countries.

6 Conclusion

The Democratic Republic of the Congo is the second largest country in Africa. The country has been challenging the continuous wars and as a consequence the transport infrastructure quality is poor. The most affected by the turmoil are roads and railway infrastructure, from the poor security suffers the air transport as well. On the other hand the country is endowed with thousands of kilometres of navigable waterways. Traditionally the water transport has been the dominant way of moving around the country. According to World Bank the need to invest into infrastructure is in DRC one of the highest from whole Africa.

According to the author the biggest obstacle to build sufficient infrastructure is the low level of security. The country is endowed with precious minerals which bring about persistent fights. To use its potential it is needed to improve the security level and brought to an end this turmoil. Only then the infrastructure could be reconstructed and the condition of roads and railways could be maintained. Further barrier is the high corruption. When there are developing programmes the money are stolen at most cases. Moreover the government of DRC does not fulfil its functions. However some progress since the restored peace in 2003 has been made, the situation remains critical mainly in eastern part of the country.

Based on the analysis the author has found out that DRC is highly dependent on the Official Development Assistance. DRC has been among the top 10 recipients of humanitarian assistance in nine of the last ten years. The aid is necessary mainly to functioning of basic social services, and the financial sources flows into the actions relating to the debt as well. Contrary, only 3% of overall ODA provided to the country flow to the infrastructure. From infrastructure sector the highest share of money is invested into the road network.

In chapter Recommendation the author proposed some recommendations that should lead to improvement of the all types of transport infrastructure in DRC, i.e. road, railway, water, and air infrastructure. Some suggestions that should increase the efficiency of Official Development Assistance allocation and use has be proposed as well as the necessity to improve the security level has been addressed.

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Appendix

Annex 1: DRC, provincies and cities chosen to analysis

(Source: Ezilon Maps, edited by author)

Annex 2: Armed groups operating in DRC, 2011

(Source: Development Daily, edited by author)
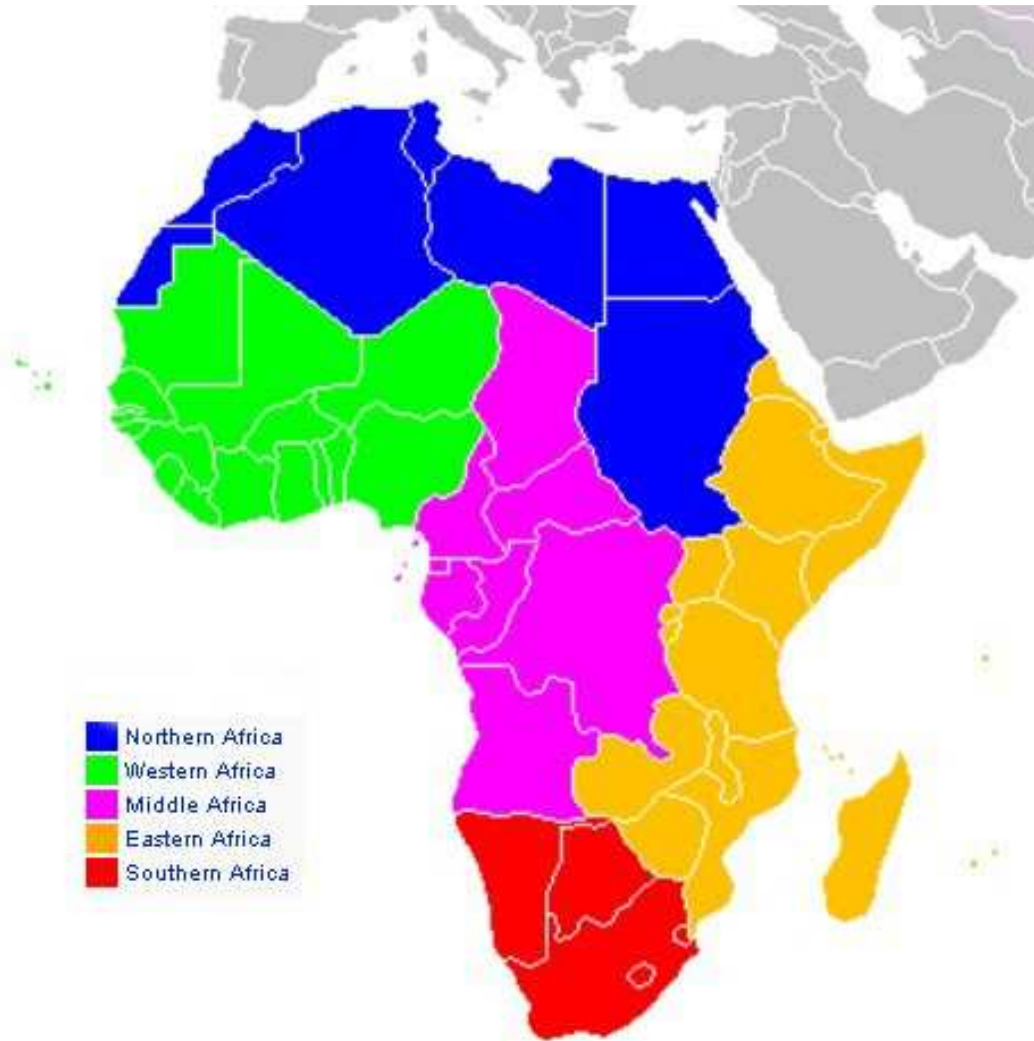
Annex 3: Sub-regions of Africa

(Source: Wikipedia)

Annex 4: ODA in sectors, 2005-2013 (million US$), average value (million US$, %)

(Source: OECD/DAC 2, edited by author)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	%
SOCIAL INFRASTRUCTURE	325,94	359,28	330,7	624,77	648,25	471,37	578,78	527,6	494,67	484,60	**28**
ECONOMIC INFRASTRUCTURE	22,94	27,2	40,75	85,91	166,59	49	44,68	11,95	41,88	54,54	**3**
PRODUCTION SECTORS	14,35	21,12	22,48	23,74	36,37	49,83	63,86	44,51	79,37	39,51	**2**
MULTISECTOR	10,91	16,95	23,42	48,65	31,36	39,27	65,93	68,77	86,5	43,53	**3**
PROGRAMME ASSISTANCE	19,27	19,58	14,38	46,81	54,24	36,83	64,32	69,2	25,22	38,87	**2**
DEBT RELATED ACTIONS	514,52	868,45	123,65	0,92	11,05	1287,4	3124,5	544,73	8,32	720,40	**42**
HUMANITARIAN AID	226,99	314,81	242,32	381,29	503,39	319,85	308,51	333,7	345,59	330,72	**20**

Annex 5: Waterways in the Democratic Republic of the Congo

(Source: Logistic Capacity Assessment 6, edited by author)

Bandundu

Annex 6: Road network distance among chosen cities of Bandundu province (km)

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum
Bandundu	xxx	393	545	313	439	
Kikwit	393	xxx	155	86,1	267	
Idiofa	545	155	xxx	238	419	
Bulungu	313	86,1	238	xxx	242	
Kenge	439	267	419	242	xxx	
Sum of length	1690	901,1	1357	879,1	1367	6194,2

Annex 7: Direct distance among chosen cities of Bandundu province (km), deviatility

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Average
Bandundu	xxx	246	305	192	166	
Kikwit	246	xxx	86	59	198	
Idiofa	305	86	xxx	119	283	
Bulungu	192	59	119	xxx	175	
Kenge	166	198	283	175	xxx	
Sum of length	909	589	793	545	822	3658
Deviatility	1,86	1,53	1,71	1,61	1,66	1,68

Annex 8: Road network distance among chosen cities of Bandundu province, accessibility (km)

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Average
Bandundu	xxx	393	545	313	439	
Kikwit	393	xxx	155	86,1	267	
Idiofa	545	155	xxx	238	419	
Bulungu	313	86,1	238	xxx	242	
Kenge	439	267	419	242	xxx	
Sum of length	1690	901,1	1357	879,1	1367	
Accessibility	338	180,22	271,4	175,82	273,4	247,77

Annex 9: Direct connections among the hubs in Bandundu province, hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	1	0	1	1	3	**2.**
Kikwit	1	xxx	1	1	1	4	**3.**
Idiofa	0	1	xxx	0	0	1	**1.**
Bulungu	1	1	0	xxx	1	3	**2.**
Kenge	1	1	0	1	xxx	3	**2.**

Annex 10: Sum of connections among the hubs in Bandundu province, hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	1	2	1	1	5	**2.**
Kikwit	1	xxx	1	1	1	4	**3.**
Idiofa	2	1	xxx	2	2	7	**1.**
Bulungu	1	1	2	xxx	1	5	**2.**
Kenge	1	1	2	1	xxx	5	**2.**

Annex 11: Sum of the road distances among the hubs in Bandundu province (km), hierarchical level

(Source: Google Earth, edited by author)

	Bandundu	Kikwit	Idiofa	Bulungu	Kenge	Sum	Hierarchical level
Bandundu	xxx	393	545	313	439	1690	**1.**
Kikwit	393	xxx	155	86,1	267	901,1	**4.**
Idiofa	545	155	xxx	238	419	1357	**3.**
Bulungu	313	86,1	238	xxx	242	879,1	**5.**
Kenge	439	267	419	242	xxx	1367	**2.**

Bas-Congo

Annex 12: Road network distance among chosen cities of Bas-Congo province (km)

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Sum
Matadi	xxx	119	202	222	229	
Boma	119	xxx	312	104	339	
Mbanza-Ngungu	202	312	xxx	415	27,4	
Muanda	222	104	415	xxx	443	
Inkisi	229	339	27,4	443	xxx	
Sum of length	772	874	956,4	1184	1038,4	4824,8

Annex 13:Direct distance among chosen cities of Bas-Congo province (km), deviatility

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Average
Matadi	xxx	48	167	126	190	
Boma	48	xxx	212	79	237	
Mbanza-Ngungu	167	212	xxx	290	24	
Muanda	126	79	290	xxx	312	
Inkisi	190	237	24	312	xxx	
Sum of length	531	576	693	807	763	3370
Deviatility	1,45	1,52	1,38	1,47	1,36	1,44

Annex 14: Road network distance among chosen cities of Bas-Congo province, accessibility (km)

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Average
Matadi	xxx	119	202	222	229	
Boma	119	xxx	312	104	339	
Mbanza-Ngungu	202	312	xxx	415	27,4	
Muanda	222	104	415	xxx	443	
Inkisi	229	339	27,4	443	xxx	
Sum of length	772	874	956,4	1184	1038,4	
Accessibility	154,4	174,8	191,28	236,8	207,68	192,99

Annex 15: Direct connections among the hubs in Bas-Congo province, hierarchical level

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Sum	Hierarchical level
Matadi	xxx	1	1	0	0	2	**2.**
Boma	1	xxx	0	1	0	2	**2.**
Mbanza-Ngungu	1	0	xxx	0	1	2	**2.**
Muanda	0	1	0	xxx	0	1	**1.**
Inkisi	0	0	1	0	xxx	1	**1.**

Annex 16: Sum of connections among the hubs in Bas-Congo province, hierarchical level

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Sum	Hierarchical level
Matadi	xxx	1	1	2	2	6	**3.**
Boma	1	xxx	2	1	3	7	**2.**
Mbanza-Ngungu	1	2	xxx	3	1	7	**2.**
Muanda	2	1	3	xxx	4	10	**1.**
Inkisi	2	3	1	4	xxx	10	**1.**

Annex 17: Sum of the road distances among the hubs in Bas-Congo province (km), hierarchical level

(Source: Google Earth, edited by author)

	Matadi	Boma	Mbanza-Ngungu	Muanda	Inkisi	Sum	Hierarchical level
Matadi	xxx	119	202	222	229	772	**3.**
Boma	119	xxx	312	104	339	755	**4.**
Mbanza-Ngungu	202	312	xxx	415	27,4	754,4	**5.**
Muanda	222	104	415	xxx	443	962	**1.**
Inkisi	229	339	27,4	443	xxx	809,4	**2.**

Katanga

Annex 18: Road network distance among chosen cities of Katanga province (km)

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Sum
Lubumbashi	xxx	304	124	578	29,4	
Kolwezi	304	xxx	181	292	333	
Likasi	124	181	xxx	455	154	
Kamina	578	292	455	xxx	607	
Kipushi	29,4	333	154	607	xxx	
Sum of length	1035,4	1110	914	1932	1123,4	6114,8

Annex 19: Direct distance among chosen cities of Katanga province (km), deviatility

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Average
Lubumbashi	xxx	245	111	416	27	
Kolwezi	245	xxx	142	222	225	
Likasi	111	142	xxx	315	103	
Kamina	416	222	315	xxx	411	
Kipushi	27	225	103	411	xxx	
Sum of length	799	834	671	1364	766	
Deviatility	1,30	1,33	1,36	1,42	1,47	1,37

Annex 20: Road network distance among chosen cities of Katanga province, accessibility (km)

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Average
Lubumbashi	xxx	304	124	578	29,4	
Kolwezi	304	xxx	181	292	333	
Likasi	124	181	xxx	455	154	
Kamina	578	292	455	xxx	607	
Kipushi	29,4	333	154	607	xxx	
Sum of length	1035,4	1110	914	1932	1123,4	
Accessibility	207,08	222	182,8	386,4	224,68	244,59

Annex 21: Direct connections among the hubs in Katanga province, hierarchical level

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Sum	Hierarchical level
Lubumbashi	xxx	0	1	0	1	2	**2.**
Kolwezi	0	xxx	1	1	0	2	**2.**
Likasi	1	1	xxx	1	0	3	**3.**
Kamina	0	1	1	xxx	0	2	**2.**
Kipushi	1	0	0	0	xxx	1	**1.**

Annex 22: Sum of connections among the hubs in Katanga province, hierarchical level

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Sum	Hierarchical level
Lubumbashi	xxx	2	1	2	1	6	**3.**
Kolwezi	2	xxx	1	1	3	7	**2.**
Likasi	1	1	xxx	1	2	5	**4.**
Kamina	2	1	1	xxx	3	7	**2.**
Kipushi	1	3	2	3	xxx	9	**1.**

Annex 23: Sum of the road distances among the hubs in Katanga province (km), hierarchical level

(Source: Google Earth, edited by author)

	Lubumbashi	Kolwezi	Likasi	Kamina	Kipushi	Sum	Hierarchical level
Lubumbashi	xxx	304	124	578	29,4	1035,4	**4.**
Kolwezi	304	xxx	181	292	333	1110	**3.**
Likasi	124	181	xxx	455	154	914	**5.**
Kamina	578	292	455	xxx	607	1932	**1.**
Kipushi	29,4	333	154	607	xxx	1123,4	**2.**

Kasai-Occidental

Annex 24: Road network distance among chosen cities of Kasai-Occidental province (km)

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Sum
Kananga	xxx	241	379	231	194	
Tshikapa	241	xxx	434	342	274	
Ilebo	379	434	xxx	149	217	
Mweka	231	342	149	xxx	68,7	
Luebo	194	274	217	68,7	xxx	
Sum of length	1045	1291	1179	790,7	753,7	5059,4

Annex 25: Direct distance among chosen cities of Kasai-Occidental province (km), deviatility

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Average
Kananga	xxx	192	270	152	129	
Tshikapa	192	xxx	231	192	136	
Ilebo	270	231	xxx	121	142	
Mweka	152	192	121	xxx	58	
Luebo	129	136	142	58	xxx	
Sum of length	743	751	764	523	465	3246
Deviatility	1,41	1,72	1,54	1,51	1,62	1,56

Annex 26: Road network distance among chosen cities of Kasai-Occidental province, accessibility (km)

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Average
Kananga	xxx	241	379	231	194	
Tshikapa	241	xxx	434	342	274	
Ilebo	379	434	xxx	149	217	
Mweka	231	342	149	xxx	68,7	
Luebo	194	274	217	68,7	xxx	
Sum of length	1045	1291	1179	790,7	753,7	
Accessibility	209	258,2	235,8	158,14	150,74	202,38

Annex 27: Direct connections among the hubs in Kasai-Occidental province, hierarchical level

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Sum	Hierarchical level
Kananga	xxx	1	0	1	1	3	**2.**
Tshikapa	1	xxx	1	0	1	3	**2.**
Ilebo	0	1	xxx	1	0	2	**1.**
Mweka	1	0	1	xxx	1	3	**2.**
Luebo	1	1	0	1	xxx	3	**2.**

Annex 28: Sum of connections among the hubs in Kasai-Occidental province, hierarchical level

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Sum	Hierarchical level
Kananga	xxx	1	2	1	1	5	**2.**
Tshikapa	1	xxx	1	2	1	5	**2.**
Ilebo	2	1	xxx	1	2	6	**1.**
Mweka	1	2	1	xxx	1	5	**2.**
Luebo	1	1	2	1	xxx	5	**2.**

Annex 29: Sum of the road distances among the hubs in Kasai-Occidental province (km),

hierarchical level

(Source: Google Earth, edited by author)

	Kananga	Tshikapa	Ilebo	Mweka	Luebo	Sum	Hierarchical level
Kananga	xxx	241	379	231	194	1045	**3.**
Tshikapa	241	xxx	434	342	274	1291	**1.**
Ilebo	379	434	xxx	149	217	1179	**2.**
Mweka	231	342	149	xxx	68,7	790,7	**4.**
Luebo	194	274	217	68,7	xxx	753,7	**5.**

Kasai-Oriental

Annex 30: Road network distance among chosen cities of Kasai-Oriental province (km)

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Sum
Mbuji-Mayi	xxx	150	130	91,6	24,6	
Kabinda	150	xxx	218	150	126	
Mwene-Ditu	130	217	xxx	110	121	
Gandajika	91,6	150	110	xxx	67	
Tshilenge	24,6	126	121	67	xxx	
Sum of length	396,2	643	579	418,6	338,6	2375,4

Annex 31: Direct distance among chosen cities of Kasai-Oriental province (km), deviatility

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Average
Mbuji-Mayi	xxx	98	96	78	20	
Kabinda	98	xxx	149	89	81	
Mwene-Ditu	96	149	xxx	63	91	
Gandajika	78	89	63	xxx	61	
Tshilenge	20	81	91	61	xxx	
Sum of length	292	417	399	291	253	1652
Deviatility	1,36	1,54	1,45	1,44	1,34	1,43

Annex 32: Road network distance among chosen cities of Kasai-Oriental province, accessibility (km)

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Average
Mbuji-Mayi	xxx	150	130	91,6	24,6	
Kabinda	150	xxx	218	150	126	
Mwene-Ditu	130	217	xxx	110	121	
Gandajika	91,6	150	110	xxx	67	
Tshilenge	24,6	126	121	67	xxx	
Sum of length	396,2	643	579	418,6	338,6	
Accessibility	79,24	128,6	115,8	83,72	67,72	95,02

Annex 33: Direct connections among the hubs in Kasai-Oriental province, hierarchical level

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Sum	Hierarchical level
Mbuji-Mayi	xxx	0	0	0	1	1	**1.**
Kabinda	0	xxx	1	1	1	3	**2.**
Mwene-Ditu	0	1	xxx	1	1	3	**2.**
Gandajika	0	1	1	xxx	1	3	**2.**
Tshilenge	1	1	1	1	xxx	4	**3.**

Annex 34: Sum of connections among the hubs in Kasai-Oriental province, hierarchical level

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Sum	Hierarchical level
Mbuji-Mayi	xxx	3	2	2	1	8	**1.**
Kabinda	2	xxx	1	1	1	5	**2.**
Mwene-Ditu	2	1	xxx	1	1	5	**2.**
Gandajika	2	1	1	xxx	1	5	**2.**
Tshilenge	1	1	1	1	xxx	4	**1.**

Annex 35: Sum of the road distances among the hubs in Kasai-Oriental province (km), hierarchical level

(Source: Google Earth, edited by author)

	Mbuji-Mayi	Kabinda	Mwene-Ditu	Gandajika	Tshilenge	Sum	Hierarchical level
Mbuji-Mayi	xxx	150	130	91,6	24,6	396,2	**4.**
Kabinda	150	xxx	218	150	126	644	**1.**
Mwene-Ditu	130	217	xxx	110	121	578	**2.**
Gandajika	91,6	150	110	xxx	67	418,6	**3.**
Tshilenge	24,6	126	121	67	xxx	338,6	**5.**

Maniema

Annex 36: Road network distance among chosen cities of Maniema province (km)

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Sum
Kindu	xxx	232	49,3	213	919	
Kasongo	232	xxx	281	444	688	
Kalima	49,3	281	xxx	209	968	
Puniya	213	444	209	xxx	1132	
Kibombo	919	688	968	1132	xxx	
Sum of length	1413,3	1645	1507,3	1998	3707	10270,6

Annex 37: Direct distance among chosen cities of Maniema province (km), deviatility

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Average
Kindu	xxx	181	46	174	110	
Kasongo	181	xxx	192	328	99	
Kalima	46	192	xxx	140	138	
Puniya	174	328	140	xxx	280	
Kibombo	110	99	138	280	xxx	
Sum of length	511	800	516	922	627	3376
Deviatility	2,77	2,06	2,92	2,17	5,91	3,16

Annex 38: Road network distance among chosen cities of Maniema province, accessibility (km)

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Average
Kindu	xxx	232	49,3	213	919	
Kasongo	232	xxx	281	444	688	
Kalima	49,3	281	xxx	209	968	
Puniya	213	444	209	xxx	1132	
Kibombo	919	688	968	1132	xxx	
Sum of length	1413,3	1645	1507,3	1998	3707	
Accessibility	282,66	329	301,46	399,6	741,4	410,82

Annex 39: Direct connections among the hubs in Maniema province, hierarchical level

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Sum	Hierarchical level
Kindu	xxx	0	1	1	0	2	**2.**
Kasongo	0	xxx	0	0	1	1	**1.**
Kalima	1	0	xxx	1	0	2	**2.**
Puniya	1	0	1	xxx	0	2	**2.**
Kibombo	0	1	0	0	xxx	1	**1.**

Annex 40: Sum of connections among the hubs in Maniema province, hierarchical level

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Sum	Hierarchical level
Kindu	xxx	1	1	1	2	5	**4.**
Kasongo	1	xxx	2	2	1	6	**3.**
Kalima	1	2	xxx	1	3	7	**2.**
Puniya	1	2	1	xxx	3	7	**2.**
Kibombo	2	1	3	3	xxx	9	**1.**

Annex 41: Sum of the road distances among the hubs in Maniema province (km), hierarchical level

(Source: Google Earth, edited by author)

	Kindu	Kasongo	Kalima	Puniya	Kibombo	Sum	Hierarchical level
Kindu	xxx	232	49,3	213	919	1413,3	**4.**
Kasongo	232	xxx	281	444	688	1413	**5.**
Kalima	49,3	281	xxx	209	968	1458	**3.**
Puniya	213	444	209	xxx	1132	1785	**2.**
Kibombo	919	688	968	1132	xxx	2788	**1.**

Nord-Kivu

Annex 42: Road network distance among chosen cities of Nord-Kivu province (km)

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Sum
Goma	xxx	272	319	284	70,6	
Butembo	272	xxx	50,7	17,6	204	
Beni	319	50,7	xxx	65,3	252	
Katwa	284	17,6	65,3	xxx	215	
Rutshuru	70,6	204	252	215	xxx	
Sum of length	945,6	544,3	687	581,9	741,6	3500,4

Annex 43: Direct distance among chosen cities of Nord-Kivu province (km), deviatility

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Average
Goma	xxx	200	240	200	59	
Butembo	200	xxx	42	11	148	
Beni	240	42	xxx	43	184	
Katwa	200	11	43	xxx	148	
Rutshuru	59	148	184	148	xxx	
Sum of length	699	401	509	402	539	2550
Deviatility	1,35	1,36	1,35	1,45	1,38	1,38

Annex 44: Road network distance among chosen cities of Nord-Kivu province, accessibility (km)

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Average
Goma	xxx	272	319	284	70,6	
Butembo	272	xxx	50,7	17,6	204	
Beni	319	50,7	xxx	65,3	252	
Katwa	284	17,6	65,3	xxx	215	
Rutshuru	70,6	204	252	215	xxx	
Sum of length	945,6	544,3	687	581,9	741,6	
Accessibility	189,12	108,86	137,4	116,38	148,32	140,02

Annex 45: Direct connections among the hubs in Nord-Kivu province, hierarchical level

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Sum	Hierarchical level
Goma	xxx	0	0	0	1	1	**1.**
Butembo	0	xxx	1	1	1	3	**3.**
Beni	0	1	xxx	0	0	1	**1.**
Katwa	0	1	0	xxx	0	1	**1.**
Rutshuru	1	1	0	0	xxx	2	**2.**

Annex 46: Sum of connections among the hubs in Nord-Kivu province, hierarchical level

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Sum	Hierarchical level
Goma	xxx	2	2	2	1	7	**1.**
Butembo	2	xxx	1	1	1	5	**2.**
Beni	2	1	xxx	1	1	5	**2.**
Katwa	2	1	1	xxx	1	5	**2.**
Rutshuru	1	1	1	1	xxx	4	**3.**

Annex 47: Sum of the road distances among the hubs in Nord-Kivu province (km), hierarchical level

(Source: Google Earth, edited by author)

	Goma	Butembo	Beni	Katwa	Rutshuru	Sum	Hierarchical level
Goma	xxx	272	319	284	70,6	945,6	**1.**
Butembo	272	xxx	50,7	17,6	204	544,3	**5.**
Beni	319	50,7	xxx	65,3	252	687	**3.**
Katwa	284	17,6	65,3	xxx	215	581,9	**4.**
Rutshuru	70,6	204	252	215	xxx	741,6	**2.**

Orientale

Annex 48: Road network distance among chosen cities of Orientale province (km)

(Source: Google Earth, edited by author)

	Kisangani	**Bunia**	**Isiro**	**Buta**	**Basoko**	**Sum**
Kisangani	xxx	1269	782	330	750	
Bunia	1269	xxx	489	947	1367	
Isiro	782	489	xxx	460	880	
Buta	330	947	460	xxx	422	
Basoko	750	1367	880	422	xxx	
Sum of length	3131	4072	2611	2159	3419	15392

Annex 49: Direct distance among chosen cities of Orientale province (km), deviatility

(Source: Google Earth, edited by author)

	Kisangani	**Bunia**	**Isiro**	**Buta**	**Basoko**	**Average**
Kisangani	xxx	572	366	260	195	
Bunia	572	xxx	322	630	742	
Isiro	366	322	xxx	320	476	
Buta	260	630	320	xxx	214	
Basoko	195	742	476	214	xxx	
Sum of length	1393	2266	1484	1424	1627	8194
Deviatility	2,25	1,80	1,76	1,52	2,10	1,88

Annex 50: Road network distance among chosen cities of Orientale province, accessibility (km)

(Source: Google Earth, edited by author)

	Kisangani	**Bunia**	**Isiro**	**Buta**	**Basoko**	**Average**
Kisangani	xxx	1269	782	330	750	
Bunia	1269	xxx	489	947	1367	
Isiro	782	489	xxx	460	880	
Buta	330	947	460	xxx	422	
Basoko	750	1367	880	422	xxx	
Sum of length	3131	4072	2611	2159	3419	
Accessibility	626,2	814,4	522,2	431,8	683,8	615,68

Annex 51: Direct connections among the hubs in Orientale province, hierarchical level

(Source: Google Earth, edited by author)

	Kisangani	Bunia	Isiro	Buta	Basoko	Sum	Hierarchical level
Kisangani	xxx	0	0	1	0	1	**1.**
Bunia	0	xxx	1	0	0	1	**1.**
Isiro	0	1	xxx	1	0	2	**2.**
Buta	1	0	1	xxx	1	3	**3.**
Basoko	0	0	0	1	xxx	1	**1.**

Annex 52: Sum of connections among the hubs in Orientale province, hierarchical level

(Source: Google Earth, edited by author)

	Kisangani	Bunia	Isiro	Buta	Basoko	Sum	Hierarchical level
Kisangani	xxx	3	3	1	2	9	**1.**
Bunia	3	xxx	1	2	3	9	**1.**
Isiro	2	1	xxx	1	2	6	**3.**
Buta	1	2	1	xxx	1	5	**4.**
Basoko	2	3	2	1	xxx	8	**2.**

Annex 53: Sum of the road distances among the hubs in Orientale province (km), hierarchical level

(Source: Google Earth, edited by author)

	Kisangani	Bunia	Isiro	Buta	Basoko	Sum	Hierarchical level
Kisangani	xxx	1269	782	0	750	2801	**3.**
Bunia	1269	xxx	489	947	1367	4072	**1.**
Isiro	782	489	xxx	460	880	2611	**4.**
Buta	330	947	460	xxx	422	2159	**5.**
Basoko	750	1367	880	422	xxx	3419	**2.**

Sud-Kivu

Annex 54: Road network distance among chosen cities of Sud-Kivu province (km)

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Sum**
Bukavu	xxx	131	218	692	68,4	
Uvira	131	xxx	86,4	561	152	
Baraka	218	86,4	xxx	474	238	
Shabunda	692	561	474	xxx	712	
Walungu	68,4	152	238	712	xxx	
Sum of length	1109,4	930,4	1016,4	2439	1170,4	6665,6

Annex 55: Direct distance among chosen cities of Sud-Kivu province (km), deviatility

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Average**
Bukavu	xxx	101	178	171	33,28	
Uvira	101	xxx	81	210	93	
Baraka	178	81	xxx	250	162	
Shabunda	171	210	250	xxx	144	
Walungu	33,28	93	162	144	xxx	
Sum of length	483,28	485	671	775	432,28	2846,56
Deviatility	2,30	1,92	1,51	3,15	2,71	2,32

Annex 56: Road network distance among chosen cities of Sud-Kivu province, accessibility (km)

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Average**
Bukavu	xxx	131	218	692	68,4	
Uvira	131	xxx	86,4	561	152	
Baraka	218	86,4	xxx	474	238	
Shabunda	692	561	474	xxx	712	
Walungu	68,4	152	238	712	xxx	
Sum of length	1109,4	930,4	1016,4	2439	1170,4	
Accessibility	221,88	186,08	203,28	487,8	234,08	266,62

Annex 57: Direct connections among the hubs in Sud-Kivu province, hierarchical level

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Sum**	**Hierarchical level**
Bukavu	xxx	1	0	0	1	2	**2.**
Uvira	1	xxx	1	0	1	3	**3.**
Baraka	0	1	xxx	1	0	2	**2.**
Shabunda	0	0	1	xxx	0	1	**1.**
Walungu	1	1	0	0	xxx	2	**2.**

Annex 58: Sum of connections among the hubs in Sud-Kivu province, hierarchical level

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Sum**	**Hierarchical level**
Bukavu	xxx	1	2	3	1	7	**2.**
Uvira	1	xxx	1	3	1	6	**3.**
Baraka	2	1	xxx	1	2	6	**3.**
Shabunda	3	2	1	xxx	3	9	**1.**
Walungu	1	1	2	3	xxx	7	**2.**

Annex 59: Sum of the road distances among the hubs in Sud-Kivu province (km), hierarchical level

(Source: Google Earth, edited by author)

	Bukavu	**Uvira**	**Baraka**	**Shabunda**	**Walungu**	**Sum**	**Hierarchical level**
Bukavu	xxx	131	218	692	68,4	1109,4	**3.**
Uvira	131	xxx	86,4	561	152	930,4	**5.**
Baraka	218	86,4	xxx	474	238	1016,4	**4.**
Shabunda	692	561	474	xxx	712	2439	**1.**
Walungu	68,4	152	238	712	xxx	1170,4	**2.**