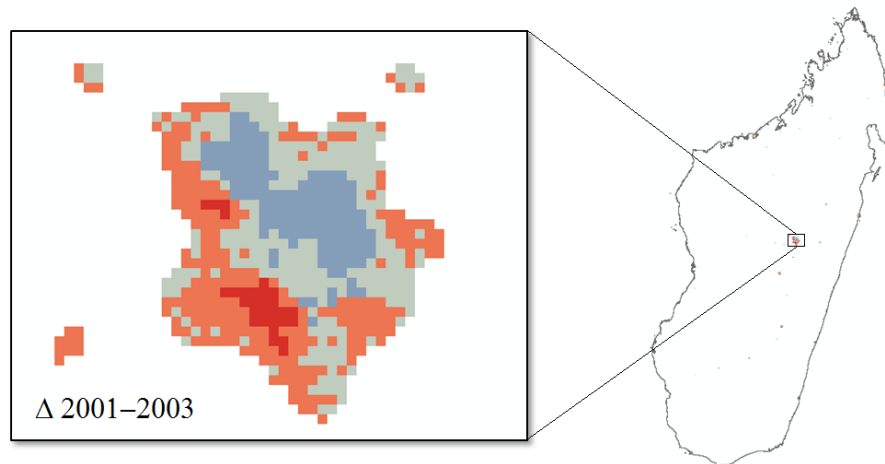# Patronage
The case of Madagascar 1992 - 2010

Δ 2001–2003

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Thesis for Master of Phylosophy in Economics

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February 1, 2013

Abstract

Madagascar is one of the poorest countries in Africa. Recently a significant amount of oil was discovered and production started in 2012. With a just distribution of the income from natural resources it has the potential to significantly decrease poverty. This thesis looks into patronage, which is an aspect of local institutions. Patronage influences distribution in terms of allocation of development programs in Madagascar. This thesis contributes to the literature in two aspects: firstly, by measuring *economic activity* to identify patronage, secondly, by looking into whether there is patronage in Madagascar over a *longer period from 1992 to 2010.*

The thesis uses satellite light data, measuring light density as a proxy for economic activity. The method used is a difference in difference approach, using a relative luminosity to analyze changes in trends of economic activity in each president's region relative to the whole country over time. The use of the difference in difference approach allows controlling for factors that influence the whole country. Another method used is a local analysis measuring changes in light density in the home towns of the presidents when they enter and when they leave office.

The results suggest patronage towards nearly all home regions of the presidents during the period. The identification of such a mechanism, that does not benefit the poor in the country, prior to receiving massive incomes from oil production, will contribute to an important debate about distributive mechanisms in Madagascar.

Acknowlegements

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1. Introduction

The motivation and context: Madagascar is one of the poorest countries in Africa. The purpose of this thesis is to look into Patronage, which is one mechanism of distribution that affects poverty reduction in the country. Patronage is that people in power prefer their own group in terms of distribution of power or economic goods (Moser, 2008). Prevalence of patronage can be a sign of bad institutions. From the litterature (Mehlum et al., 2006) we know that the quality of institutions is desicive for a country's ability to exploit natural resources to increase growth and potentially reduce poverty.

Oil has recently been discovered in Madagascar. The discovery of a natural resource may lead the country to a brighter future and can potentially be a way out of poverty. Mehlum et al. (2006) find that the counterintuitive is often observed in countries with bad institutions.

Institutions is a wide term and represents broad aspects of a society. In the thesis I look into patronage, which is one specific aspect of institutions. Patronage is often given little attention in the research on economic growth and distribution. The study of patronage is interesting because patronage might hinder effective use of resources for further production and possibilities of growth. If the groups that receive benefits due to patronage are not the same as the poor, patronage reduces the chance of eradicating poverty. The identification of such a mechanism prior to receiveing massive incomes from oil production, will contribute to an important debate about redistributive mechanisms in Madagascar.

The hypothesis: My hypothesis is that there is patronage present at Madagascar in the period of 1992-2010. Despite democratic reforms in many parts of Africa many young democracies seem to retain characteristics of former neopatrimonial regimes (Moser, 2008). This is also the case in Madagascar (Ødegård, 2011). Do vestiges of past inefficient institutions persist long after democratization?. Recent literature finds that this is the case in many African countries (Nunn, 2009). My study is inspired by Moser (2010) and Moser (2008), who identify mechanisms of patronage in allocation of development projects in Madagascar in 2001 and in 2007. Moser uses survey data from these two years and exploits that there are two different presidents in the two years. Moser also looks at allocation of public goods (2008) and development projects (2010). My study contributes further on two aspects. Instead of looking into only two years, I explore whether patronage exists over 20 years from

1992-2010. Secondly, by using light density data I am able to do a broader study of the overall economic activity in the whole country.

The results: The results of this thesis suggest patronage in Madagascar. The results give indications that patronage is present as a living institution in Madagascar. The satellite night time light data suggest that all the presidents in the period from 1992 to 2010, except the first democratic president after 17 years, favor their home region or their group. I analyze the results and briefly discuss strengths and weaknesses of the results and the use of night time satellite light as a proxy for economic activity over time.

The data and method: To the extent of my knowledge, data on economic development or economic activity over time on local levels in Madagascar is not available. To overcome the lack of information, I explore the method of using night time satellite light as a proxy for economic activity. This method has been used broadly in the literature in the recent years. The night time light data is available from the National Geophysical Data Center of the US National Oceanic and Athmospheric Administration (NOAA) website. I also used maps on adminitrative areas from DIVA-GIS, developed by Hijmans (2012). This data is based on physical measurements from satellites, and is therefore unbiased by politics. The data is available for the whole globe, and thus comparable between any region.

The analysis of the data is done with the software ArcGIS. To identify total light density in an area I have aggregated the data in the different administrative levels in the areas that have had a president. The tools used for aggregating the light data are described in Appendix A. As the data covering the 20 years comes from 6 different satellites that measure slightly different, the data must be calibrated. When exchanging a satellite the new satellite is nearly always used together with the old for at least one year to allow comparison and calibration of data over time. The reason for measuring differently is that the satellites get worned during the years they run, and also no sensor measure exactly the same as another. Much effort is put in the work on calibration and I explored three methods of data calibration and use a fourth method based on an in house calibration key that the NOAA kindly shared with me. All methods are described in the Appendix A.

I used two methods for identifying patronage. A relative luminosity analysis based on a difference in difference approach analyses economic activity in a region relative to the whole country over time. I also utilize local luminosity analysis that illustrates the changes in economic activity in the presidents' home towns when they enter and leave office.

The structure of the thesis: The first chapter introduces the topic and gives an overview of the thesis. In chapter 2, I give an introduction of the Malagasy context

and particularly the political and economic environment when large oil reservoirs are discovered. The chapter gives a short overview of Malagasy economics, politics, environment, and petroleum law to prepare for the analysis in chapter 5. In the third chapter I presents the institution of patronage and a former study of patronage in Madagascar. Chapter 4 describes the night time satellite light data and the reason for using this data. In chapter 5 I present the results and the analysis of the results. The light data suggest patronage in most periods of my study. Finally, chapter 6 gives a brief discussion of the method and the results.

2. Context analysis of Madagascar

Political and Economic Background   Situated in the Indian Ocean, on the east coast of the African continent, Madagascar has for a long time been one of the poorest countries in the world. It is presently ranking 151 out of 187 countries in the Human Development Index (HDI) (UNDP, 2011) which, in addition to measures income per capita, measures levels of education and levels of health and survival. The country has also experienced a massive growth in population over the past two decades. Data from the World Bank shows nearly a doubling from 12 million inhabitants in 1993 to 20.7 million inhabitants in 2011. The combination of population growth and the widespread poverty in the country could lead to a pessimistic outlook of the future. However, great natural wealth has been discovered. The local office for national mines and strategic industries, OMNIS, has positive outlooks for the economy of the country because of several discoveries of petroleum and gas. Exploration blocks were sold in 2006 and several international companies are conducting test drilling and have plans for production in the near future (OMNIS, 2012).

The island, as one of few countries, was a united, independent kingdom before it became a French colony in 1896. Madagascar regained independence in 1960, but it

was not until the beginning of the 1990s that governmental power could be considered democratic. (Table 5.1 in chapter 5 gives an overview of the presidents since the democratic processes started in the 1990s.) The social-Marxist Didier Ratsiraka governed without opposition from 1970-1991. During 1991-1993 the opposition questioned Ratsiraka's presidency and after several demonstrations and strikes the 17 years of single-party rule was ended by free Presidential and National Assembly elections. Zafy Albert won the election and got the presidential seat in 1993. Dahl (2008) writes that Zafy Albert represented a huge democratic change in the country. One of his goals was to terminate Ratsirakas power. And with that also the patronage that had become an integrated part of the Malagasy socialism. Didier Ratsiraka returned to power again in 1997. In 2001, the presidential election stood between the followers of Didier Ratsiraka and Marc Ravalomanana. Didier Ratsiraka did not want to loosen his grip onto power. He declared his home region Toamasina for an independent state, nearly causing secession of half of the country. In April 2002, the High Constitutional Court announced Ravalomanana the winner and after half a year of disputes Ratsiraka fled the country for France. The former businessman and entrepreneur Ravalomanana was a stable leader and considered a savior for the economy. He liberalized the economy. His motto was to govern his country like he governs an enterprise (Dahl, 2008 p.140). The country experienced a period of economic growth when his policy was implemented. As the results from the satellite lights indicate, the relative growth was largest in Antananarivo; the capital and Mark Ravalomanana's hometown. However, in 2008 he got accused of several cases of corruption and Malagasy institutions were under pressure (Dahl, 2008).

The country is still in a phase of political instability after a coup d'ètat and the following non-democratic shift in presidency in early 2009. The accusations of former president Marc Ravalomanana for corruption cost him the presidency. The young mayor of the capital, Andry Rajoelina, played a role in the destabilized period and the military appointed Andry Rajoelina as President of the High Transitional Authority after the coup d'état in March 2009. Both the National Assembly and the Senate were dissolved by the High Transitional Authority. SADC, the Southern African Development Community, is facilitating political discussions between the transitional president Andry Rajoelina and the three former presidents Marc Ravalomanana, Zafy Albert and Didier Ratsiraka and their political groups. The aim of the discussions is to agree upon new democratic elections in Madagascar and whether all the former presidents can run for presidency. The discussions have led to some common understanding called "the road map". Despite of almost four years of transitional government the road map is still under discussion and elections keep being postponed (Dahl, 2012). Dahl (2011) writes that ex-president Zafy Albert accuses France of directing the political crisis in Madagascar. He also accuses the High Transitional Authority for deviating from the road map in favor of self-interest. Zafy Alberts political group is therefore not willing to build new institutions in cooperation with the transitional authorities. To do so would make them "become slaves of the colonists and the leaders of the High Transitional Authority" (Dahl,

2011). The crisis hit the economy, but also the institutions and not surprisingly the score on institutional quality dropped dramatically in 2009 according to the "Polity IV Country Report 2010: Madagascar".

The political crisis has moved the country into greater poverty as income from tourism and trade have been severely hit. Most international aid has also been stopped or frozen as a result of the unsolved political situation, leaving the poorest to suffer even more. The inter-governmental organization "Southern African Development Community" (SADC) and other regional and international organizations are facilitating negotiations suggesting to form a power-sharing government. After being postponed several times, elections are now due in May 2013 (Tribune, 20.08.12). The political situation has led the country into a seemingly weightless condition where everyone is waiting for each other and growth has stagnated. This is in contrast to the recent period of growth where the export performance improved in the first decade of this millennium. Between 1998 and 2007 export volumes grew on average by 9 % a year, up from 5 % during the previous decade according to IMF (Eyraud: 2009, p.4). The same report points out that the country's economy also has experienced several negative shocks. The political crisis in 2002, which led to domestic inflation, as well as the termination on special agreement benefiting textile products in 2005 and the increase in commodity prices in 2008 which increased the production cost for exporters are shocks that have hurt the country's competitiveness, and therefore the whole economy.

A resource based development strategy will meet a number of challenges from a macroeconomic perspective. The ministry of energy and mines, OMNIS and the Directorate of good governance (2006) have proposed to establish a trust fund of revenues from the petroleum. This can be compared to the Norwegian Pension fund.

OMNIS (Office des Mines Nationales et des Industries Stratégiques)   OMNIS is state-owned, operating under the auspices of the Ministry of Energy and was created in 1976. The organization is in charge of the legal framework for upstream oil and gas activities in Madagascar. In addition to managing exploration data, doing laboratory analysis of samples, and the acquisition of technical exploration data, OMNIS is engaged in promoting petroleum activity and investment in Madagascar. According to their website (29.08.12) OMNIS, based on its main activities, endeavors to develop partnership with oil and mining companies. Their objectives are firstly to create incentive and competitive environments for foreign investments, and secondly to review and systematically update the exploration data to allow easy and reliable prospect appraisal.

OMNIS divide the petroleum exploration history in Madagascar into three main periods. The first period is from the French colonial period prior to 1960. During this period, exploration was conducted mainly by SPM, a subsidiary of ELF Aquitaine (the French national oil society, today called Total). After independence the first non-French international companies entered. Since the creation of OMNIS

in 1976 Madagascar has established important partnership with major international oil companies. Presently there are 75 exploration wells: one in onshore Ambilobe Basin, 8 in Majunga Basin, 65 in Morondava Basin and one in offshore East Coast (OMNIS, 2012).

Mineral Activity Prospects   Madagascar's oil reserves are significant according to Madagascar Oil, one of the main oil companies operating in the country; a Bermuda registered American administrated oil company. The company's recent field tests and studies suggest that one of their principal fields, Tsimiroro, have excellent potential for economic development. At both Tsimiroro and Bemolanga, the two main fields of Madagascar Oil, there are multi-billion barrel resource volumes in place (Madagascar Oil, 14.08.2012). Production from the Tsimiroro steam flood pilot project was expected to start in the fourth quarter of 2012. Despite the political instability the start was celebrated on October 30th with representations from the transition government. However it is worth noticing that the french friendly president Rajoelina did not attend to the anglophone celebration despite the importance of the production start.

Madagascar Oil has drilled over 68 wells the recent four years on the Tsimiroro Block 3104. They have also conducted geologic and reserves studies. Their result shows that the Tsimiroro Field may contain over 5.5 billion barrels of total oil-in-place. 1.78 billion barrels can currently be classified as contingent oil-in-place, which means that it is in a sub commercial stage and has a great chance of commercialization (CRIRSCO and SPE, 2007). This is only studies conducted by one of the companies exploring in Madagascar. (As a comparison Norwegian total estimated reserves, including undiscovered reserves, are 82.4 billion barrels (Oljedirektoratet, 27.06.12)).

The Tsimiroro block is expected to reach a peak of production 12 years after production start. Estimations indicate that Madagascar will by then place in the top 10 producers in Africa according to Madagascar Oil. Further discoveries are also expected to be done, and could bring oil and gas production to higher levels. This can potentially give the Malagasy government an important income.

Mineral Revenue Prospects   The country has superior interest of keeping sovereignty over own natural resources, but to improve investment climate and to increase foreign investment the country's "Code Petrolier" was revised in 1996 with the aim of getting a legal climate that enhances international investment incentives. (Loi N 96-018, Repoblikan'i Madagasikara, 1996). The law (art.51) gives exemptions from royalties and direct tax on hydrocarbons that are either used directly into further production, reintroduced into the deposits or are unusable. These exemptions are crucial in attracting investors. By reducing the direct costs, through taxation on economic activity in the initial non profiting phase, risk of default decreases and companies might be willing to undertake more investment. The Code is further encouraging investors as article 48 states that paying "Direct Tax on Hydrocarbons"

releases the companies from paying other taxes such as "Tax on Mobile Capital Outcome", "Tax on Lump-Sum Transfers" and "Tax on the Corporate Profits". In addition to reduce the tax costs of the companies it simplifies the administrative costs on tax collection.

By using this taxing strategy, which is the same as Norway do, Madagascar has improved the opportunity of attracting several petroleum companies. This will according to Madagascar Oil, which is the largest of many operators in the country, generate income of over US\$ 2 billion a year to the Malagasy government for several years and at least US\$ 1 billion a year for a period of 20 years (Madagascar Oil, 14.05.2012). As the company is registered in the tax paradise Bermuda one shall not be surprised if the revenue to the Malagasy government will not reflect the companies profit. The cost of climate and environmental degradation is also most likely left for the Malagasy government to cover.

Environmental challenges   Petroleum production in Madagascar is potentially a large threat to the environment. More than 80% of the island's fauna and flora are endemic, meaning that they are only found in Madagascar. Also, since the island was inhabited around 2350 years ago only 10 % of its original forest remains. Together this illustrates the huge responsibility that lies upon the implementers of environmental challenging activities in the country.

Much of the country's deposits are tar sand. However, available technology today such as "steam assisted gravity drainage" (SAGD) is less polluting than traditional mining industry. If a relative small revenue from oil production is payed in tax and the Malagasy government do pay for the negative externalities that the degradation of the environment is, one can question how much revenue will come to the benefit of the local population.

From a prospect of efficiency and fairness one can still argue that petroleum production in one of the world poorest country is defendable, despite the environmental challenges. One can argue that it is fair that development countries can profit from their resources the same way that western countries have done, long before the knowledge we have today about environmental challenges related to petroleum and CO2 emissions was available. In question of efficiency I would believe the only efficient for Malagasy politicians is to make use of the natural resources. However, this is a larger environmental debate that I do not have room for in my discussion here. The discussion here is concentrated on redistributive mechanisms in Madagascar, and more precisely on patronage. This is further described in chapter 3.

3. Background for the thesis

3.1. Concepts and theories of patronage

What is patronage?

Patronage is when a politician favors his base of support when allocating economic support (Moser, 2008). It is distinguished from vote buying because the politician's supporters will always vote for him, whether they get some privilege or not. Patronage can possibly hinder poverty reduction if the groups who receive benefits from patronage are not the same as the poorest groups . Finan (2005) shows that, in the case of Brazil, patronage may divert public goods from a need-based allocation. Abers (2000) says that "Not only does this system tend to concentrate power in the hand of incumbents who have access to state resources, but [patronage] also inhibits systematic planning and the implementation of generalized, egalitarian social policies." Patronage may, however, be implemented in different ways.

Different types of patronage

Patronage can occur in many ways. Moser (2008) finds that in Madagascar allocation of projects funded by foreign aid are often motivated by patronage. Khwaja and Mian (2005) find that politically connected firms in Pakistan borrow 45 percent more and have 50 percent higher default rates than other firms. Allocation of development projects and availability of cash and loans are important for development, and may hinder poverty reduction if the poor are deprived from it due to patronage. This is often the case; as Abers (2000) and Finan (2005) show. Another type of patronage is analyzed in Fisman (2001). He finds that the stock market value of companies in Indonesia are heavily influenced by their connections to president Suharto. The closer the connection was to the president, the heavier the stock market value was influenced by shocks in Suharto's health. The threat of his decease was shown to reduce the stock market value of connected companies. Both increased access to liquidity due to patronage as in Khwaja and Mian and increased profit as in Fisman, increase income for the connected groups.

Construction of public infrastructure projects such as roads, road lighting, airports and harbors is other possible ways to canalize economic patronage, by the president devoting more means in areas with large bases of support, regardless of need. Such projects will in themselves generate economic activity. In addition they will facilitate further production, resulting in more economic activity over time. Lump sum

transfers to the population or tax cuts can be other mechanisms of patronage that increase private spending, which in turn increases economic activity.

I do not look into what type of patronage that is prevalent in Madagascar. Rather I concentrate on whether existence of patronage may be revealed using satellite light data, but it is useful to understand the concept of patronage as a basis for my analysis. As will be discussed further in chapter 4 on data and method, I assume that several types of patronage generate economic activities that generate light and therefore is visible on the satellite light data.

3.2. How patronage affects poverty reduction

The study of patronage is interesting because it has enormous implications on people's lives. If the group of poor is not the same as the group which the president favors, patronage will hinder poverty reduction in two ways: Firstly the poor will remain poor. Secondly the poor will continue to spend most of their energy on survival strategies rather than productive activity that could generate growth and increase resources available; and therefore reduce poverty. On the contrary; if the group which the president favors, is the same group as the poor, patronage will benefit the poor and reduce poverty.

Moser (2008) calculates that in Madagascar, with the existence of patronage, only around 30% of communes that are in severe need of health care receives so. The same is the case for communes that lack basic educational services. I will therefore assume that patronage has negative effects on poverty reduction in Madagascar in the further analysis of the thesis. When resources are scarce, and some receive benefits due to patronage there will necessarily be less resources for others. Especially in poor countries the use of patronage may hinder not only development, but also poverty reduction when resources are not used where they are most needed. In Madagascar more than 15 millions survive on less than 2 US PPP$ a day (UN Human Rights, 2012).

Moser (2008) diverts between needs-based motivation for distribution in opposition to the motivation of patronage or vote-buying. A need-based motivation is usually coinciding democratic preferences of the population in contrast to patronage that is characterized by it's non-democratic nature, favoring one specific group without any democratic power to do so. By favoring one specific group, democratic principles are violated. In a poor country patronage will even violate the human rights. When resources are scarce and the need is great, an avoidance of allocating resources towards groups that do not have access to resources to cover their basic needs such as access to clean water, food, shelter, healthcare and education, is a violation of the human rights. The same is true when vulnerable groups are systematically hindered from access to participation and access to employment.

It might be fruitful to identify patronage before a large governmental increase in

income from oil: Frank and Rainer (2012) use data from 18 Sub-Saharan countries and find that "ethnic favoritism is more prevalent in countries where governments have greater fiscal resources". In the period I study; from 1992 to 2010 Madagascar's fiscal resources are scarce. Nevertheless Moser (2008) results strongly indicate ethnic favoritism in Madagascar. It therefore might be an advantage to identify an discuss patronage before an substantial increase in government income from oil in Madagascar. An identification of patronage as a characteristic of the political system can possibly slow down the use of patronage or break the trend, witch in turn can increase probability that the whole population, and especially the poor receives the benefits of the country's natural wealth.

3.3. An exploration of a previous study on patronage in Madagascar

The research question in this thesis is inspired by Moser's work, especially the working paper Moser (2010) that examines factors that determine the allocation of development projects in Madagascar. The fact that the country is one of the poorest in the world motivates Moser: "Given the high demand for and limited supply of project funding, it is easy to imagine that personal, political or ethnic connections could influence which localities receive development projects" (p1). Moser uses a panel data set of nearly all 1395 communes in Madagascar for 2001 and 2007 and finds that the political and ethnic characteristics of the recipient community heavily influence the allocation of externally-funded projects in Madagascar. The results show that "communes with mayors affiliated with the party in power tend to receive more projects" (p.1). In addition the results show that "ethnically fragmented communes, more isolated communes and those lacking in communication infrastructure access fewer projects" (p.1). More importantly: "The empirical results demonstrate that while development projects may be externally funded, their allocation is still heavily influenced by internal political and social factors" (p.2).

Moser uses data from surveys from 2001 and 2007. The data is detailed and gives information such as availability of health clinics, schools and pumped water. However data on mean income, poverty, unemployment and literacy rates are available only from 1993 and are therefore time-invariant. Nevertheless Moser includes several of these variables since "they are the only available nation-wide data and it is likely that they are still used by decision-makers" (2010, p.13). The analysis exploits variation in the local leaders party affiliation and the change of president and party in power at the national level during the period of study. Moser runs ordinary least squares regressions and incorporates commune fixed effects in the panel data to control for unobserved heterogeneity between communes.

Moser considers both the supply side and the demand side of development projects in her study. The supply side are the one who fund the projects, the government

that administrate them and the ones who implement them. The demand side are the population and beneficiaries. The suppliers might be altruistic, wanting to maximize benefits across localities. On the other hand they may allocate development projects according to motivations of patronage and according to political and strategic interests. Moser however emphasizes that one shall not ignore the local communities ability to influence the allocation of projects themselves. It might be done through lobbying, or by using personal, political or ethnic connections. Alternatively the communes might simply apply for projects if information is available.

Availability of information is another aspect influencing mechanisms of redistribution. Moser (2010) "contributes to the literature related to the importance of access to information. The results show a strong, positive association between access to telephones and radio reception and the number of projects received". She also found that in Madagascar" [m]ore isolated communes and those lacking in communication infrastructure access fewer projects" (2010). Knowing that decentralized areas often are the poorest areas in developing countries (Ray: 1998, p36) this is bad news for the large, poor and decentralized population in the country.

3.4. How can patronage be visible on the satellite light data

The lack of data on economic growth and economic activity, both on local levels and on national levels, and the wish of looking at data over time, are the reason that I wish to explore other sources of data and method than what Moser (2010) does. I explore the use of satellite light data as a proxy for economic activity. This gives data for all years from 1992 to 2010 on all administrative levels, which gives possibilities to explore trends of patronage over a period of nearly 20 years. Several papers have recently used satellite light data on similar research. Hodler and Rashky (2010) find that foreign aid fuels personal, regional and ethnic favoritism. By using satellite data on nighttime light for 91 aid recipient countries in panel data from 1992 to 2005 they trace higher light density in the regions of the leaders' birth. Patronage seems to be linked to the quality of political institutions. Hodler and Rashky (2010) further find that "in countries with poor political institutions the effect is significantly higher in the region in which the current political leader was born than in other regions" Hodler and Rashky (2010, p.1).

I want to explore whether patronage is a characteristic of Malagasy political system over time. The satellite light data gives more information over time than what Moser uses (2010), but less detailed information than the surveys used in Moser (2010). Patronage however can be identified by exploring the variation of satellite light density in different parts of the country. By looking at the light density on regional levels relative to the total light density in the country I control for effects that influence the whole country; such as trends in national economic growth. The

data and method are further described in chapter 4.

Almost all economic activity demands light; light is generated both in the production and in consumption of goods (Henderson et al., 2012). The different types of patronage mentioned in chapter 3.1 generate light in different ways. Foreign aid projects generates lights in terms of light in health clinics or afternoon schools. Construction projects will generate light if work is done in the evening, and when finished and used at night time. Some aid projects generate electricity and light directly such as solar cell panel projects. Development projects will often generate a general increase in welfare in the society that contributes to both increased production and increased consumption. Both are usually light consuming.

Increased availability of cash, either by lump sum transfers from the president, from tax reduction, from increased availability of loans or from increased surplus from businesses, are likely to increase both production and consumption. Production will increase if the cash is invested in production. Consumption is increased either by direct consume or through increased income from increased production. Public infrastructure projects will increase light density when built. More importantly they will facilitate other economic activity and therefore generate increased light density over time.

4. Data and method

4.1. Light density data: a proxy for economic development

I explore whether there is patronage in Madagascar in the period from 1992 to 2010. Do sitting presidents favor their home community? In this chapter I will explain the data and the method that I use. In order to look into the mechanisms of patronage I need data on economic activity on local levels. Madagascar is a poor country with weak statistics, especially on local levels of administration. I want to look at patronage over time. By doing so I am able to see whether patronage is a characteristic of Malagasy institutions. In most less developed countries it is very hard to get good statistics on local levels. Henderson et al. (2012, p.994) says that "Relative to developed countries, in many developing countries a much smaller fraction of economic activity is conducted within the formal sector, the degree of economic integration and price equalization across regions is lower, and most significantly, the government's statistical infrastructure is weaker. These factors make the calculation of nominal GDP (total value added, in domestic prices) difficult."

The lack of traditional data has pushed researchers to explore other sources of information. Satellite light density at night has been used as a proxy for local economic activity in several papers recently, see for example Michalopoulos and Papaioannou (2011), Henderson et al. (2012), Alesina, Michalopoulos and Papaioannou (2012), Hodler and Raschky (2010) and Chen and Nordhaus (2010).

Michalopoulos and Papaioannou write that light density captures "economic activities of the underground economy, which are not reflected in the aggregate statistics. As the share of the shadow economy is high in Africa (La-Porta and Shleifer, 2008), the usage of luminosity data i particularly desirable" (2011, p.8). The literature argues that light density at night is a good proxy for economic activity as there is a strong association between access to electricity, luminosity and public goods provision, especially across low income countries (p.9). Henderson et.al (2012, p.999) argues that "consumption of nearly all goods requires light". Further the access to light improves other aspects of social welfare that are not necessarily measured by GDP. Among other health and security in local communities are improved. Health is improved as availability of light increases hygiene measures when household members are ill. For instance bacteria are less likely to be transmitted with improved hygiene. Security is improved and gender based violence reduced. Women are es-

pecially vulnerable at night without lit streets and most households in developing countries have sanitary facilities outside of the house. Also women get a more general freedom of mobility after dark. In addition housework can be done at night which allows women to work during day.

Access to light usually implies access to electricity which improves other aspects of health and development. Michalopoulos and Papaioannou (2011) show for instance a negative relationship between light density and infant mortality across African regions, see their illustration shown in figure 4.1. This is a good argument for light density as a good proxy for living standards. This suggests that, not only is the light density a proxy for economic development, but for development in other crucial aspects of human life. In some countries light density could be a better proxy for living standards than GDP. Henderson et al. (2012) have looked into this and have developed a welfare measure that is based on both GDP and light density.

Figure 4.1.: Light density as a proxy for living standards.
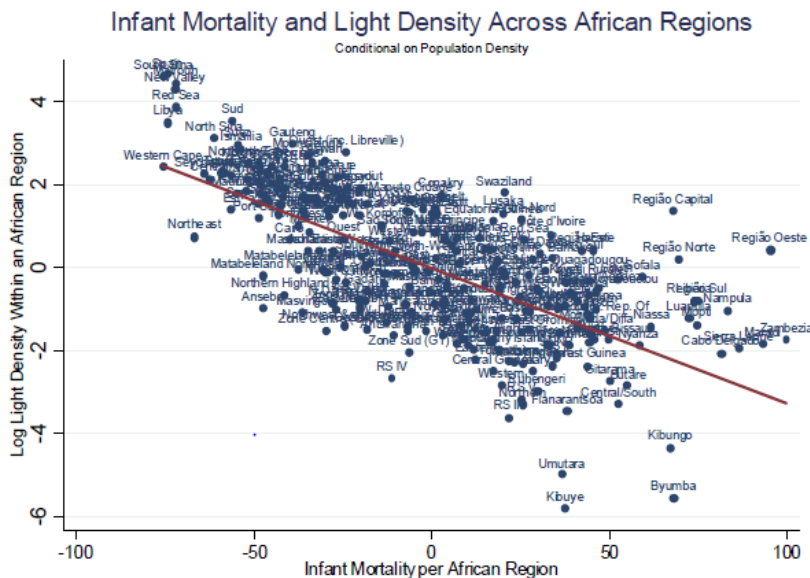
Source: Michalopoulos and Papaioannou (2011)

Michalopoulos and Papaioannou (2011) claim these night time satellite data are uniquely suited for spatial analysis of economic development in Africa. I do find that this is valid for Madagascar as well. Firstly, like most African countries, Madagascar has low quality income statistics. Statistics that exists on the country's four administrative levels: commune (fokotany), district (fivondronana), region (faritra) and autonomous province (faritany mizakatena) are often poor. Even at the national level income statistics are poor in most African countries. In the Penn World Tables all African Sub Saharan countries get the lowest scores on data quality (Henderson et.al, 2012 p.995). Secondly there is a great lack of data, some survey data are available for Madagascar, but only for a very few years.

4.2. The data

From 1992 until 2010 there are 31 satellite pictures available. The pictures are taken by satellites and report night time images of the earth captured between 20:30 and 22:00 local time every day (Henderson et.al, 2012). All these pictures are processed to make average light density images for every year. The luminosity data is from the Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) gathered by the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

The satellite sensors were originally designed for the purpose of detecting moonlit clouds. They have run since the 1970s and are available digital from 1992. Recorded lights from human settlements is a highly valuable byproduct. The data are processed to select the highest quality data to distribute to the public. According to NOAA (2012) a large number of constraints are used to select the highest quality data. Henderson et.al (2012) explains that scientists at NOAA "remove observations for places experiencing the bright half of the lunar cycle, the summer months when the sun sets late [and] auroral activity". In addition observations with clouds and forest fires are excluded. The restrictions leaves mainly man-made light, as intense sources of natural light are removed. These preparations of the data makes them good for purposes of social science research.

The data is presented as .tif files, which is a type of georaster data, readable as picture files. To be able to analyze the data they should be managed in the program of ARC GIS. The data files are marked by the satellite and year. The data covers -180 to 180 degrees longitude and -65 to 75 degrees latitude. The level of detail is 30 arc second grids, which is equal to 1/3600 of a degree (longitude and latitude), and allows for detailed information on local level.

Furthermore there are three types of data available for each satellite and year:

- "cloud free coverage data"

- "the raw average visible band"

- "cleaned up average visible band".

I have used the last one as it contains the lights from cities, towns, and other sites with persistent lighting, including gas flares. Further ephemeral events, such as fires have been discarded, and background noise has been filtered out and replaced with values of zero (NOAA, 2012). Between the three types of data available this will give the best proxy for econoimic activity in Madagascar. This file is also the one used in the literature such as in Michalopoulos and Papaioannou (2011). In table 4.1 available satellite data is presented. All satellites are running for several years and most years are covered by more than one satellite.

Table 4.1.: Satellite data available

Satellites	F10	F12	F14	F15	F16	F18
1992	F10.1992					
1993	F10.1993					
1994	F10.1994	F12.1994				
1995		F12.1995				
1996		F12.1996				
1997		F12.1997	F14.1997			
1998		F12.1998	F14.1998			
1999		F12.1999	F14.1999			
2000			F14.2000	F15.2000		
2001			F14.2001	F15.2001		
2002			F14.2002	F15.2002		
2003			F14.2003	F15.2003		
2004				F15.2004	F16.2004	
2005				F15.2005	F16.2005	
2006				F15.2006	F16.2006	
2007				F15.2007	F16.2007	
2008					F16.2008	
2009					F16.2009	
2010						F18.2010

The satellites available (F10, F12, F14, F15, F16 and F18) are measuring average visible stable lights and cloud free coverages for the years 1992-2010.

4.3. Data aggregation

To be able to observe the economic activity on local levels over time I need to aggregate the light density. I have done so for all the regions and administrative levels that have had a president. The results and trends are similar for the different administrative levels. Only data for the regions are therefore included in the presentation of results and in the analysis in chapter 5. Data for the other administrative levels are presented in Appendix B. To aggregate light density data within an administrative unit I have used the program ArcMAP, witch is a part of the geographical design and analysis system ArcGIS. Two sources of data are used. Maps on administrative areas are taken from DIVA-GIS developed by Hijmans (2012). The night time satellite image and data processing is from US NOAA's National Geophysical Data Center, who uses satellite data collected by US Air Force Weather Agency.

Each satellite image holds extremely large amounts of information since each pixel on the image has a value. This demands large spaces on the hard disk. The method I've used to prepare the data for analysis is further described in Appendix A. In total I have prepared 124 maps to be able to do a proper analysis on three administrative

levels. Much effort is also done in the calibration of the data, see Appendix A.

4.4. Method for identifying patronage

To be able to identify patronage I have used an approach of difference in difference (diff-in-diff). The method requires data available both before and after "treatment". The treatment in this study is for one region to have a sitting president from its own region. The method therefore requires the time series data that I have aggregated as described above. When using a diff-in-diff approach I look at the differences in trends for two units of study. Here that means that I look at the difference in the trend in economic activity for example for the region of Toamasina and for the whole country as such. The first difference is the difference over time for one unit, for instance Toamasina. The second difference is the difference between the trends of the the two units. A crucial assumption is made when using diff-in-diff: the trend over time are equal for the two units we look at. This means that the trend in economic activity in Toamasina is equal to the trend in the whole country when there is no president from Toamasina. In absence of patronage it is plausible that the trend of economic activity in Toamasina shall not be different from the whole country. The presence of a difference in difference can suggest patronage. Figure 4.2 illustrates the method. The difference between the gray and the blue bullet at t=1, minus the difference between the gray and the blue bullet at t=0 is the impact of a "treatment", here: of patronage.

Figure 4.2.: Method of difference in difference
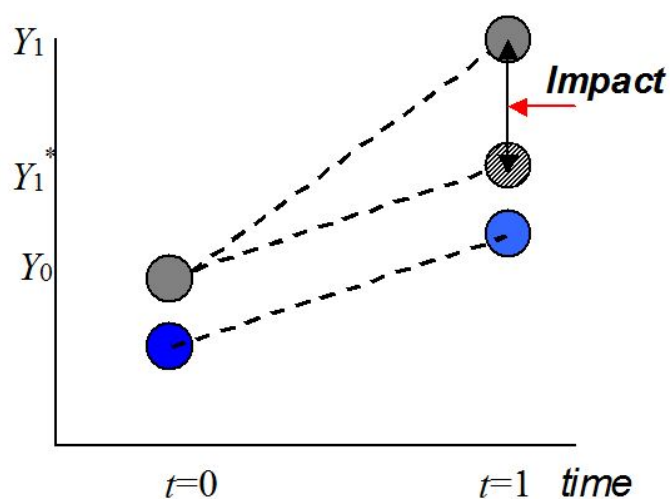
Source: (Kotsadam, lecture notes, 2012)

The impact in this study is patronage. The hypothesis is that economic activity increases in the sitting president's home region when he is in power. One could

argue that the economic activity should be reduced to the pre-trend levels, but it is plausible that some positive economic effects may have an effect for a short time after patronage upholds as well. It is also plausible that the effect of patronage is not immediatly visible and therefore visible first after a year or more. For this reason time series data are crucial for the analysis.

The main problem with diff-in-diff is that something else may have happened at the same time. Another challenge with diff-in-diff is that the trend might be different between the area from where an incumbent comes from and the whole country. On example in Toamasina, which is the main harbor and experienced a larger growth trend than the rest of the country, towards the end of the period of study, due to the construction of pipe systems for transportation of nickel to the harbor and the following export of this. Apart from this there are few indications of this to be the case in this study. However, lack of data makes it difficult to control for omitted variables.

Yet another relevant challenge for the analysis when using diff-in-diff on this question is the population growth. A growth in population may be the reason for increase in lights in a region. Increase in light will not reflect improved living standard per capita, but only an increase in economic activity due to larger population in the area. The population growth in the regions I study are equal to the growth in the country and do therefore not represent a deviation in trend of economic activity.

5. Results and analysis

Due to the large number of results and figures to be presented, the analysis of the results is done immediately after the presentation of each result. Also, to give a short introduction, the summary of the results is presented in chapter 5.2, before the individual in-depth presentations and analysis of the results. There are five different presidents in the period. One of them, the former one-party president Didier Ratsiraka, governs a second period from 1997-2002. President Norbert Ratsirahonana only governs for half a year and can hardly be considered to have had any political or economic effect on the country. The presidents come from three different regions: Toamasina, Diana and Analamanga. The three different home regions of the presidents are presented in different sections in the chapter. The presentation therefore deviates slightly from the chronology of their presidency. Table 5.1 below presents the presidents, their period of govern and their home regions. The administrative level of "region" is the second of four administrative levels. The home province and home district of each president are presented in Appendix B.

Table 5.1.: The presidents, their period of presidency and their home regions.

President	Period of presidency	Region (adm. level 2)
Didier Ratsiraka	June 1975 - March 1993	Toamasina
Zafy Albert	March 1993 - Sept.1996	Diana
Norbert Ratsirahonana	Sept.1996 - Feb.1997	Diana
Didier Ratsiraka	Feb.1997 - July 2002	Toamasina
Mark Ravalomanana	Feb.2002 - March 2009	Analamanga
Andry Rajoelina	March 2009 -	Analamanga

5.1. Expectations and methods of analysis

As discussed in chapter 3 the literature shows that the institution of patronage plays an important role for economic activity and for distribution. Patronage is an archaic institution that leads to distribution along other criteria than the criteria of need. Moser (2008) have calculated that in Madagascar only 26 % of the communes which qualify for health programs, under a regime of poverty minimization, will get access to these programs in a regime of patronage. The numbers are 35% for education programs and 65% for construction programs respectively. The higher number for construction programs could be due to the visibility of such programs.

Moser gets significant results, suggesting that patronage does play a role in the allocation of social development programs (2008, p.149). My question is whether the presidents in Madagascar favor their own regions over the period from 1992 until 2010 and I expect there to be active mechanisms of patronage in the political and economic institutions of Madagascar during this period. I use two methods to approach the hypothesis: a local analysis and a relative analysis. Both are quantitative.

Local analysis   In the local analysis I measure the change in light density in the hometown of each president when he gets into power, and when he steps down from the presidency. I measure the change in light density from the year before he enters/leaves office and the year he actually enters/leaves office. Because it is likely that it takes at least one year to implement patronage in a country, especially in a poor slow-moving country, I also measure the change in light density from the year before the president enters/leaves office and the year after he enters/leaves office, in some regions. The second measurement gives a gap of one year. It is reasonable to expect the trend of economic growth to be positive over time and therefore the trend of change in light density to be positive as well. A negative shift in the observed light when the president leaves office may therefore give stronger indications of patronage. Here follows some of my expectations:

I expect the change in light density to be positive when comparing the year the incumbent got into office with the previous year as an indication of patronage. This will be visible in the figures as warmer colors of orange and red. The color scale below shows that yellow means no change in light density. The warm colors of orange and red represent an increase of respectively less than 3,5 in light density and more than 3,5 in light density. The cold colors of blue represent similar proportional reductions in light density as the scale indicates.

- -10 -
- -3,5 - -10
- -0,0 - -3,5
- 0
- 0 - 3,5
- 3,5 -
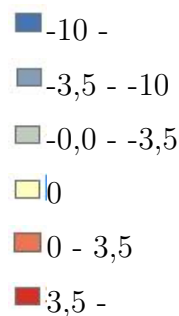
Equally I expect the change in light density to be negative when comparing the year the president got out of office with the previous year. This will be visible in the figures as different colder colors of blue. Because the incumbents are changed at different months during the year and the satellite light only gives information on a year level, and, as mentioned above, and discussed in chapter 3, because it is likely that the effects of patronage need more than a year to be visible on satellite lights, I also look at the difference between the year *before* the incumbent got into

office and the year *after*. I then expect the change in light density to increase and be warmer from the year the incumbent gained power till the year after he gained power. Equally I expect there to be a reduction, that is negative and cold values, in the light density from the year *before* the incumbent left power compared to the year he left and the year *after* he left. See for instance figure 5.4 for an example.

The light densities have values between 0 and 63 in the satellite light data. The number 0 means that no light is observed. Only 0,1 percent of the pixels globally are censored at 63 (Henderson et.al, 2012). Madagascar, as a poor country, has mainly low values, despite its' population density that is similar to that of the US. According to Henderson et al. (2012) 99.73% of Madagascar is censored as 0 when measuring the average light density over the period 1992 to 2008. For a comparison, less than 70% of the US is censored as 0, and 20% is between 6 and 62. In the densely populated Netherlands, 88% of the country is censored between 6 and 62, whereas only 8% is censored on these values in the even more densely populated, but poor country, Bangladesh. The most common observations in Madagascar are the values from 3 to 5. However, these values are registered in only 0.15% of the country. This gives some powerful insight into the extreme poverty the country is faced with, especially in rural areas. Figure 5.1 below illustrates this.

Only urban areas are registered on the satellite images to the right in figure 5.1, despite the large populations in the rural areas of Madagascar as illustrated on the left map in figure 5.1. The poor, rural Madagascar lacks electrical light and the welfare that follows. The map of people per square kilometer, at the left, is from The Food and Agriculture Organization of the United Nations, based on data from 1998 and 2000. The light density map, on the right, is made by using satellite light data from NOAA from 2000. On the satellite light map low values are indicated by a darker color of red, in contrast to the population map. This is to be able to actually observe the small units of light in the country.

Relative analysis   The second method I use to approach the hypothesis is a relative luminocity analysis. In the relative analysis I present the light censored in the president's region as a percentage of total censored light in the country. For instance figure 5.3 shows that in 1992 Toamasina region stood for 11% of total light registered in the whole country. The light in Toamasina Region had a dramatic drop of 50% in 1993 to only 5.5% of total light in the country. By measuring light density in one region relative to the whole country, factors that influence the whole country such as national growth trends and global financial crisis are controlled for.

I expect the trend in light density in regions with a sitting president to be increasing relative to the light density on national levels. Figure 5.2 presents an example of the expectations of differences in trend if all else but the patronage is equal. Figure 5.2 does not represent real data and is only an example of how patronage would be clearly read out of the data if all else is equal. The example strongly suggests patronage in the period from 2002 to 2008.

Figure 5.1.: Population density and light density in 2000
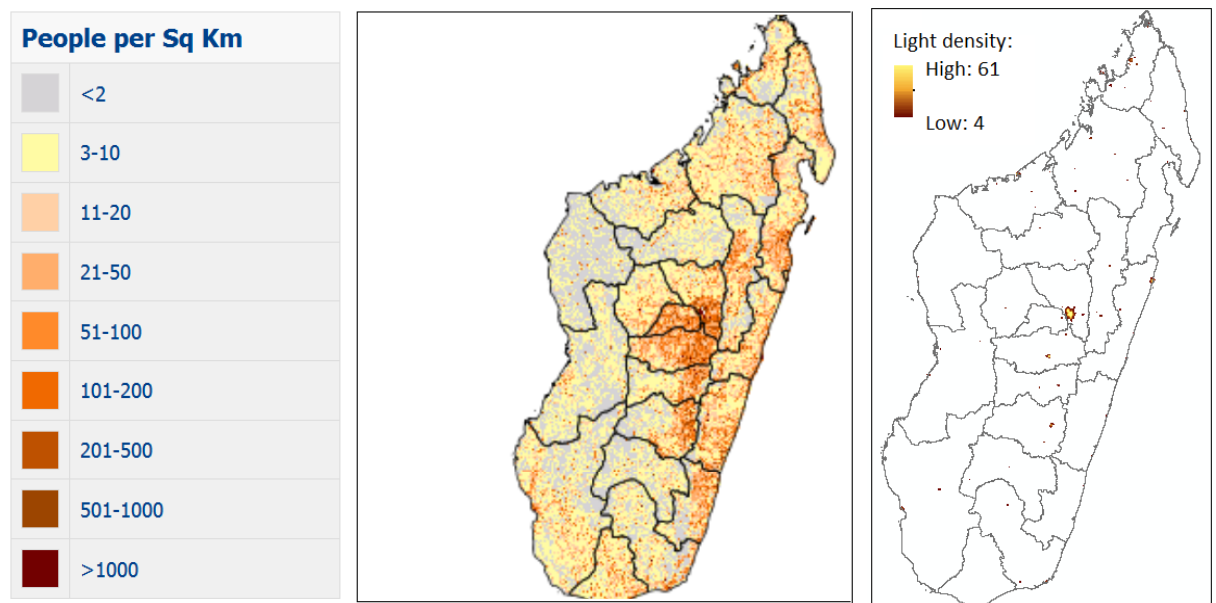
However, the real data are not as straight forward to analyze and some knowledge of local context is an advantage to be able to do a proper analysis. There is much noise in the data, as only factors that influence the whole country are controlled for. Still, the data strongly suggests patronage in some periods and some areas. Keep in mind that the different satellites are presented by different colors in the relative luminosity figures and that the years with two colors have observations from two satellites.

5.2. Summary of patronage in Madagascar 1992-2010

To give a short introduction to the complex story of patronage in Madagascar in 1992-2010, I will shortly sum up the results of the satellite light data and my analysis of them, before presenting and discussing the details.

Didier Ratsiraka (1975-1993) and (1997-2002) The data show a decrease of 50% in light density in Toamasina, Didier Ratsiraka's home town, after he left office in 1993. This result suggests that the satellite light data reveals that president Ratsiraka had a relationship of patronage towards his home region of Toamasina in his period of govern that ended in 1993. The results from the second period of govern from 1997-2002 show a lower difference(negative or positive difference?) in the trend of economic activity during his govern, relative to when he did not govern. However, the difference is remarkable. When Ratsiraka entered office in 1997 there was an increase of 10% in light-registered economic activity in Toamasina region,

Figure 5.2.: Revealed patronage: an example
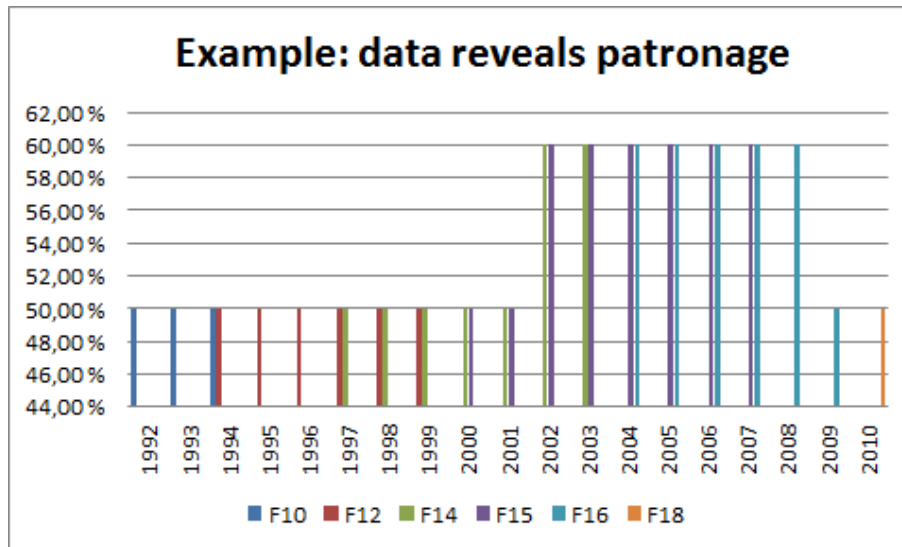
whereas the reduction when he left office in 2002 was of nearly 20%. Both the relative presentations of the results and the local three-dimensional figures suggest patronage in both of president Didier Ratsiraka's periods of govern.

Zafy Albert (1993-1996)   President Zafy Albert won the elections based on the democratic movements in Madagascar that were influenced by the same movements globally. His outspoken policy was to concentrate on other aspects of politics than neopatrimonial patronage . It is therefore not a surprise that the light data do not suggest patronage under Zafy Albert's govern.

Norbert Ratsirahonana (1996-1997)   President Norbert Ratsirahonana governed for only half a year and is considered a parenthesis in Malagasy economic and political history. The light data are based on yearly averages and it is therefore difficult to do a proper analysis for a president that governed for such a short period. The nature of patronage also requires more time to be able to show its significanse.

Mark Ravalomanana (2002-2009)   After a period of focus on democratic movements in the country, and less focus on economic growth, president Mark Ravalomanana won the elections in 2002, a man considered to be a savior for the economy. He liberalized the economy and the data suggests that president Mark Ravalomanana was a patronizing president. The light data suggest that he had patronage relations towards his hometown of Antananarivo, and especially towards a group that shared his view on liberal economics, in the southern part of the capital. He industrialized this part of the capital and the growth in economic activity in this area is very clear on the figures of local luminosity.

Andry Rajoelina (2009-)   It might still be early to analyze the effects of the presidency of the transitional president Andry Rajoelina. The data available are until 2010, only a year after he got to power. However, the data suggest a large difference in the trend of development in light density in the region of Toamasina during Andry Rajoelina's govern. This is interesting since Rajoelina is from the capital but is accused of having patronizing relationships towards Toamasina. The relative increase in light-registered economic activity is of as much as 100% in Toamasina region after Andry Rajoelina came to power. It has increased from a fraction of around 6% in the whole period of Mark Ravalomananas presidency to 13% in 2010. There are good reasons to take former president Zafy Alberts worries about French interests in Madagascar into considerations. The data suggests that there might be mechanisms of patronage towards the region of Toamasina under the presidency of the transitional non-democratic president Andry Rajoelina. I will come back to the discussion of this result in the discussion in chapter 6.

5.3. Results and analysis of the results for the district of Toamasina

In the following, the local and the relative analysis are presented in parallel. The local results are presented as prepared satellite images of night time light. I have zoomed in on the cities where the presidents come from and scaled the colors of the pixels according to the color scale presented in chapter 5.1. These figures are three-dimensional. Yellow indicates that there is no change in light density from one year to the other. The different scales of cold colors of blue indicate a reduction in light density and the warm colors of red and orange indicate an increase. All the maps represent the difference from one year to another, as indicated in the description of the figures. This means that the values of the pixels are not the observed light density, but the difference in the density in each specific pixel from one year map to another.

It is worth noticing that for the cities on the coast, such as Toamasina, the light observed offshore on the prepared satellite images (see for instance figure 5.4) is not included in the relative analysis. The method used to aggregate data uses the borders as limits and the reflection of light in the ocean could wrongly give too high values of light density.

The relative presentation of the results show a region's share of light relative to total light registered in the country for the period of 1992-2010. Keep in mind that by doing so, effects that influence the whole country are controlled for. The results are presenting the "second difference" in trend, as explained in chapter 4.4 on the difference in difference approach. The different colors of the graphs represent data from different satellites. Keep in mind that the years with two columns have observations from two satellites. I have chosen to include both to give the true

picture of the results from the data. The circles on the graphs indicate the periods when there is a president from the region. In figure 5.3 an extra circle is included because I want to look into whether the president in 2009 and 2010 has patronizing relations to the region of Toamasina because of accusations that claim he does.

President Ratsiraka governs from 1975 - 1993.

Toamasina: effects when he leaves office in 1993 President Didier Ratsiraka is from the district of Toamasina. He led a socialist experiment on the country with strong relations to communist countries (Dahl, 2008 p.132). He entered office in June 1975 and left office in March 1993. Scandals of corruption in state-led companies and devaluation of the Malagasy currency led the country and especially the economy into a large crisis in the last years of his govern. The period of 1991, 1992 and 1993 represent a political crisis that nearly led the country into a civil war. The population was largely dissatisfied with president Didier Ratsiraka and his failed socialist experiment. Despite the political crisis, Toamasina, Ratsiraka's home region and the main harbor of the country, represented a large fraction of the country's economic activity in 1992.

Figure 5.3 illustrates that Toamasina region stood for more than 11% of total light density in Madagascar in 1992. According to population numbers from the World Bank, Toamasina stood for only 6% of the country's population in 1992. The results can indicate that Toamasina was much richer than the rest of the country in 1992. Toamasina's fraction of the country's population is stable on 6-7% for the whole period I study. It is therefore interesting to read the results in figure 5.3 that measure only a fraction of 5.5% light density in Toamasina in 1993. Controlled for the fraction of population, this represents a decline of 50% in light density in only one year. A similar effect is found on all administrative levels, see the graphs in Appendix B.

It is also interesting that on neither of the administrative levels does the region of Ratsirakas hometown gain the same relative levels of economic activity, relatively to the whole country, until the years of 2008, 2009 and 2010. I will come back to this under the analysis of Toamasina in this period.

Both illustrations in figure 5.4 show the same strong decline in light density in Toamasina from the last year Ratsiraka governed to the first and second following year. The blue colors indicate a negative change. The darker blue represents a strong cooling of the economic activity. The result from the difference from 1992 to 1994 is included to the right in figure 5.4 and strengthens the argument. The change in light density is still negative. The negative change in light density from the last year in office for President Didier Ratsiraka until two years after, gives indications that strengthen the theory of the Toamasina region suffering for loosing their patronizing president. The economic activity is still not back to the level it

had before Ratsiraka left office, after two years with a new president from another region.

Figure 5.3.: Light density in Toamasina Region as a fraction of the whole country.
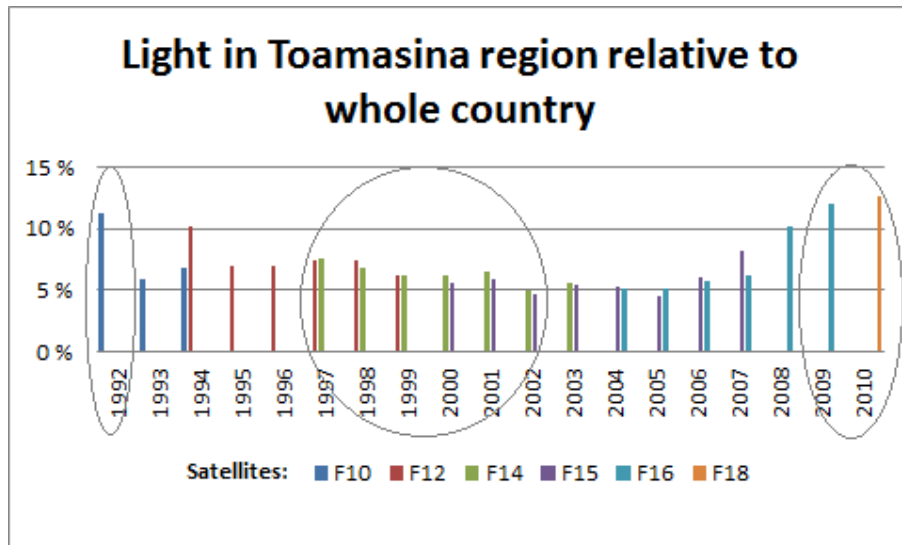

Description of figure 5.3: Trends in the fraction of light density in President Didier Ratsiraka's home region relative to the whole country. The periods in the two first circles are the periods when he was in power. The period when Andry Rajoelina governs is included in the last circle.

The reduction in economic activity observed by the negative change in light density suggests patronage in Toamasina. Since the trend of economic growth is normally positive, this can be interpreted as a clear indication that mechanisms of patronage can have played a role in Ratsiraka's relation to his hometown Toamasina.

An alternative explanation could be that the city of the national harbor is hit more strongly by the political and economic crisis than the rest of the country. However the reduction is severe and lasts for a very long period. The end of Ratsiraka's government could have immediate effect on economic activity because he had to flee the country and went to exile in France. It is likely that he had to give up control of both public and private initiatives with immediate effect when he left. The results are not surprising, knowing that Didier Ratsiraka governed as a one-party leader for 17 years and had a long period to build up mechanisms of patronage. It would be interesting to look into the period before 1992 if these satellite light data get digitalized and published to see whether the large fraction of light registered in Toamasina region in 1992 is representative for the period of Didier Ratsiraka's one-party presidency.

A weakness when looking at the trend before and after Ratsirakas presidency in the early 1990s is, as mentioned, that there is only data from one year prior to his loose of presidency. Another weakness is that the main harbor of the country might be

**Figure 5.4.:** Toamasina town: differences from 1992-1993 and 1992-1994.
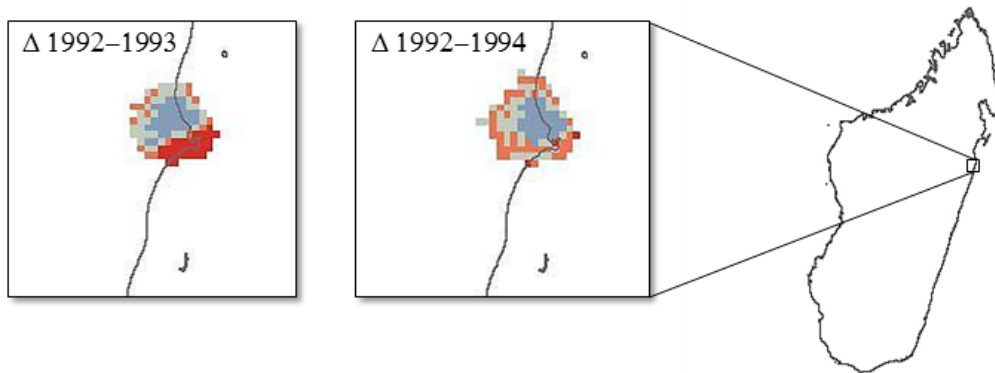
influenced by many other factors than patronage that I am not able to control for here.

President Ratsiraka governs from 1997 to 2002.

Toamasina: effects when he enters office in 1997   Despite the democratic movements in early 1990s Ratsiraka regained political power, won the presidential elections in 1997 and came back from France. According to the data suggesting patronage in his former period of presidency, one would expect to see an increase in the trend of economic activity also in his next period of presidency, from 1997 till 2002, in the relative analysis in figure 5.3. The long term trend is actually the opposite; mainly negative until 2005. However, figure 5.3 show that there is a greater level of economic activity the first two years of Ratsirakas new period of presidency. From representing 7% of the country's economic activity, the level of economic activity in Toamasina increases by nearly 10% to 8% when Ratsiraka entered office. For relative illustrations of the other administrative levels, see appendix B.

The local analysis in figure 5.5 does not give a clear image of whether there is an overall increase or decrease in light density from the year before Ratsiraka got into power again, in 1996, to the year he is back in charge in 1997. However, the illustration to the right in figure 5.5 is clearly warmer. This can reflect an optimism among president Didier Ratsiraka's group of base and suggest that patronage is playing a role in the start of the president's new governing period. The illustration in figure 5.5 suggests that patronage is stronger the second year of governance than the first.

However, there are many factors that can affect the satellite light and the economic activity at the same time as patronage. Still there is not enough evidence in data to reject that there is no patronage towards Toamasina during Didier Ratsiraka's second presidency. On the contrary it is likely that it requires large effort and a longer period of time for Ratsiraka to build up his former empire and possibilities

**Figure 5.5.:** Toamasina town: differences from 1996-1997 and 1996-1998.
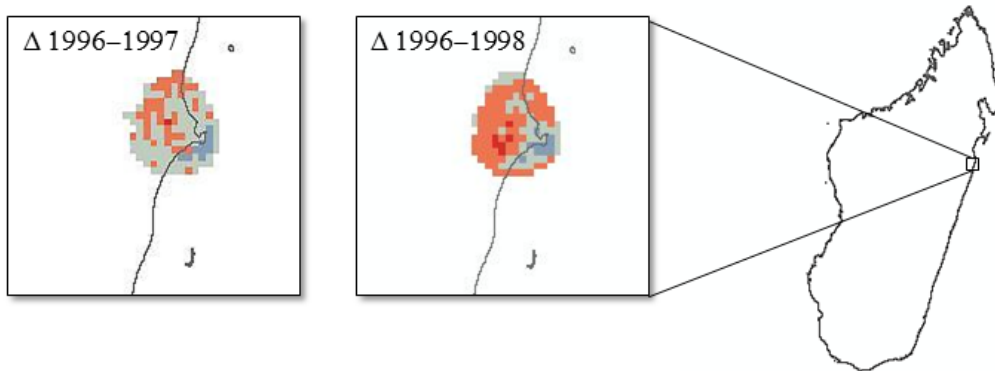
for patronage. The relatively higher fraction, even thought it is small, of economic activity during his second presidency compared to the period after, might therefore suggest patronage.

Toamasina: Effects when president Ratsiraka leaves office in 2002 The effect of patronage is expected to be most visible when the incumbent leaves office. A negative change indicates a larger change than a positive because, all else equal, the trend of economic activity is expected to be positive. Figure 5.6 suggests therefore that there is a drawback effect for Toamasina, from 2001 to 2003, when president Didier Ratsiraka left office. However, keep in mind that there can be good reasons to exclude the light from the ocean. The results are therefore not unambiguous.

The fraction of light censored in Toamasina is lower in the 3-4 years after Didier Ratsiraka lost the presidency than before. From representing a fraction of 6-7% of the country's light, it reduces by almost 20% to represent only a fraction of 5% of total light censored in the country in a period of four years after Ratsiraka left office.

Keep also in mind that Toamasina region's fraction of the country's population is stable over the whole period so emigration from the region is not the driving factor for the reduction. It is likely that data suggest patronage towards the region of Toamasina in the period when Ratsiraka governed 1997-2002, and it stopped when he left office in 2002.

**Figure 5.6.:** Toamasina town: differences from 2001-2003.
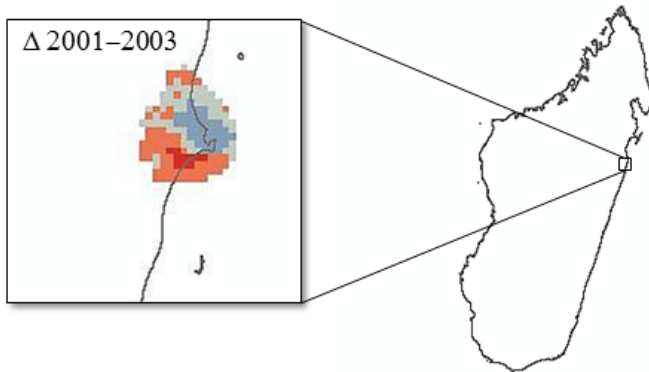
President Rajoelina is the sitting transitional president since 2009:

Toamasina: effects when he enters office in 2009   In January 2009 a period of political instability started. The leader of a political opposition movement Andry Rajoelina (then mayor of Antananarivo) sought to oust President Marc Ravalomanana from the presidency. On the 21 of March 2009 Andry Rajoelina was officially declared the president of the High Transitional Authority of Madagascar. The international community immediately condemned the leader and his ascension as unconstitutional and financial support and foreign investments stopped. The country fell into one of the worst economic crises in its history.

Despite the economic crisis the illustration to the left in figure 5.7 shows that there was a significant increase in economic activity in Toamasina from 2008 till 2009. The size of the city has also increased towards the south when comparing figure 5.6, which shows the beginning of the 2000s, and figure 5.7, showing the end of 2010s. The transitional president Rajoelina is not from Toamasina, he is from the Merina tribe in the region of the capital. I therefore find it interesting that while the rest of the country goes into an economic crisis, Toamasina blossoms.

Figure 5.7.: Toamasina town: differences from 2008-2009 and 2008-2010.
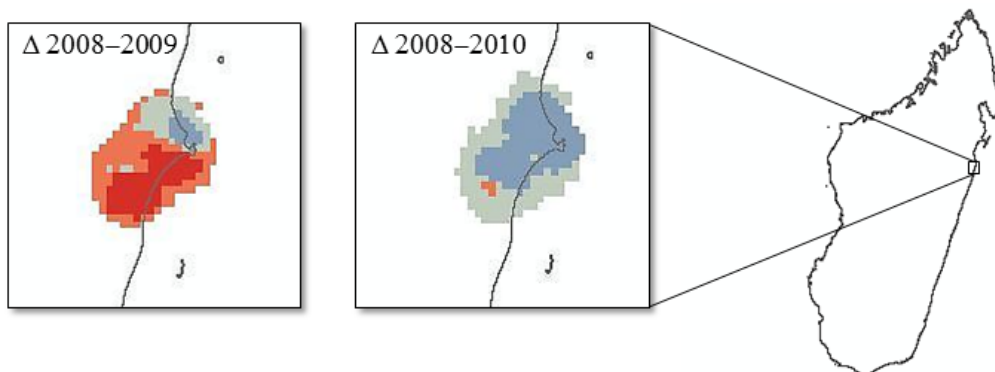
It is also interesting that on neither of the administrative levels (see also Appendix B) does the region of Ratsiraka's hometown gain the same relative levels of economic activity, relatively to the whole country, until the years of 2008, 2009 and 2010. These years coincide with the period when the transition president Rajoelina was in power. As mentioned, Rajoelina is from the Merina tribe from the highlands and does not have ethnic or obvious patronizing relations to Toamasina. However, the main common feature of Rajoelina and Ratsiraka are their loyalty to France, where ex-president Ratsiraka is living in exile. Could the night time satellite light data suggest that there are mechanisms of patronage towards Toamasina in the period when Rajoelina governs? If so, could this be related to French interests in the petroleum resources? Former president Zafy Albert accuses France of directing the political instability in Madagascar (Dahl, 2011). This must be done in cooperation with someone with a broad network in the country. A cooperation between former president Didier Ratsiraka, the transitional non-democratic president and French interests is not impossible.

While the rest of the country is in an economic crisis Toamasina has increased activity relative to the country.The light density increases with over 100% from the period of Mark Ravalomananas presidency (2002-2009), when the fraction of light in Toamasina relative to the whole country was of only 6%, till 2010 when the fraction increased to 13%. The data could suggest patronizing mechanisms from the sitting president towards the hometown of former president and France-friend Didier Ratsiraka.

The illustration to the right in figure 5.7 shows another picture, showing that the change in economic activity from 2008 till 2010 is strongly negative. This could indicate that also Toamasina got negatively influenced by the economic crisis after two years with the transition president. However, the satellite that measures the light density in 2010; F18, only has one observation and the measurement of a new satellite might be slightly less reliable the first year it is running, despite of the data being calibrated.

5.4. Results and analysis for two districts in the north: Ambilobe and Antsiranana

President Zafy Albert governs from 1993 - 1996:

Ambilobe: effects when he enters office in 1993 President Zafy Albert was the first democratically elected president in Madagascar. He comes from the northern region of Diana, from the town of Ambilobe. Ambilobe is the smallest town in figure 5.8, represented by the light in the bottom corner to the right. Zafy Albert is a doctor and former Minister of Health from the period before Didier Ratsiraka's one-party govern. President Zafy Albert represented a democratic hope and democratic spirit

after the long nondemocratic govern by Didier Ratsiraka. Zafy Albert's popularity and the wind of democratization that inspired the Malagasy people must be seen in relation to the global wind of democratization after the fall of the Berlin Wall and the Soviet Union in 1989 (Dahl, 2008). Zafy Albert's focus on democratic processes might have reduced the neopatrimonial tradition of patronage. One of Zafy Albert's goals was to settle with former president Didier Ratsiraka, including the patronage that was integrated in the Malagasy socialism he represented.

The local analysis in figure 5.8 shows both an increase and a decrease in light density in the town of Ambilobe, Zafy Albert's home town, from 1992 to 1993. The change in light density does not give any indications of patronage as the change is neither generally positive nor negative.

Figure 5.8.: Ambilobe town: difference from 1992-1993.
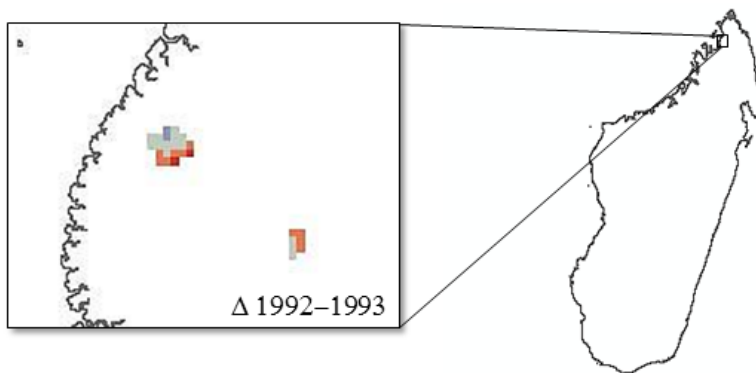
However, in the relative luminosity data the trend of light density in Ambilobe is increasing relative to the trend in the whole country. Figure 5.9 show that there is an increase in light density in Ambilobe the period Zafy Albert is in office, compared to the previous period. This could be an indication of patronage if nothing else happens at the same time. The results are the same at the provincial level and on the level of district, see Appendix B. However, the activity in Diana region is "bungee jumping" in his period of govern. The data do not have any clear suggestions. Still, the hypothesis of patronage can not be rejected. There might be some mechanisms of patronage at place, that can not be revealed by the use of satellite light data. Equally likely is it that the focus on democratic change dominates effects of the neopatrimonial institution of patronage.

Ambilobe: Effects when president Zafy Albert leaves office in 1996 When Zafy Albert leaves office in 1996 light density is spread out on a much larger area in his hometown than it was before he came to power, indicating growth in the period, see figure 5.10 compared to figure 5.8. This can be an indication of patronage. The result in figure 5.10 also suggests patronage as the whole town has a negative shift in light density and economic activity after their president left office. As discussed

Figure 5.9.: Light density in Diana Region as a fraction of the whole country.
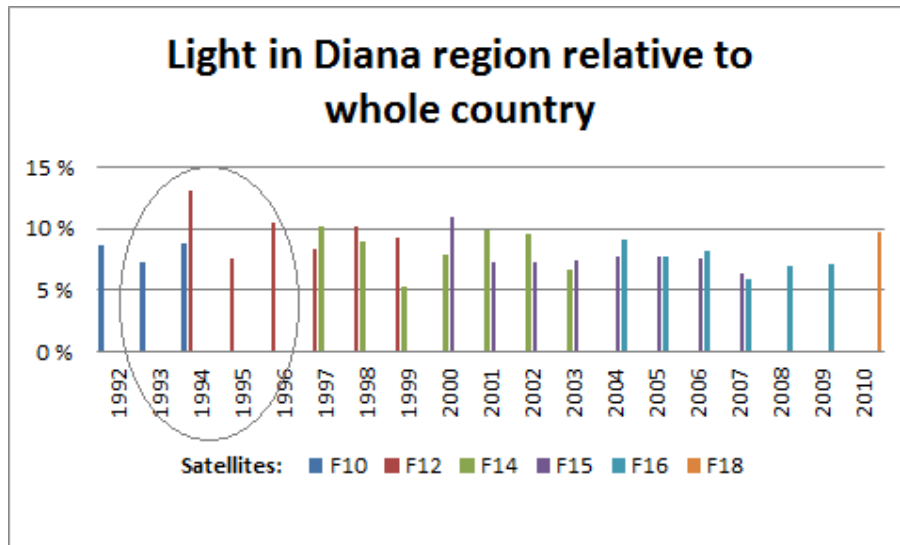
Description of figure 5.9: President Zafy Albert and President Norbert Ratsirahonana's home region: trends in light density relative to the whole country. The circle represents the years of Zafy Albert's presidency.

previously, a negative shift when the president leaves is more likely to indicate patronage than a positive shift when he enters office. It is likely that the trend in economic growth is positive rather than negative from one year to another. The negative shift is therefore interesting. However, figure 5.9 shows that, despite the drop of 20% in light density; from measuring a fraction of 10% in 1996 to only 8% in 1997, there is a similar increase of 20% again from 1997 to 1998 in the fraction of light density in the region relative to the whole country. The data presented in figure 5.9 shows that despite that the fraction of light registered in Diana region is fluctuating, it does not seem that there is any correlation in trends with the period of presidency from the region. In contrast to Moser's results based on data from only two random years, my use of data over time reveals this potentially wrong analysis of the data. Even though I can not reject that there is patronage, there is no suggestion in the data for patronage in Diana region during Zafy Alberts presidency. This is consistent with the knowledge of his focus on democratization rather than economic aspects.

Another aspect that is worth noting when analyzing the fractions of light in Diana region is that there is an increase of nearly 40% of light density from 2009 to 2010. According to Dahl (2011) local media report that enormous amounts of illegally logged rosewood from the national parks in Diana region have been confiscated in recent years. A closer look at the satellite light data reveals large decentralized increase of light in the national parks during the present transitional political period. The transitional president Andry Rajoelina said in his speech to the United Nations on the 26 of September 2012 that despite the suspension of international aid during

his presidency, which used to represent 60% of the national budget, they manage to run the governmental administration and their projects normally (Rajoelina, 2012). Members of higher authorities are accused of standing behind the illegal logging in cooperation with Chinese companies (Dahl, 2011). The illegal logging and dramatic degradation of the remaining of Madagascar's endemic rainforest seems to be financing the non-democratic president and his government. WWF "strongly condemn the traffic of these hardwoods as [they] can see no benefit going to the local people's livelihoods" (WWF, 2010).

This example suggests that the causal relationship goes the other way around. Increased light density is not due to the president patronizing a region and improving living conditions for the local population. Rather the increase in economic activity can be due to the president's plundering of a region for own benefit. However, since president Andry Rajoelina does not have any patronizing obligations towards the region of Diana, the indication of plundering of this regions natural resources, does not reject patronage towards own region. On the contrary, it is less likely that Rajoelina would plunder his own region, considering the historical roots of patronage.

Figure 5.10.: Ambilobe town: difference from 1996-1997.
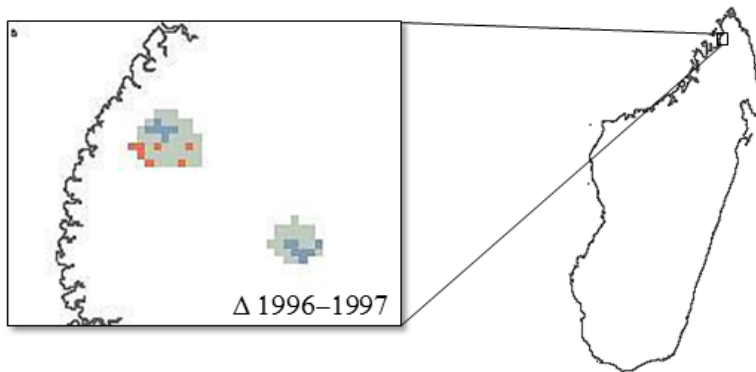
President Norbert Ratsirahonana; a parenthesis in Malagasy economic history.

Antsiranana: effects when he enters office in 1996 and leaves office in 1997. The govern of Norbert Ratsirahonana, who is from the district of Antsiranana, the same region and province as Zafy Albert, can be considered as a parenthesis in Malagasy political and economic history. He reigned from September 1996 until February 1997. Based on the previous indications that patronage needs some time to have any effect, it is unlikely that we shall see any effect in Antsiranana from the 6 months of Norbert Ratsirahonana's governance.

The figures in figure 5.11 could however suggest, all else equal, that such a mechanism may be in place. There is a large increase in light density from 1995 to 1996, and a matching reduction from 1996 to 1998. However, the northern region is especially exposed to variations in logging legislation of protected species of wood. In

legislative "windows" of export possibilities, activity might be much higher. This can result in an unstable level of economic activity and it is likely that this variance in economic activity drives the changes in light density to a larger degree than mechanisms of patronage.

Figure 5.11.: Antsiranana town: difference from 1995-1996 and 1996-1998.
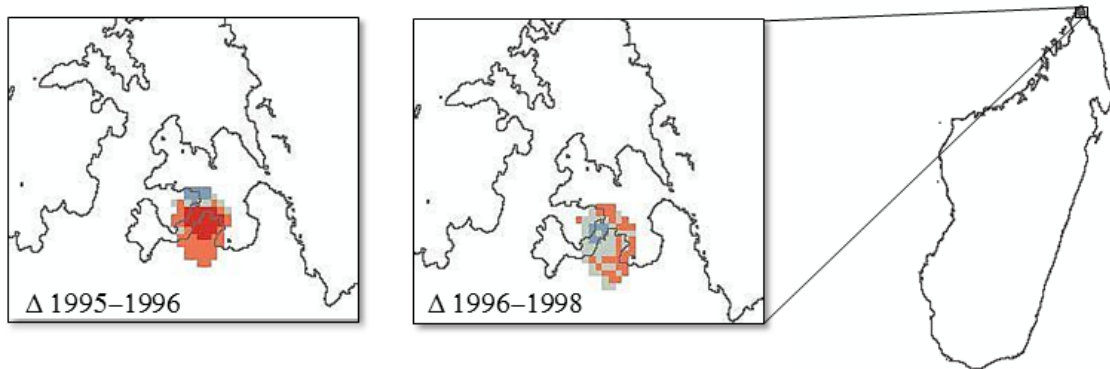

5.5. Results and analysis for the capital Antananarivo

President Marc Ravalomanana governs from 2002-2009

The capital Antananarivo: effects when he enters office in 2002   Marc Ravalomanana was elected president in the elections in December 2001 with a majority in the first round. He took office as president in February 2002 despite that the former president Didier Ratsiraka did not want to step down from the presidency until July 2002. Ravalomanana was re-elected in December 2006, again with a majority in the first round. Ravalomanana resigned under pressure to the non-democratic president Andry Rajoelina in March 2009.

The figures of the capital are more difficult to analyze than other cities. The region has more than half of all light observed in the whole country. The exogenous and endogenous factors that affect light density are many more and of much larger size here than elsewhere in the country.

Figure 5.12 represents the change in light density, as a proxy for economic activity, in the capital from 2001 to 2002, and from 2001 and 2003. The areas in the inner city, which make up the old city center, experience a decrease in the beginning of Mark Ravalomana's presidency. In contrast the suburbs and especially the south of the city experience a large growth. These are the areas of industrialization that Mark Ravalomana prioritized during his presidency in his work on liberalizing the economy.

Figure 5.12.: Antananarivo town: differences from 2001-2002 and 2001-2003.
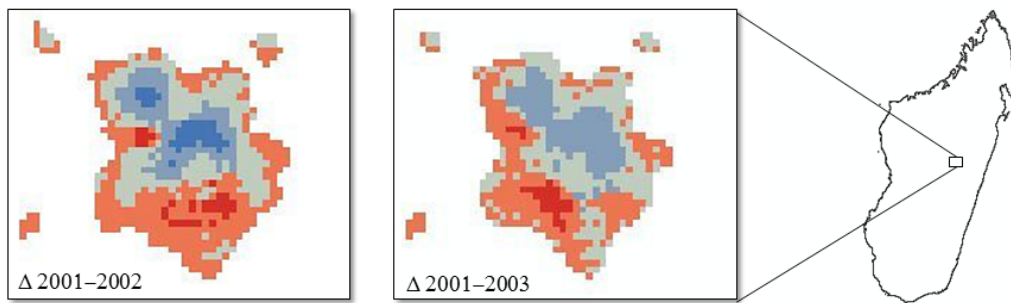
When looking at the trend of light density in the province of Antananarivo and the region of Antananarivo over time, the picture is quite stable. This is not surprising since this region contains more than half of the country´s light. It is also likely that aspects that affect the whole country also affect the region of the capital. What is worth noticing is the increase towards the second half of Mark Ravalomananas govern, marked in the first circle in figure 5.13. From 2006 till 2007 for instance, there is an increase in the fraction of light registered in the capital of 25%. From representing 55% of the country´s light density in 2006 the capital represents 70% of the light density the previous year. This result indicates that the capital has grown much more than the rest of the country in the period of Mark Ravalomananas govern. The satellite light data suggest patronage in the region of the capital, Analamanga region, under the presidency of Mark Ravalomanana.

Another interesting aspect is the large reduction in the fraction of light in the capital region under the presidency of the transition president Andry Rajoelina. Since the numbers are relative to the whole country, some large increase in economic activity must take place elsewhere in the country or there must be a large decrease in economic activity in the capital. This means that we are most likely not only talking about the effects of the financial crisis. As figure 5.3 shows it seems that the province and region of Toamasina is getting some of the relative increase in economic activity since the transitional presidency entered office. Some of this increase might be due to the construction of nickel industry in Toamasina. More important is it that president Mark Ravalomanana, who liberalized the economy and facilitated economic investments for businessmen in the capital, lost the presidency. The non-democratic president following him has tried to ruin Ravalomananas economic empire, aiming to increase the dissatisfaction of him among the population. For instance areas of industry in the capital were vandalized and destroyed during the political instability in 2009. The satellite light data captures this reduction in economic activity in the capital. The fraction of light is reduced from 55% to 46% from 2008 to 2010. This represents a reduction in light in the capital of nearly 20% from the period before the transitional government till two years after.

Figure 5.13.: Light density in Analamanga Region as a fraction of the whole country.
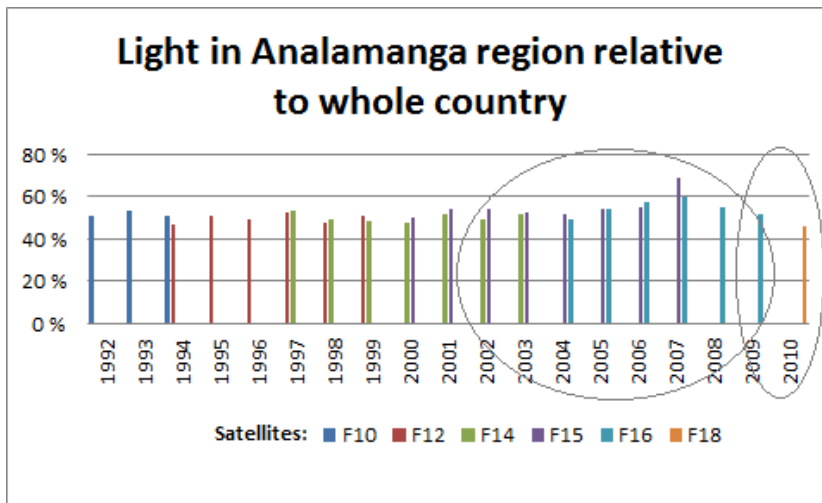

Description of figure 5.13: President Marc Ravalomanana's and Transitional President Andry Rajoelina's home region: trends in light density relative to the whole country. The circles indicates the periods Ravalomanana and Rajoelina governed. Ravalomanana from February 2002 to March 2009 (he was reelected in 2006) and Rajoelina from March 2009.

The capital Antananarivo 2009:

President Marc Ravalomanana leaves office and President Andry Rajoelina enters office Figure 5.14 shows the changes in light density in the capital in absolute numbers, that is; not relative to the whole country. We observe that there was still growth in the capital from 2008 to 2009, illustrated by the warm colors of red and orange. The cold colors of blue in the illustration of the difference in light density from 2009 to 2010 show a severe reduction in economic activity. There is a huge reduction of the economic activity, and no increase in any parts of the capital, under the non-democratic president Andry Rajoelina.

However, some of the reduction from 2009 to 2010 might be due to the new satellite F18. As discussed previously there are reasons to look further into the reliability of the data from this satellite, since it is the first year running of a new satellite and the only observation from this satellite. An argument for relying on the data also from F18.2010 is that it is calibrated.

Figure 5.14.: Antananarivo town: differences from 2008-2009 and 2009-2010.
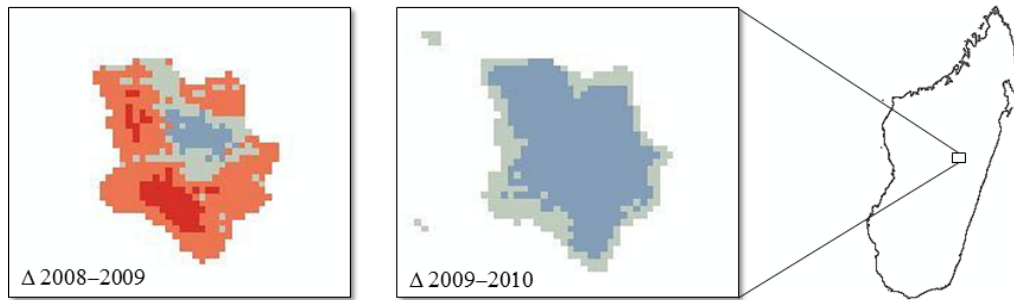
The results in this chapter give strong indications for patronage in Madagascar in the period from 1992 to 2010. Both the president from the eastern coast Didier Ratsiraka and the two presidents from the highlands, Mark Ravalomanana and Andry Rajoelina seem to have patronizing commitments towards their regions according to the satellite light data. For the presidents from the North, Zafy Albert and Norbert Ratsirahonana there the data can not clearly suggest patronage.

6. Discussion

I will shortly undertake two discussions. The first is about the method; the use of satellite data as a proxy for economic development, and the reliability of the results. The second is about the reasons for patronage and the possible effects of patronage, especially upon increased oil income.

6.1. Method and results.

The use of satellite light data as a proxy for economic development has some great advantages and some major challenges. Satellite data is an especially welcome tool when doing research on economic development on local levels in developing countries, due to lack of data. Light density can be an important tool for cross national studies. Different countries often have different measures of GDP. When working on cross national data, it is therefore often hard to compare data across countries. The light data is claimed to be of similar quality across the globe. In addition to these positive features the data is free and can be downloaded from the web.

The strength of the data when measuring economic activity is that nearly all consumption of goods at night requires electricity and light. As income increases, consumption usually increase and light usage per person increase. When trying to find whether there is patronage in Madagascar or not, the use of light density is therefore an innovative and good use of data.

In some countries, light density can be a better proxy for living standards than GDP. Michalopoulos and Papaioannou write that light density captures "economic activities of the underground economy, which are not reflected in the aggregate statistics. As the share of the shadow economy is high in Africa (La-Porta and Shleifer, 2008), the usage of luminosity data is particularly desirable" (2011, p.8). Furthermore the access to light improves health and security in local communities. It measures more aspects of human welfare than GDP does. Also large amounts of private surplus are invested in other countries than where it is earned. These numbers will appear in GDP, but not necessarily in the satellite data. GDP can in some cases measure too much economic activity and growth, whereas light density measures a more true picture of actual growth in the country over time. For example, the use of tax havens, where companies invest their profit in another branch of the company, localized in a country where they pay no tax, hinders a potential trickle

down effect of larger economic investments. This in turn reduces the country's conditions for economic growth and poverty eradication.

However, the use of satellite night time light has some major challenges as well. The main challenges met in the work on the creation of time series for Madagascar was the need for calibration of the satellites. To explore the effects of patronage over time, satellites that measured the same object at the same time must give the same data. Even using the calibration method developed by NOAA did not give clean calibrated data. Therefore the advantages discussed above might not come without a cost of some insecurity in the data. When doing research using data from only one satellite, the results might be more reliable as there is no need for calibration.

Another challenge is whether to include offshore data. In the methods used here I have excluded offshore light. The main reason is that much offshore light might be due to glare from onshore activity in the harbor towns. Including offshore glare would give too large numbers of light density relative to towns inland. Another reason not to include the light from the ocean is that fishing in the sea around Madagascar to a large degree are shipped to other countries without leaving much surplus in the country. Much offshore light will then most likely not be related to patronage.

However, despite some challenges in the use of the data, the literature seems to embrace the method that gives a whole new base of data to explore.

6.2. Patronage: reasons and effects.

The results in chapter 5 suggest that patronage is an important mechanism in economic activity in Madagascar. Since the groups that benefit from patronage to a large degree are different from the groups of poor (Moser, 2008), such mechanisms can contribute to less reduction in poverty than could otherwise have been possible. Considering that Madagascar is one of the worlds poorest countries, patronage can have fatal consequences for the poor and underprivileged groups of the population. Patronage will also be an inefficient way of redistribution, in terms of welfare maximization, as the ones with the highest marginal utility of the resources are not the ones who receive them.

The data strongly suggests that I can reject that there is no patronage. However, there are many things going on in the same periods and the geographical areas that disturb the picture. One aspect that could have an impact on the economic activity, that is not caused by patronage are cyclones. But cyclones may be correlated with patronage, as the incumbent might use that as a reason for increasing the transfer of goods and the facilitation of economic activity in the region. Other disturbances are positive income that are irregular, such as the export of exclusive lumber.

In Madagascar, the incumbent may legalize sale of expensive, fine-grained lumber such as rosewood and ebony for a short period after cyclones. The reason for doing

so is that cyclones might have damaged trees to the extent that they must be logged and a potential gain from cyclone damaged trees shall not be stopped. However the windows in legislation for export of rosewood and ebony after cyclones creates an illegal marked for logging. The areas of expensive and fine-grained lumber are in the north and therefore not likely to influence economic activity in Toamasina and Antananarivo. However, it is a variable that is more relevant in the discussion of the results for the presidents from the north.

Another variable that might affect the fraction of light density in a region is population growth and migration. The population in Madagascar have grown to the double from 1992 to 2010. The growth paths in the regions I am looking at are the same as in the country in total. The fraction of population in the regions of Diana, Analamanga and Toamasina are therefore constant over the period. Population growth and migration will therefore not affect the fractions of light density in the regions and do not have any important effect on the analysis of patronage by the presidents towards their home regions.

This is also the case for the analysis of Toamasina under the govern of the transitional president Andry Rajoelina, who is from an other region. Population growth does not seem to be the driving factor for the increase in the fraction of light density and economic activity in the Toamasina region in 2008, 2009 and 2010. The fraction of population in Toamasina is constant on 6% in the whole period from 1992 till 2010 despite of the doubling in population in the country.

Another development in Toamasina in recent period is some large investments in production of nickel that is refined in Toamasina. This can be a secondary explanation of the increased fraction of light density in Toamasina under the govern of the transitional president that is accused of close relations to French interests as some of the large increase in light density in Toamasina, in 2009 and 2010, can be traced to the economic activities related to the preparation of this industry. The actual production started in 2012, but the building of the refinery and other installations have generated large amounts of economic activity in the period prior to the start of production. However, the large increase in light density is likely to come from other sources as well and I can not reject that there is no patronage towards Toamasina under the presidency of Rajoelina. The data could even suggest that the incumbent who came to power in March 2009 after a longer period of instability have indirect patronage commitments towards Toamasina. This could indicate that French interests in Madagascar are strong, especially in the recent years, as production of valuable natural resources are starting.

According to Mehlum et al.(2006) the quality of institutions is a decisive factor in whether a country will be trapped in the resource curse or benefit from natural resources. According to the results in chapter 5 a clear advice to the Malagasy government will be to look into the institution of patronage. If this aspect of the local informal institution can be repealed; one aspect of the resource curse threat for the country may be reduced. More energy can then be used on poverty eradication.

Taxation is another key to avoid the resource curse. Through the tax income a democratically elected government can administrate the wealth and provide social services to the population. An investment in social services such as schooling and health will increase human capital which again raises economic growth and the potential curse will be no curse, but a benefit for the whole country for generations. Another way to distribute income from natural resources is to redistribute cash like the custom is in Alaska. This increases individual freedom, but does not unfold the potential of the society.

However, related to taxation and redistribution Moser (2010) argues that the local population should require better coverage by the media, and more easily access to the media. Information gives power. By getting information rural populations can demand transparency to secure that tax revenues are indeed spend on projects for the population, and not according to mechanisms of patronage. Availability of information is crucial for right holders to hold the duty bearers accountable. But be capable to do so requires proper information, and to be ability to read and to analyze information the population must get access to basic education.

The income might be extracted in a very short period. This might create a boom in the economy that is harmful for the entire economy over time. This mechanism can be down-scaled by the use of a petroleum fund. A petroleum fund can also redistribute over generations, which might be considered fairer than keeping all surplus from a resource that has used hundreds of generations to accumulate and getting valuable, for one or two random generations.

It likely that the mechanisms of patronage will continue to play its role when the country starts to benefit from the petroleum production. If measures of efficiency or measures of righteousness are thought to make the foundation of redistribution, several precautions could be taken to avoid distribution based on for instance patronage towards own ethnic groups. From the government's side, considering fairness, there should be allocation mechanisms ensuring a rather need based redistribution scheme. If the presidents were democratically elected, the redistribution they decide upon reflects the peoples' will. Following this argument an allocation of public resources based on ethnicity can be defended as democratic. However, prioritizing according to basic needs would be in accordance with the UN human rights, which is often believed to be universal. One could also consider basic capabilities instead of basic needs, giving the individuals more freedom over own lives.

Following Sen's (1993) capability approach I believe each society could, in a democratic manner, for instance by the parliament, make a list of basic capabilities. By doing so the moral foundation of consideration of a good life and the foundations of redistribution would be cultural sensitive, as Sen suggests talking about development as freedom (2000). Such a basis for redistribution might be more democratic than following a list from the UN, which does not have a democratic mandate, organizational structure, and even less, balance of power. It might also be more democratic than regular redistribution schemes since the parliament represents all

political parties, in contrast to the government.

The contribution of this thesis is to encourage a discussion, about distributive mechanisms in the country, among the Malagasy people, and especially among the poor majority of the Malagasy people, who are powerful if they are able to use their democratic voice. The results in the thesis suggest patronage in Madagascar, based on neutral data from outer space that, despite their weaknesses, are not biased by any political agenda or poor availability of data. My hope is that the natural wealth in Madagascar can benefit the local population by eradicating poverty, enhance economic growth and develop a welfare state, all by enabling Malagasy men, women, boys and girls to live their lives with the dignity every human being are entitled to. Identifying and reducing patronage that do not benefit the poor can be one little step on that path.

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A. Appendix

A.1. Method used to prepare data for analysis

Due to the size of the data sets I have first cut out a polygon around Madagascar. By doing so, the size of the data for one year satellite image is reduced from 709 000 KB to 1 800 KB and I keep only the information I need. This gives me the possibility to store the new maps I create. Data aggregation within borders is done by using the program tool "Zonal Statistics; Zonal" in the "Spatial Analyst Tools" in the program ArcMAP. By doing so on all data set available on the administrative levels of: the nation, the autonomous province (faritany mizakatena), the region (faritra) and the district (fivondronana) I get 124 maps as a base for the information I need (31 satellite/year * 4 administrative levels). In the analysis I look at effects of patronage in the administrative units that have bread a president. To give a better analysis I create time series over the different administrative levels mentioned above. By looking at the different administrative levels I can identify whether local affiliation or regional affiliation is strongest. By using time series I can look at the effects over time and not only around time of elections. Data on light density within the administrative areas of interest are collected manually.

A.2. Calibration of satellites

Different satellites measuring a region in the same year are in principle measuring the same object. However, when I aggregate the total observed light density in Madagascar I find that different satellites give different measurements on the same year. This is a clear challenge for the use of satellite light data in time series. The problem is most severe when comparing measurements from years with different satellites. We are unable to say if the measure of for instance the satellite F15 (marked in purple in the figure below) in 2000 can be seen as a continuation of the measurement of the satellite F12 (marked in red in the figure below) in 1999, see the figure below. Alternatively the measurement of satellite F14 could be more correct.

Figure A.1.: Light density at national level: uncalibrated
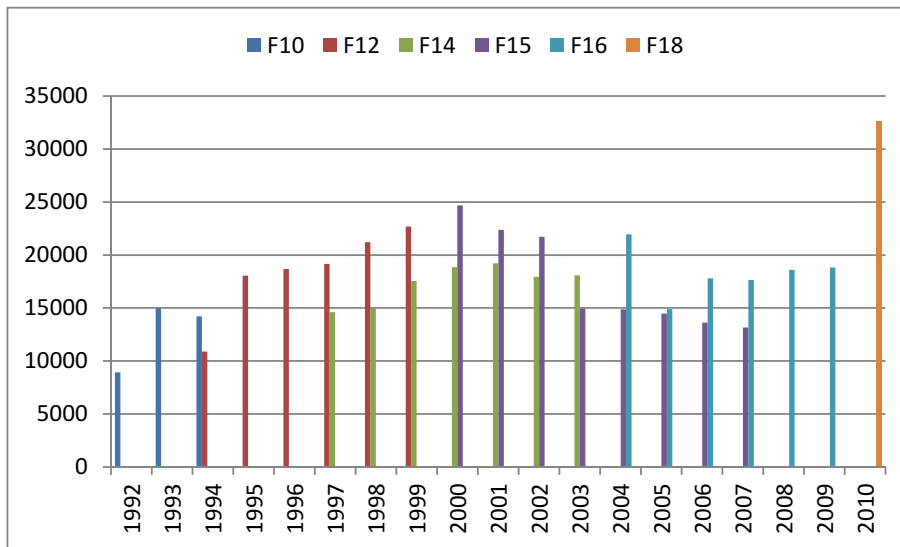
To be able to do a proper analysis of the data I need to calibrate the satellites. To answer the question of whether we can observe patronage over time, it is crucial to be able use the whole data set as a time series. A calibration will make the data fit into one time series, and will allow me to compare the light density over time. I have tried different methods of calibration of the aggregated data. However, the calibration did not smooth out the differences properly and I kept meeting challenges. Upon contact with the producers of the data I got an "in house" calibration method from NOAA. By this method, I calibrate each picture before aggregating the data. The result is much more convincing than the methods I first used when calibrating the aggregated data. The three different calibration methods that I developed are presented below. The three strategies use one of the satellites that has measurements from two years as a tool for inter calibration. It is more difficult to find a way to be able to compare the data from 2009 and 2010, when there are no overlapping satellites.

Method I   Method I gives a slightly smoother trend than without calibration, but there are still many irregularities between what different satellites measure in a same year.

The light density is calibrated based on the first year of each satellite running by finding a relation number between the two measurements of one year and increasing the following numbers by this relation number. Calibrating the satellite F12 on F10 in 1994 is done by dividing the number of light density in the whole country measured by the satellite F12.1994 by the one from F10.1994. This gives the relation number 1.31, by which all numbers from F12 are multiplied with. For the other satellites I have calibrated F14 on F12 in 1997 and multiplied all numbers from F14 by 1.71. I have calibrated F15 on F14 in 2000 and multiplied all numbers from F15 by 1.31 and calibrated F16 on F15 in 2004, multiplied all numbers from F16 by 0.89. This

method do not allow for calibration of F10 and F18, and gives the results presented in the figure A.2.

GDP is included to show the different measure between the satellite light as a proxy for economic development and the traditional measure of GDP. The period where GDP is higher than light density can indicate that the economic growth does not benefit the local population, at least not in terms of electricity for housing, road lightning for security, hospitals, enterprises and so on. The period where the light density is relatively higher than the GDP, compared to the inverse period, can give indications that there was more economic activity in the population than what GDP was able to measure. Another possibility is that the effects on light density and on the welfare of the people after the liberalization of the economy by president Marc Ravalomanana (2002-2009) are lagged.

Figure A.2.: Light density, calibrated with method I
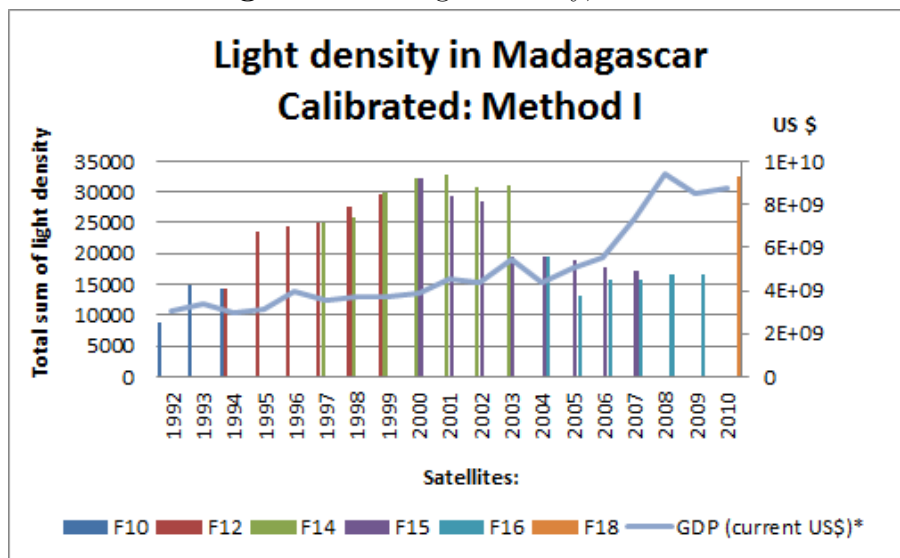
Light density at national level: calibrated on the first year of the satellite running, including GDP

Method II Since the satellites seem to give numbers that divert from the trend the first year of running I have tried to calibrate them based on the second year of the satellite running by using the same method as above. For instance, instead of calibrating F14 on F12 in 1997 (the first year F14 is running), I calibrate in the second year F14 is running, namely in 1998.

Calibrating F14 on F12 in 1998 is done by dividing the number of light density in the whole country measured by F14.1998 by the one from F12.1998. This gives the relation number 1.41 by which all numbers from F14 are multiplied with. For the other satellites the numbers are: calibrate F15 on F14 in 2001: 1.21 and calibrate F16 on F15 in 2004: 1.18. This method does not allow for calibration of F10,

F12 and F18. The result shows much clearer trends when there are more satellites measuring the same year that gives the same result, see figure A.3.

However, there are still some serious irregularities in what different satellites measuring the same object in the same year report. I have therefore tried a third method of calibration of the aggregated data.

Figure A.3.: Light density, calibrated with method II
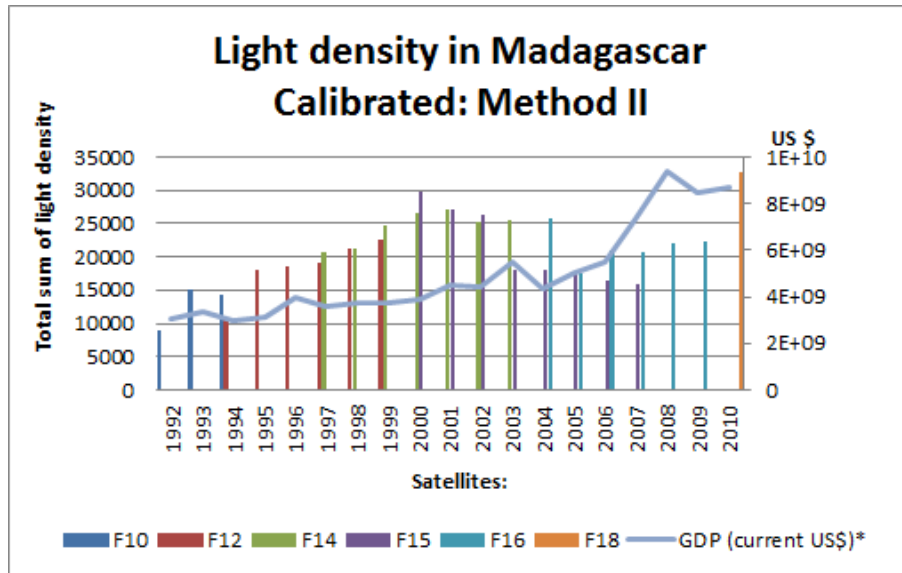
Light density at national level: calibrated on the second year of the satellite running, including GDP

Method III   By doing a calibration on the average of difference between two satellites, for years when there are two satellites, smooths out the variation between different satellites better than the two previous calibration strategies. This method gives the following calibration numbers: When calibrating F12 on F10 in 1994 -1661 is subtracted to the numbers of F12. When calibrating F14 on F12 on the average from 1997 to 1999 -6944 is subtracted to the numbers of F14. When calibrating F15 on F14 on the average from 2000 to 2003 -4532 is subtracted to the numbers of F15. When calibrating F16 on F15 on the average from 2004 to 2007 -489,5 is subtracted to the numbers of F16. F10 and F18 could not be calibrated when using this method. The results are shown in figure A.4.

Figure A.4.: Light density, calibrated with method III
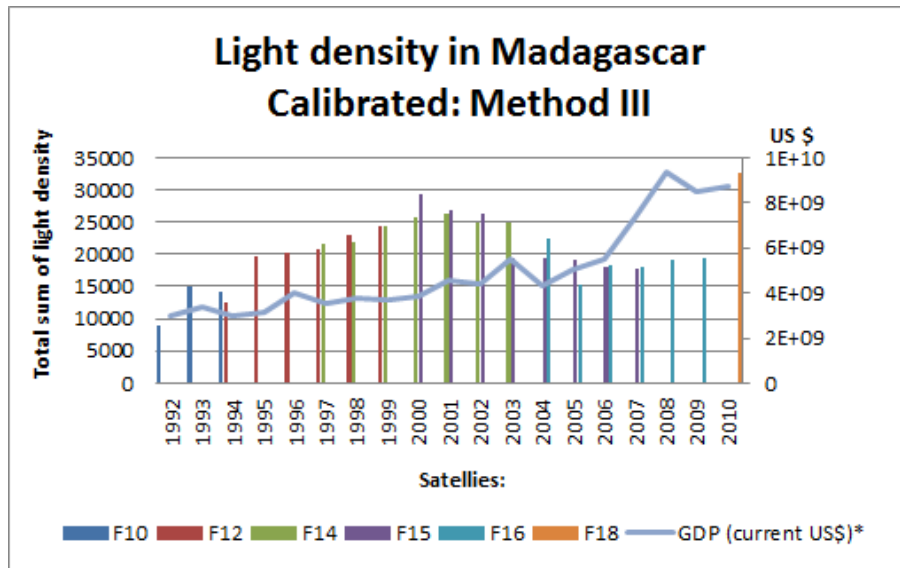
Light density at national level: calibration on the average of difference between two satellites for years when two satellites

If following up this method of calibration I would have chosen to use the satellites that measure the highest amount of light each year (on national levels). The following criteria: to use the ones that measure most light is a good choice, because we get the most detailed information. One exception, as you see on the uncalibrated data in figure 4.1, is 2004 where I would have chosen to use satellite F15 instead of F16. The reason is that F16 gives a measure of density in 2004 that gives a high jump relative to the trend. On the calibrated national data this jump is faded away, which is a good reason for choosing F15 for 2004, so that the uncalibrated data has the same trend slope as the calibrated. This would have led me to use the following satellite data sets:

Table A.1.: Satellites chosen for method I calibration

| Year/Sat elites	F10	F12	F14	F15	F16	F18
1992	F101992					
1993	F101993					
1994	F101994					
1995		F121995				
1996		F121996				
1997		F121997				
1998		F121998				
1999		F121999				
2000				F152000		
2001				F152001		
2002				F152002		
2003			F142003			
2004				F152004		
2005					F162005	
2006					F162006	
2007					F162007	
2008					F162008	
2009					F162009	
2010						F182010

By using this method, I would not have calibrated the satellite data on local levels. The local levels are measured relative to the whole country, which means that it also controls for satellite. One reason for calibrating on local levels could be if the satellites are biased towards measuring more light in one region relative to what they measure in the rest of the country. I assume that this is not the case. This assumption implies that when controlling the levels of other satellites the relative light in district A relative to the country will be equal for two satellites measuring the same year. However, I do not apply this method further. Calibrating each and every pixel of information gives more accurate calibration, which is presented under Method IV.

Method IV Despite of improving the calibration method used above, I kept searching for better methods of calibration to get more accurate estimates of patronage . Upon contact with the US Earth Observation Group NOAA National Geophysical Data Center, who are producing the satellite data, I got the chance to use their most recent "in house" calibration for stable light data that they kindly shared with me. This method is much better than the ones above as it calibrates each value number of light density instead of calibrating the aggregate numbers for any administrative level. The calibration for the stable light data is based on the method published

in Elvidge et al. (2009) on the average light. "The objective of the inter calibration is to make it possible to pool the sum of lights index values from each year of the time series" (Elvidge et al., 2009, p.601). The article further describes that the satellites do not have any on-board calibration. Each composite was inter calibrated via an empirical procedure. Several lighting from cities was examined to find the best "baseline". Data from satellite F12 in 1999 had the highest digital values. Of all the areas examined Sicily had the most favorable characteristics. Light density from Sicily on the satellite F12.1999 was used as the reference and the data from all other satellite years were adjusted to match the F12.1999 data range. A second order regression model was developed for each satellite year for inter calibration. The second order regressing model for each satellite and each year used in the calibration of the data in the thesis is found in the attachment. To calibrate the data I used the tool "Raster Calculator" in "Map Algebra, Spatial Analyst Tools" in ArcMAP 10 calibrating each raster picture separately. I use the mathematical equation and set in the whole picture in the equation. ArcMAP calculates the new values for each pixel and form a new calibrated picture.

This calibration calibrates all values of light and therefore gives calibrated values for all administrative levels as well. The figure below presents all calibrated satellite lights on the national level. As you see in figure 4.3 this calibration gives another point of view for the analysis. This method gives a more correct picture of economic activity in Madagascar. However, it is worth to notice that the value for 2010 is from a new satellite (F18) and might not give a true picture despite being calibrated. The reason to question the satellite is that 2010 is the only year from which we have an observation by this satellite and it deviates from the previous trend by a reduction of nearly 50%.

Figure A.5.: Light density at national level: calibrated
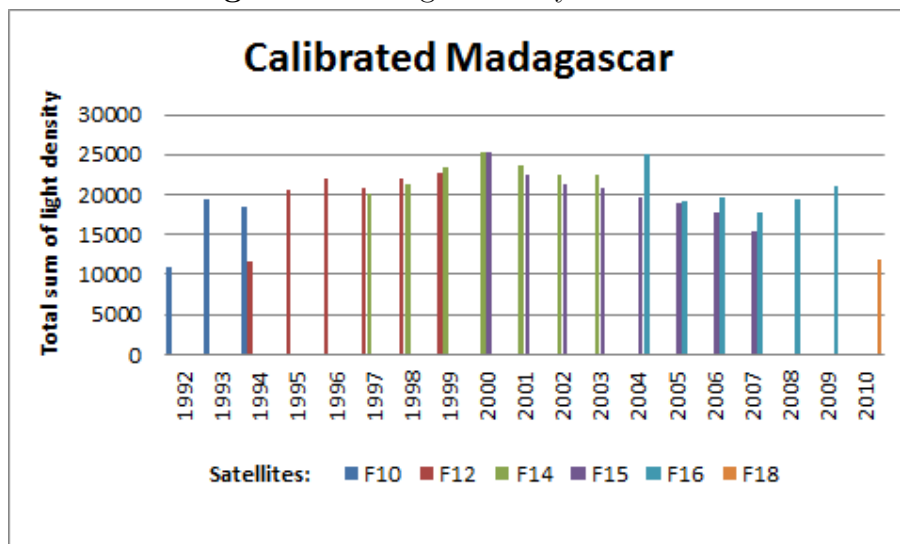
Apart from the analysis of 2010, all the local analysis in the thesis are from the same satellites when looking at differences from years to others.

For the development from 2009 to 2010, where there is no overlap in satellites, the relative data is more reliable as it measures the relative level of activity in a region relative to the whole country. Everything else equal this shall be the same as previous years even if we look at a different satellite.

B. Appendix

B.1. Three administrative levels

Table B.1.: The presidents and their period of presidency at three administrative levels.

President	Period	adm1	adm2	adm3
Didier Ratsiraka	June 1975-March 1993	Toamasina	Toamasina	Vatomandry*
Zafy Albert	March1993-Sept.1996	Antsiranana	Diana	Ambilobe
Norbert Ratsirahonana	Sept.1996-Feb.1997	Antsiranana	Diana	Antsiranana
Didier Ratsiraka	Feb.1997-July 2002	Toamasina	Toamasina	Vatomandry*
Mark Ravalomanana	Feb.2002-March 2009	Antananarivo	Analamanga	Antananarivo
Andry Rajoelina	March 2002-	Antananarivo	Analamanga	Antananarivo

adm1: Autonomous Province (Faritany Mizakatena)
adm2: Region (Faritra)
adm3: District (Fivondronana)
*Using "Toamasina Rural" instead in the analysis since Ratsiraka is closer linked to the urban district of "Toamasina Rural" than to the neighboring rural district of "Vatomandry".

B.2. Results on the administrative levels of province and of district

In the following only the relative results representations of the results are included. It must therefore be read in relation to the presentation of results and the analysis in chapter 5.
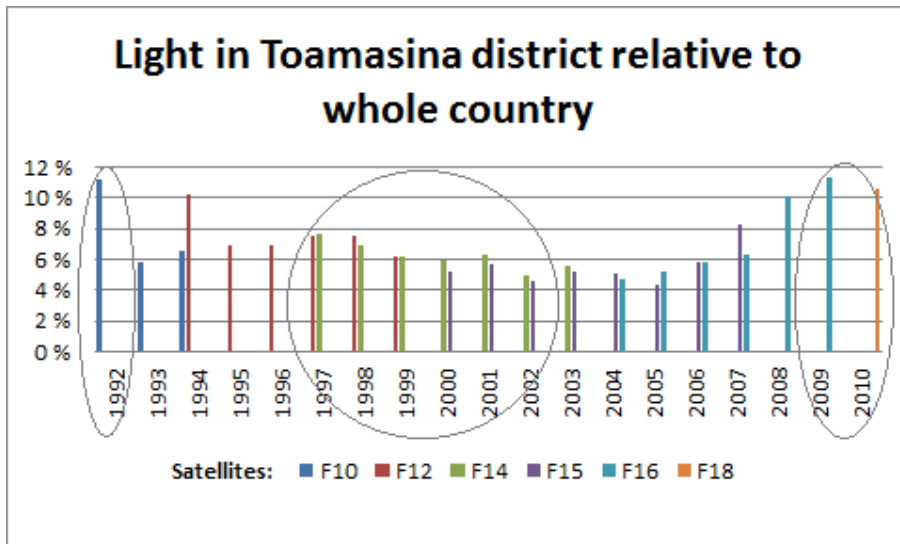
Figure B.1.: Light density in the Province of Toamasina
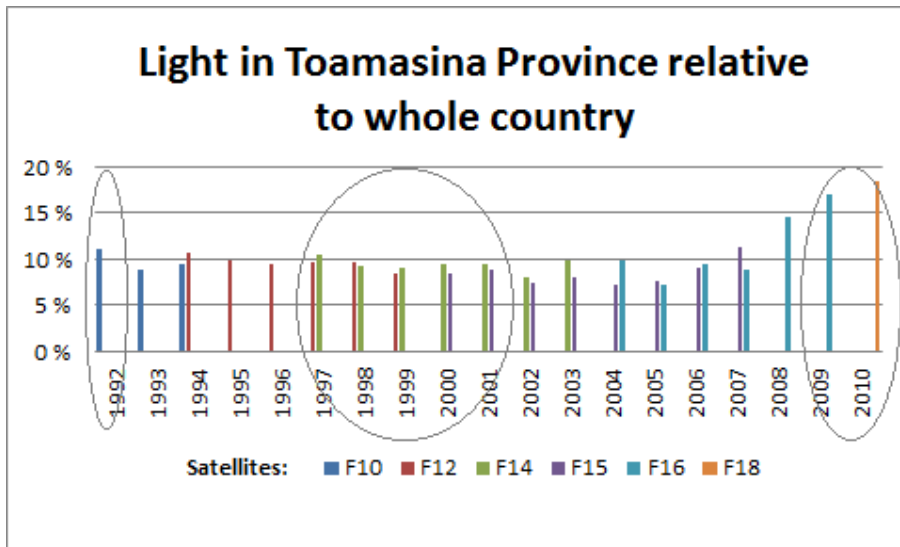
President Didier Ratsirakas home province: trends in light density relative to the whole country. The periods in the two first circles are the periods when he was in power. The period when Rajoelina governs is included in the last circle.
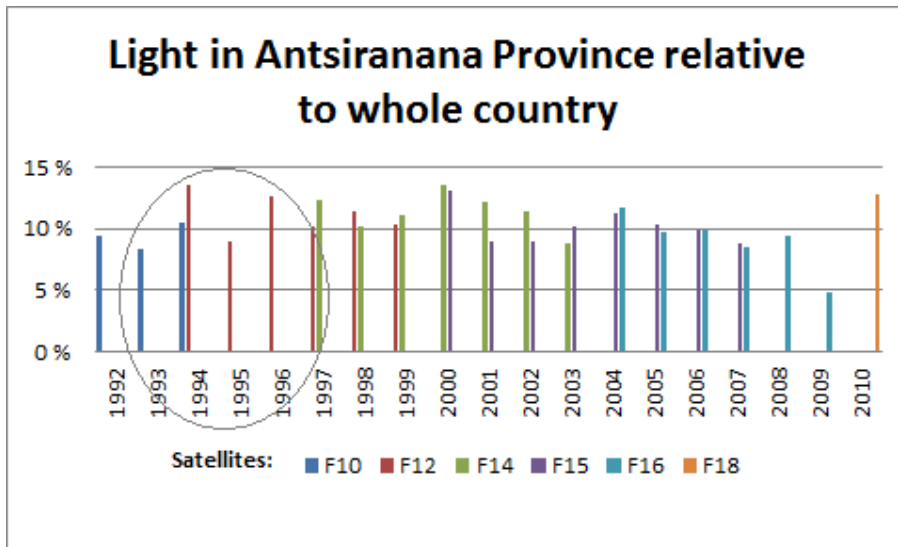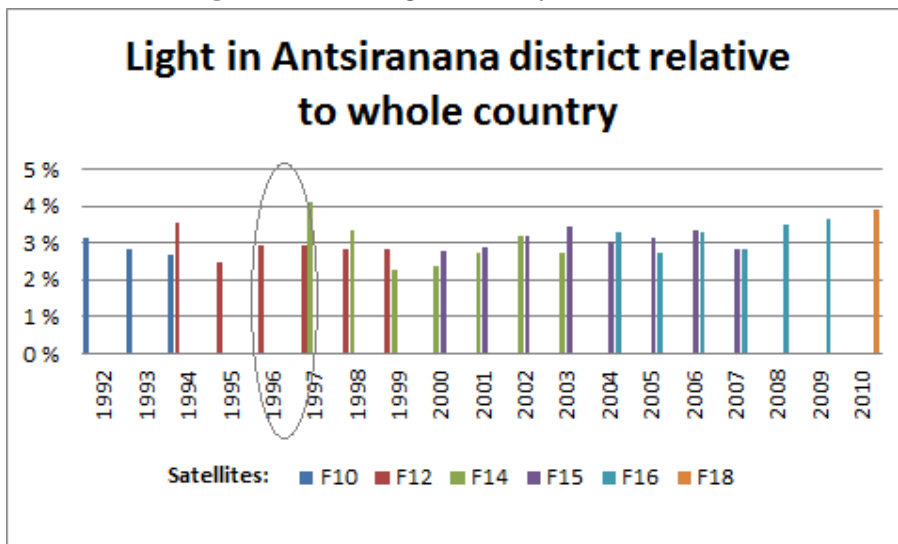
Toamasina:

Figure B.2.: Light density in the District of Toamasina

President Didier Ratsirakas home district: trends in light density relative to the whole country. The periods in the two first circles are the periods when he was in power. The period when Rajoelina governs is included in the last circle.

The North

Figure B.3.: Light density in the Province of Diana

President Zafy Albert and President Norbert Ratsirahonana's home province: trends in light density relative to the whole country. The circle indicates the period Albert and Ratisrahonana governed. Albert from March 1993 to September 1996 and Ratsirahonana from September 1996 to February 1997.
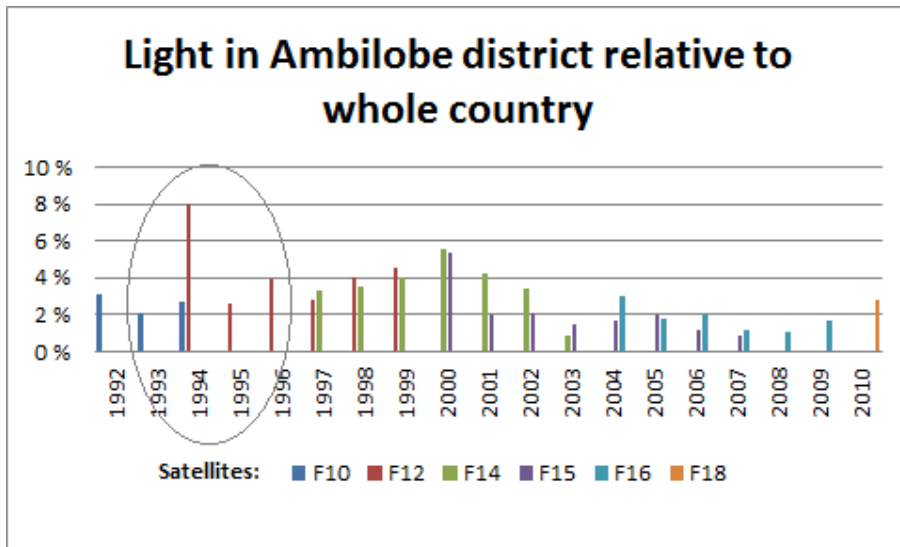
Figure B.5.: Light density in the District of Antsiranana

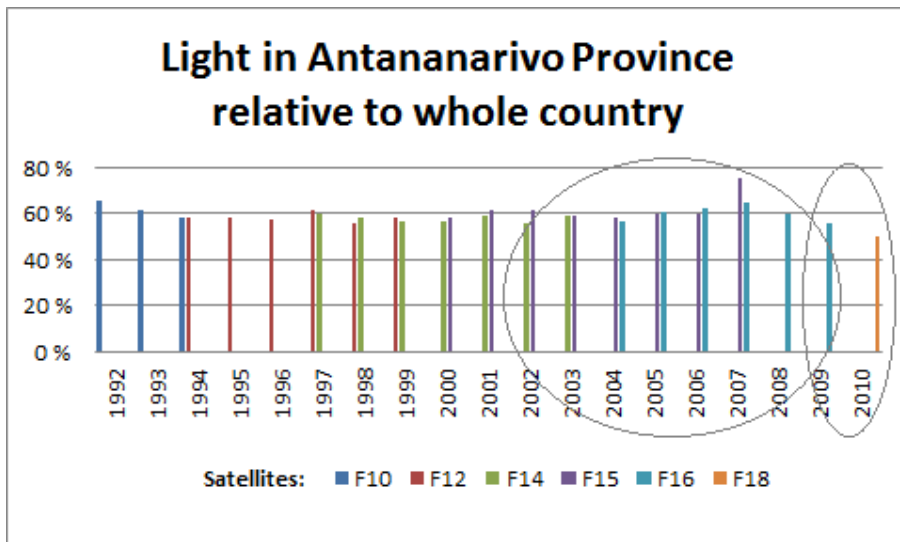President Norbert Ratsirahonanas home district: trends in light density relative to the whole country.

Figure B.4.: Light density in the District of Diana

President Zafy Alberts home district: trends in light density relative to the whole country.

The capital Antananarivo

Figure B.6.: Light density in the Province of Antananarivo

President Marc Ravalomanana and Transitional President Andry Rajoelinas home province: trends in light density relative to the whole country. The circles indicates the periods Ravalomanana and Rajoelina governed. Ravalomanana from February 2002 to March 2009 (he was reelected in 2006) and Rajoelina from March 2009. New elections are due in mid 2013.

Figure B.7.: Light density in the District of Antananarivo Nord