EUI WORKING PAPERS
ECO No. 2006/22

Economic Consequences of Wars: Evidence from Landmine Contamination in Mozambique

OUARDA MERROUCHE

EUROPEAN UNIVERSITY INSTITUTE
Department of Economics

EUROPEAN UNIVERSITY INSTITUTE
DEPARTMENT OF ECONOMICS

Economic Consequences of Wars: Evidence from Landmine Contamination in Mozambique

OUARDA MERROUCHE

EUI Working Paper **ECO** No. 2006/22)

ISSN 1725-6704

Printed in Italy
European University Institute
Badia Fiesolana
I – 50016 San Domenico di Fiesole (FI)
Italy

http://www.iue.it/
http://cadmus.iue.it/dspace/index.jsp

Economic Consequences of Wars: Evidence from Landmine Contamination in Mozambique*

Ouarda Merrouche†

First draft: January 2004
This Draft : April 2006

Abstract

This paper evaluates the economic returns to improved households access to infrastructure, public services and land in the context of a large landmine clearance program in post-war Mozambique. The International Campaign to Ban Landmines production and use estimates that there are more than 80 billion landmines in the ground in more than 80 countries. Despite the scale of the problem and large investments by OECD countries to clear mines in low income countries, the economic consequences of landmine contamination have been so far unexamined by economists working on the economics of wars, perhaps due to the lack of data thus far. The evaluation uses a unique dataset on landmine contamination intensity covering 126 Mozambican districts to evaluate the causal

*For comments and discussions I thank Eliana La Ferrara, Steven Levitt, Massimo Motta, Theresa Osborne, Roberto Perotti, Imran Rasul, Francis Vella, and participants at the RTN conference in Microdata Methods and Practice in Copenhagen, the Institute for Fiscal Studies and Uppsala University. All remaining errors are my own. I acknowlegde financial support from the French Ministry of Foreign Affairs through the Lavoisier fellowship and the European Commission through the Marie Curie Research Training Program.

†European University Institute and IFAU Uppsala University, RTN network in microdata methods and practice, contact at ouarda.merrouche@iue.it

impact of landmine contamination on income and welfare. The method uses a difference-in-difference estimator to correct for selection in landmine placement. I find large and statistically significant effects of landmine contamination on poverty (in level and depth) and consumption per capita. Hence, the cost-benefit analysis indicates that despite the high cost to clear a mine under reasonable assumptions the program generates a positive return.

JEL codes: O1, O55

1 Introduction

The International Campaign to Ban Landmines production and use estimates that there are more than 80 billion landmines in the ground in more than 80 countries. Mozambique is among the most severely affected countries (in terms of both the number of mines and the size of the land area contaminated) along with Angola, Afghanistan, Cambodia and Vietnam. Cambodia with a population of 10 million has between 4 and 6 million landmines on the ground. In Afghanistan, it has been estimated that 88 per cent of the land is unusable due to landmine contamination. In some parts of Angola landmines have reduced food production by more than 25 per cent (Landmine Monitor Report, several years).

Landmines may be considered a serious threat to long-term development and post-war recovery. They adversely affect agricultural development, human capital development and often block access to public infrastructure (roads, schools, power line, water plants, dams). Landmines have removed vast areas of land and resources from productive use. As more agricultural land is taken out of production, regions which were once self-sufficient become dependent upon outside sources for their food. In addition, the mining of irrigation systems and water-delivery plants adversely affects productivity in mine-free regions. Impoverishment is also reflected in the depreciation of assets caused by the presence of mines. In the absence of valuable assets, access to credit is restricted which reduces investments in new technologies and fertilizer. This in turn hampers productivity and agricultural growth.

Landmines are one of the most widely used weapons in contemporary conflicts because they are cheap to buy and profitable to sell. Despite the growing awareness within the international community that what has come to be known as the "global landmine crisis" has far-reaching consequences on development, effort to clear landmines is taking place in only 34 countries. A major factor explaining such under-investment in landmine clearance is probably the cost: while a landmine costs about 3 dollars to produce, according to the UN mine action program, it costs between 300 to 1000 dollars to clear a mine. As a consequence policymakers in landmined countries often argue that investing in landmine clearance cannot yield a positive return. This may be the case because landmines remain active for a limited time varying between 25 to 50 years (see Landmine Impact reports).

Most landmine clearance programs are financed by OECD countries through bilateral or multilateral assistance. Landmine clearance assistance has followed a steady upward trend during the last ten years with a rapid acceleration started in 1999 with the signature by hundreds of countries of a Treaty to Ban Landmine Use and Production. The European Community (EC) assistance amounted to 42 million Euro in 2002, a 48 per cent increase relative to the previous year. The US remains the largest aid donor with about 80 million USD allocated to 37 countries worldwide. Between 1993 and 2002 the US invested 560 million USD in mine action assistance of all forms: demining, technical assistance, mine action education and so on so forth (Source: Landmine Monitor Report issues 1999 to 2003). Both the US and EC mine action programs expect to include an increasing number of countries in the coming years. In 2002, the top recipients were Afghanistan ($ 64.4 million); Iraq ($30.6 million) ; Cambodia ($ 27.3 million) and Mozambique ($ 18 million). For Afghanistan demining assistance from the EC and US represents about 15 per cent of total Overseas Development Assistance funds received. Despite growing donors assistance to clear landmines there is scant empirical evidence on the economic impact of landmine contamination to assess the cost-effectiveness of these large interventions.

This paper contributes to a rapidly growing literature on the economic consequences of wars and conflicts. Recent contributions to this literature include Miguel and Roland (2005), Abadie and Gardeazabal (2003) and La Ferrara and Guidolin (2005). Miguel and Roland (2005) evaluate the long term economic impact of US bombing in Vietnam. However, their results are inconclusive. They do not find a robust negative impact of U.S. bombing on poverty rates, consumption levels, infrastructure, literacy or population density through 2002. Abadie and Gardeazabal (2003) and La Ferrara and Guidolin (2005) use the event study approach to study the relationship between civil war, per capita output and private investment. The economic consequences of landmine contamination have been so far largely unexamined by economists working on the impact of wars on development perhaps due to the lack of data thus far. Here I use a unique dataset on the incidence of landmine contamination covering 126 districts of Mozambique. Landmine contamination is measured by the size of the area cleared in a district following the implementation of the national landmine clearance program in 1993.

Mozambique offers an ideal setting for this study for several reasons. First of all, the data necessary for the analysis including measures of landmine contamination, information on the national demining program and variables of economic performance were readily available and all measured at district level. Second, Mozambique is one of the rare countries to have adopted a clearance program immediately after the end of the conflict it experienced. Third, Mozambique is one of the most heavily mined countries and (as a consequence) one of the top aid recipient. It is estimated that mine action funding for Mozambique totalled \$ 177 million from 1993-2002 (Landmine Monitor Report 2003). Concerning the choice to focus on a single country, it is motivated by the fact that it will help reduce problems of selectivity and sample selection that plague cross-country evaluations. Problems of omitted variables are likely to be less than in a cross-country sample because sub-regions within a country are more similar with regard to observable and unobservable characteristics.

The ordinary least squares (OLS) method may be inadequate to derive causal effects of landmine contamination on welfare and consumption due to potential selection in landmine placement and measurement error. In order to determine priorities for de-contamination mine impact scores were assigned to all areas. Hence landmined areas in remote places (mountains etc..) were assigned low mine impact scores. The dataset records the area cleared by district since 1996 and identifies the areas cleared pre and post-2000. This allows to correct for endogeneity using a difference-in-difference estimator by exploiting two sources of variation in a district's exposure to the damages caused by landmines: variations in the size of the area contaminated and variations in the timing of de-contamination.

The OLS estimates imply that a one standard deviation fall in the area contaminated (measured in km2) is associated with a 294.39 Metrical (local currency) increase in the daily per capita consumption, or 2 per cent of the daily consumption per capita. Totally demining the most highly landmined district would increase average daily per capita consumption in that district by about 2272 Metical, which is around 40 per cent of the actual daily consumption per capita in that district in 1996. These effects are about 30 per cent larger when I correct for endogeneity.

I then use the estimate of the average impact of landmine contamination on consumption per capita to derive the benefit of the landmine clearance program. Under both conservative and generous assumptions on the length of the benefit period, the benefit appears to largely outweighed the total cost of the program. This result is obtained assuming variations in consumption entirely reflect variations in income and the program's impact on consumption is immediate and with limited distributional effects.

The remainder of the paper is organized as follows. Section II gives a historical overview of the war and landmine use in Mozambique. Section III provides information on the national demining program. Section IV describes the data and sources. Section V develops and motivates the statistical framework. Section VI discusses the results. Section VII reports the cost-benefit evaluation of the National Demining Program. Section VII discusses caveats about the cost-benefit analysis and section VIII concludes.

2 The Context[1]

Mozambique today has a total population of 17.6 million. It is estimated that 64 per cent of the population lives off subsistence agriculture and that 2/3 of the population is in absolute poverty. The mean monthly consumption is today around 9.4 USD.

Armed opposition to the Portuguese began in 1964, led by the Mozambican Liberation Front (henceforth, FRELIMO). The Portuguese withdrew and granted control to FRELIMO in 1974, which instituted a one-party Marxist system. Around 1976 Mozambican National Resistance (henceforth, RENAMO), an opposition group supported by South Africa, initiated a violent insurrection against FRELIMO.

South Africa had an interest in destabilizing Mozambique for many political reasons. In 1980, the white minority government in South Africa anticipated problems resulting from a situation in which they were increasingly surrounded by hostile neighbors. A destabilized Mozambique allowed them to maintain their political and economic hegemony over the region (Vines, 1994).

The country emerged from a long and brutal war at the end of 1992 with the distinction of being one of the poorest countries in the world. The war inflicted about 18 billion dollars worth of damage in a country where the GNP was less than two Billion (Willett, 1995). It had an enormous human, capital and economic impact, in terms of death, disability, displacement, and trauma suffered by the population. In addition, the war destroyed the social and economic infrastructure, including hospitals, trading posts, schools, roads, bridges, railways and energy facilities. An estimated 58 per cent of the existing 5886 primary schools in Mozambique were destroyed or forced to close during the war. Of the 1,195 health posts in 1985, 500 were closed or destroyed. Warfare often resulted in the wholesale destruction of villages and landmines were used indiscriminately to deny people access to their farms and other means of survival.

Landmines constitute the primary obstacle to the reconstruction and development

[1] This section heavily relies on Heynen et al (2003), Vines (1994,1997), and Landmine Impact survey report (2003) at http://www.sac-na.org/surveys_mozambique.html.

in Mozambique. Although systematic use of landmines in Mozambique occurred as far back as 1965 in the conflict between the Portuguese and FRELIMO, FRELIMO and RENAMO laid the majority of landmines between 1978 and 1990 (Vines, 1997). Many tactics determined the placement of mines, including the random deployment of mines and the deliberate targeting of civilian populations (Vines, 1994). The distribution of mines was not mapped by either the FRELIMO or the RENAMO, and has constituted the primary obstacle to the reconstruction and development in Mozambique. Because of the need to protect their land-based interests from the RENAMO insurgency, FRELIMO used landmines for defensive purposes. In many cases, initial mine fields were laid around strategic installations, but often these proved inadequate against attacks. Hence, FRELIMO in many cases continued to add to sites until large areas extending well beyond the immediate perimeter of installations were protected. In doing so, they often disrupted large parcels of arable land as well as important transportation routes (Heynen et al, 2003). As part of a larger-scale strategy, FRELIMO laid many mines along its border with South Africa during the 1980s fearing increased collaboration between RENAMO and South African forces (Vines, 1994).

Alternatively, RENAMO laid mines primarily in an attempt to devastate the government's economy. RENAMO frequently mined commonly used roads in order to slow and divert troop movement, as well as to stop deliveries of military goods and transport of agricultural produce. In order to attack troops directly, RENAMO laid mines in large rural tracts that were used for troop movement and food collection and production. Airfields used by the government were also mined in order to further prevent the movement of people and goods (Heynen et al, 2003). According to the Mozambique landmine impact survey (MLIS), landmines currently affect all 10 provinces of Mozambique and 123 out of 128 districts. At least 1.5 million persons, representing no less than nine per cent of the national population in 1997, live close to a landmined area. The UN landmine program considers Mozambique one of the most heavily mined countries in the world.

Annexes 1 and 2 and maps in the appendix report several statistics and mapping of the incidence and distribution of landmines in Mozambique[2]. The 791 landmine-affected communities identified are distributed throughout every Province and 123 over 128 (96.1%) Districts. 768 of the landmine-affected communities are rural and 23 urban (including larger populations than rural areas). There is a widespread distribution of landmine-affected communities.

The survey counts a total of 1,374 suspected mined areas (SMAs) over an aggregate area of about 562 square kilometers. SMAs most frequently block access to agricultural land (464 communities, 950,000 persons, 369 square kilometers); roads (231 communities, 369,000 persons); and non-agricultural land used for hunting, gathering firewood, and other economic and cultural purposes (180 communities, 291,000 persons, 137 square kilometers). SMAs are not distributed randomly. They cluster close to major transportation infrastructure. Roads, trails and former military installations are the most numerous of the functional categories to which SMAs could be assigned, but wells, bridges and village perimeters are all important.

A total of 2,145 landmine victims is recorded among which 172 had come to harm during the two years preceding the MLIS. Male outnumbered female by a factor of almost three to one. The most frequently represented victims age groups were from the working age population; 30 to 59 years among women (62.1% of female victims) and from 15 to 44 years among men (57.4% of male victims). Individuals who survive a landmine accident most often suffer from irreversible trauma. Although it is difficult to precisely record the number of people who have been injured by landmines (due to under-reporting especially in highest mined areas), the estimated number of amputees for Mozambique ranges between 9,000 and 12,000 and children represent a non-negligible share of these victims (Landmine Impact Reports UN). Children with disabilities who are excluded from education are virtually certain to be life-long poor.

[2] All information was taken from the landmine impact survey report available at http://www.sac-na.org/surveys_mozambique.html.

3 The Program

In 1992 Mozambique initiated a demining program mostly financed through aid received from OECD countries. The National Demining Institute (IND) is a semi-autonomous governmental institute reporting directly to the Minister of Foreign Affairs, which coordinates all mine clearance activities in the country. A total of about 58 million square meters of land was cleared from 1993 to 2004 at a cost of about 96 million dollars. In February 2003, the IND director announced: "To date (...) four of the 19 high impact sites, ten of the 165 medium impact sites, have been already cleared. These include improved access to bridges and roads, schools, villages and power lines. In that process, 1,013 mines were destroyed." In its 2002 activity report, IND states that a total of 11,532 mines (of which 10,401 were antipersonnel mines) and 1,862 unexploded ordonances (UXO) were destroyed. . According to the annual plans of demining priorities (see http://www.ind.gov.mz/en/) the areas targeted in priority were: areas for the resettlement of populations; social infrastructure such as educational centres, hospitals centres, water supply sources and commercial infrastructure; areas around and within population settlements; areas containing objects of socio-economic interest, in particular areas already identified as having high agricultural - livestock potential, roads, railways, electricity transmission lines and industrial infrastructure. This strategy followed since 2003 was confirmed and reinforced in 2001 with the publication of the LIS which recorded the number of SMAs by district (not their size) and assigned mine impact scores to all communities in order to determine priorities for de-contamination (see Map 1). The approach used to rank communities on the basis of their impacts is described in details in the LIS report. The value of the score for a given community reflects three aspects of the mine situation as it affects the community: the type of landmines, munitions, UXO suspected to be present; the categories of land, infrastructure and service areas to which mines are blocking access; the number of victims of landmines or UXO in the two years preceding the survey

Table 4 A reports yearly costs and output records for the period 1993-2004. Note that although the program´s budget remains quite stable from 1999, the program´s output increases over time for several reasons. First of all, at the program's early stage a significant share of the investment is allocated to non-demining activities such as training deminers or doing a landmine survey. Second, productivity may increase over time due to learning by doing i.e. as deminers acquire more experience. This is relevant especially for manual demining which is extensively used in Mozambique. Third, the strong depreciation of the Metical (local currency) against the dollar over the study period allowed to hire more deminers paid in local currency[3]. Last, the demining technologies adopted at later stages of the program i.e. mechanical demining and rats are more productive (see http://www.ind.gov.mz/en/).

IND expects the total de-contamination of the country will be achieved by 2009 provided the current level of international assistance and productivity is sustained.

4 The Data

The main dependent variables investigated in the paper are: the poverty headcount index, the poverty gap and daily per-capita consumption obtained from the International Food Policy Institute who was exceptionally granted access to the household survey (IFPRI, Simler, K., and V. Nhate (2002)[4]). These indicators, all measured at district level, have been computed by using consumption data from the 1996 household survey. The National statistics Office of Mozambique usually does not grant access to the survey. The survey is a multi-purpose household and community survey, in the same vein as the World Bank's Living Standard Measurement Study (LSMS) surveys, and was designed and implemented by the National Institute of Statistics. The data

[3]In Mozambique the number of local demining agencies involved in the program has increased steadily over time (see http://www.ind.gov.mz/en/). However NGOs and foreign demining agencies continue to be allocated the lions' share of the funds. Privileging NGOS and foreign demining agencies is viewed by some donors as a way to counter corruption.

[4]I refer to their paper for a detailed description of how these indicators were derived using the 1996 household survey.

collection took place from February 1996 through April 1997, covering 8,250 households living throughout Mozambique. The sample is designed to be nationally representative, as well as representative of each of the ten provinces, the city of Maputo, and along the rural/urban dimension. It is the first survey of living conditions in Mozambique with national coverage, and is the only national survey that measures welfare using comprehensive income or expenditure data. Two indicators of poverty are used: the poverty gap (PG) and the headcount index (HI). The later measures the share of a district population living under the poverty line (one dollar a day). The former is the mean distance separating the population from the poverty line (with the non-poor being given a distance of zero), expressed as a percentage of the poverty line. The poverty gap ratio (PGR) is the sum of the income gap ratios for the population below the poverty line, divided by the total population; hence it is a measure of the depth of poverty. The consumption measure includes food and nonfood items, acquired through home production, market purchases, transfers, or payments in kind. Consumption also includes the imputed use value of household durables, and an imputed rental value for owner-occupied housing[5].

Landmine contamination is also measured at district level by the square meters of land cleared since 1996. The data were provided by IND for the two sub-periods 1996-2000 and 2001-2004 and cover 126 districts. I use district level data because data at a more disaggregated level are not available but also because this choice allows to reduce bias from spillover effect whereby landmine contamination in one region would also affect neighboring regions.

5 Statistical Framework

The relationship to be estimated using ordinary least squares (OLS) is:

$$y_d = \beta + \alpha LC_d^{96-04} + \delta Area_d + \varepsilon_d \quad (1)$$

[5] See Simler, K., and V. Nhate (2002) for details.

where d stands for district . y_d stands for one of three outcomes: the poverty rate, the poverty gap and per capita per day consumption. LC_d^{96-04} is the square meters of land cleared in the period 1996-2004 in district d. Under some assumptions the parameter α measures the average causal effect of one square meter of contaminated land on the outcome y_d. The only (exogenous) control variable included in the model is the district area size ($Area$).

This specification assumes that LC_d^{96-04} is exogenous. That is, variations in landmine contamination across districts are independent to other shocks that affect these districts reflected in the error term. However, in this context endogeneity may arise in two ways: selective landmine placement and measurement error. Each of these factors would cause a violation of this assumption of exogeneity and I discuss them below and describe the method used to address them.

5.1 Selection in Landmine Placement and Clearance

Ideally, one would like to compare the outcomes between districts that only differ in the level of landmine contamination. A problem of endogeneity arises if omitted unobservable characteristics that differ across districts affect the outcomes and are also correlated with landmine contamination. This would cause part of the effect captured by equation (1) to reflect the effect of omitted variables causing either a positive or a negative bias. For instance, landmine contamination and poverty will be spuriously (negatively) correlated if more landmines were led in more fertile lands. Section II points out that a significant number of mines were found close to roads and bridges and other public infrastructures. In other words, districts with relatively more mines may also be the districts better endowed in infrastructure (historically) and this determines their level of development. Simler and Nhate (2002) find that the presence of a good road is associated with lower than average poverty indices in Mozambique. Similarly, landmine clearance may have progressed more rapidly in more prosperous regions if better work conditions are offered to the deminers and more effective collaboration of local authorities. Further, one cannot exclude clientelism and patronage effects in the allocation of funds to clear mines across districts. However, the problem of selection in landmine clearance is reduced by the fact that the program targeted small areas within districts but there was no targeting at district level.

5.2 Measurement Error

If there is a (classical) measurement error in LC_d^{96-04} the estimated impact of LC_d^{96-04} on y_d is attenuated. Measurement error arises in part due to incomplete landmine clearance. The total de-contamination of the country is not timed before 2009. However, the problem is reduced by the fact that the clearance program targets in priority regions where mines are likely to cause significant economic damages. Nonetheless, another source of measurement error arises from misreporting of the land cleared. Indeed, some deminers complained that they had cleared more land than reported in the official data (see Landmine impact report 2003, Mozambique report). Locale authorities may have an incentive to exaggerate the contribution of some locale demining companies in order to alter the allocation of funds across foreign and locale agencies to favor the later. In addition, according to anecdotes there are incentives for the authorities to alter the data in order to hide misuses of funds related to corrupt practices and avoid donors' sanctions.

5.3 Addressing Endogeneity

The regions' exposure to the damages caused by mines varies along two dimensions: the size of the area contaminated and its proximity to habitations, arable lands and public infrastructure. Hence, the identification strategy corrects for the potential endogeneity in LC_d^{96-04} by constructing exogenous variables which are the interactions between the size of the area cleared and the timing of landmine clearance. Again, this is motivated by the fact that the program targeted in priority communities living in close proximity to landmined areas.

The regression reads:

$$y_d = \beta_1 + \alpha_1 LC_d^{96-00} + \alpha_2 LC_d^{01-04} + \delta_1 Area_d + \varepsilon_d \quad (2)$$

This approach allows to disentangle the selection effect from the causal effect using areas cleared post-2000 as controls for areas cleared pre-2000. One expects α_2 to be lower than α_1 and possibly insignificant statistically and economically. I will also test the robustness of the results to controlling for the size of the population living in close proximity to habitations and the number of mine victims since these two variables determine whether landmined areas were given priority or not. Note that for many districts both LC_d^{96-00} and LC_d^{01-04} exceed zero i.e. within a same district different areas were cleared either pre or post 2000 and vice versa some districts have experienced no clearance at all or clearance either pre 2000 or post 2000 only. In table 1 panel B I report descriptive statistics of the main outcomes conditional on a district experiencing some clearance either pre or post 2000. The descriptive statistics are very similar meaning that districts targeted in priority are not different with regards to observables relative to districts cleared post 2000. Again this clearly reflects the fact that a district level of poverty was not what determined priority. The program targeted small areas within districts and priority was determined by the proximity of mines to habitations, infrastructures and agricultural land but not according to a district's level of development.

6 Results

Welfare Table 1 reports descriptive statistics for the variables used in the analysis. The poverty rate ranges from 22.82 percent in Ilha de Mocambique to 98.61 percent in Maringue. The measures of landmine contamination have very high standard deviations meaning that there is a large variation across districts in the extent of landmine contamination.

Table 2 reports the OLS results for the three outcomes of interest. Each cell gives the estimates of a regression where the row variable is the main regressor and the column variable the outcome. The first column-first row reports the estimated average impact of 1 km2 of contaminated land on the poverty headcount index using the area cleared over the entire period 1996-2004 to measure the incidence of mines. The estimate has the expected sign, is statistically significant at the one per cent level and relatively large in magnitude. The point estimate implies that a one standard deviation fall in the km2 of land contaminated can be associated with a 3.2 percentage point decrease in the proportion of the population living under the poverty line which is about one fourth of a standard deviation. The impact is a 1.2 percentage point fall in poverty at the mean. Another interpretation is to say that totally demining the most contaminated district would contribute to reduce poverty in that district by about 25 percentage points. The poverty rate is a rather crude measure of poverty and so I also use the poverty gap as a measure of poverty. The results are similar. This means that clearing landmines in Mozambique would contribute to reducing both the level and the depth of poverty.

In the second row I report results using specification (2). As expected the estimates are significant statistically and economically and of about the same magnitude as before for LC_d^{96-00} and insignificant statistically for the area cleared post-2000. Again this clearly reflects the fact that priority was given to regions with high mine impact scores. It also indicates that if OLS estimates are biased due to endogeneity, the bias is not large enough to yield non intuitive results. Note that the area demined during 1996-2000 and 2001-2004 are quite equivalent in size (see descriptive statistics in table 1) [6] so this result may not be explained by the fact that LC_d^{96-00} covers a longer period than LC_d^{01-04}. However in order to check whether the results are not driven by the fact that the variability in LC_d^{01-04} is lower than the variability in LC_d^{96-00} I re-estimate the equations by dropping the zeros.The standard deviations of LC_d^{01-04} and LC_d^{96-00} become about equivalent (175.85 for LC_d^{01-04} against 244.44 for LC_d^{96-00}) and although the sample

[6] due to three factors: (1) Increased productivity over time; (2) the reallocation of funds towards productive operations and away from training activities; (3) the increase in the number of demining agencies involved in the program.

size drops to 41 observations the results remain qualitatively the same and larger in magnitude. Last, all results are robust to controlling for two major determinants of LC_d^{01-04} and LC_d^{96-00} : the size of the population living in close proximity to landmined areas and the number of mine victims (injured or killed)[7].

Consumption The impact of landmine contamination on the daily per capita consumption is also very large. The result implies that a one standard deviation increase in LC_{96-04} translates into a 294.39 mt (local currency) decrease in the daily per capita consumption on average and 109.8 mt at the mean. This represents about 2 per cent of the mean daily consumption. Totally demining the most highly landmined district would contribute to increase the average daily per capita consumption in that district by about 2272.45 Metrical which is around 40 per cent of the actual daily per capita consumption in that district in 1996. As expected, the estimates are about 30 per cent larger when I correct for endogeneity.

This analysis confirms the existence of a strong relationship between welfare and landmine contamination. The reason why endogeneity appears negligible may be explained by the fact that selection in the placement (and clearance) of mines operates within districts but not (systematically) across districts.

Transmission Channels Table 4 reports further evidence on the impact of landmine contamination with the aim of highlighting possible transmission mechanisms. Unfortunately without access to the household survey containing information on households access to public services and infrastructure this exercise cannot be carried out in detail but here I consider some additional outcomes that are possibly relevant: the female-to-male ratio, the average family size, the number of firms in the district, the number of employees working in these firms and the size of these firms´businesses. Given the small number of mine victims recorded so far relative to the aggregate population one expects the population structure to be altered mostly through migration

[7] Available upon request

effects and this may be reflected in variations in sex ratios. The number of firms located in a district and their size is also worth examining because one could presume that firms will have a higher incentive to locate in districts offering a better access to public services and infrastructure. Given that one major effect of land mines is blocked access to infrastructure (in particular roads and bridges) this is a relevant outcome to consider here.

The table is organized like Table 2. The impact of landmine contamination on the sex ratio is insignificant statistically. If one expected landmine contamination to alter the family structure through male migration then this result suggests that landmine contamination is associated with insignificant migration flows across districts[8]. I also find no significant effect on the population density. This result is somehow reassuring because a recurrent issue in program evaluation is that OLS estimates can be biased due to migration selectivity. If the war caused selective migration this introduces a (non-classical) measurement error into the outcome variables. The total effect of landmine contamination would include (i) the direct effect of mines in the original, resident population; (ii) the change in the outcome variables caused by the compositional change in the population via migration that is induced. In this case the effect of interest is only given by the first term, if all pre-contamination site populations have the same mean characteristics or if the pre-contamination site population is representative (Rosenzweig and Wolpin (1988)). Based on these results however, I find no evidence that migration flows have been large enough across districts to significantly alter the conclusions drawn so far. A more serious analysis would require additional data on migration flows but no such data exist.

I find a significant positive effect on the average family size. This result may reflect the fact that the extended family is used as insurance against poverty associated to landmine contamination. In the third to fifth columns I report results for the number of firms located in a district and indicators of firms size. The estimates are all insignificant

[8] Short distance migration i.e. within districts and international migration of refugees to neighboring countries may have been larger.

statistically. This is explained by the fact that these firms are located mostly in urban areas while landmines were led mostly in rural areas. Hence, this results actually provide good control experiments.

7 Comparing Costs and Benefits of the National Demining Program

The estimates of the average impact of mine contamination on the consumption per capita can be used to compare the cost of demining and the additional wealth generated by the demining program. The program yearly cost is given by the aggregate aid received each year since the program is almost entirely financed through aid; the government contribution is negligible. It includes all forms of assistance i.e. technical or purely financial.

Several assumption are needed for the calculation of the program's discounted net present value (see Table 4 A). Given that most mines remain active for periods varying between 25 and 50 years I will report results assuming the program generates benefits over 25 and 50 years. In addition, I assume a 5 per cent yearly discount rate and report all monetary variables in 2004 USD. I assume a zero population growth over time because the marginal effect may not be the same in the long-run on a larger population. This means that the benefit may be larger than the benefit I report here.

So, the program benefit is calculated as follows:

$$Benefit = \alpha * \left[P * \sum_{d} \left(LC_d^{93-00} \right) \right] \tag{3}$$

α is the estimated average effect of LC_d^{96-00} on the daily per capita consumption. P is the population in the districts targeted by the program pre-2000. I assume clearance in the areas targeted post-2000 generates a zero return. The benefit is multiplied by 365 to get the yearly benefit.

I compute the future value of the benefit and compare it to the immediate cost.

The results of this exercise are reported in Table 4 B. Whatever the assumption made on the length of the benefit period the net benefit is very large.

8 Discussion

In addition to the explicit assumptions already highlighted, the cost-benefit analysis relies on three implicit assumptions which I next discuss.

8.1 Long-Term Impacts

By assuming a limit to the length of the benefit period equal to the maximum period a mine remains active, one also assumes landmine clearance has no long-term economic effects. Of course, this assumption is disputable. There are several channels through which the effects of landmine contamination can be visible in the long run. For instance, this effects could operate through a fall in school attendance and education quality and translate into subsequent effects on labor market outcomes. In a companion paper I find evidence that successive conflicts have had significant effects on Cambodia's human capital. On the other hand assuming an infinite length for the benefit period would lead to assume a constant return over time which is likely to be incorrect.

8.2 General Equilibrium Effects

The program's benefit is derived using the average impact of one square meter of land contaminated on the daily consumption per capita. This assumes that any fall in consumption fully reflects a fall in income and that general equilibrium effects are not important. However, one can imagine several channels other than a change in income through which landmine contamination could alter consumption. For instance blocked access to public health services or schools could alter consumers´health status and thereby cause a change in preferences which can materialize in a reallocation of resources towards goods or services not included in the basket of goods used to measure households´consumption. Also, if demining causes an increase in income, households could choose to save or invest rather than consume the additional wealth generated by the program. This would in turn result into a long-term growth effect. In this case the approach used here undervalues the program's benefit.

8.3 Problem with Ex-Ante Evaluations

A cost-benefit analysis of the demining program based on cross-section estimates of the effect of landmine contamination is relevant if the program´s impact is immediate and if its distributional effects are not important. Given that landmines are active for a limited time, if for some reason the program's impact takes several years to materialize, its profitability would fall dramatically. People may not adjust immediately to the program due to psychological factors or because the returns from (new) investments in cleared areas takes time to materialize. Addressing this issue would require ideally a dynamic framework. Unfortunately, the data required to apply such approach are not available for most developing countries including Mozambique.

9 Conclusion

The paper has provided evidence on the economic consequences of civil wars in the context of landmine contamination in Mozambique. The evaluation uses aggregate data covering 126 districts and corrects for endogeneity using a difference-in-difference framework. The selection effect appears to be negligible indicating a quasi-random placement of landmines at district level and suggesting that recurrent identification problems encountered in program evaluation can be corrected by accurately choosing the level of data aggregation. The causal effect is sizeable and statistically significant on poverty and consumption measures. Improving households access to infrastructure and land through mine clearance is likely to generate large returns and therefore considerably boost recovery in countries emerging from wars. Despite the high costs of clearing landmines I also show that such interventions may generate large net benefits provided the programs are implemented early enough after the conflict and designed to target regions really in need of assistance.

References

[1] Abadie, A. and J. Gardeazabal (2003), .The Economic Costs of Conflict: A Case-Control Study for the Basque Country,. American Economic Review, 93(1), 113-133.

[2] Heynen N. et al (2003), The Political Ecology of Recovery from Armed Conflict: the case of landmines in Mozambique, Political Geography 22 (2003) 841-861

[3] La Ferrara E. and M. Guidolin (2004), "Diamonds Are Forever, Wars Are Not. Is Conflict Bad for Private Firms?" , CEPR Discussion Paper 4668.

[4] Landmine Impact Survey Report (several years), http://www.sac-na.org/surveys_mozambique.html

[5] Miguel E. and Roland G. (2005), “The long-run impact of bombing Vietnam”, Berkeley mimeo

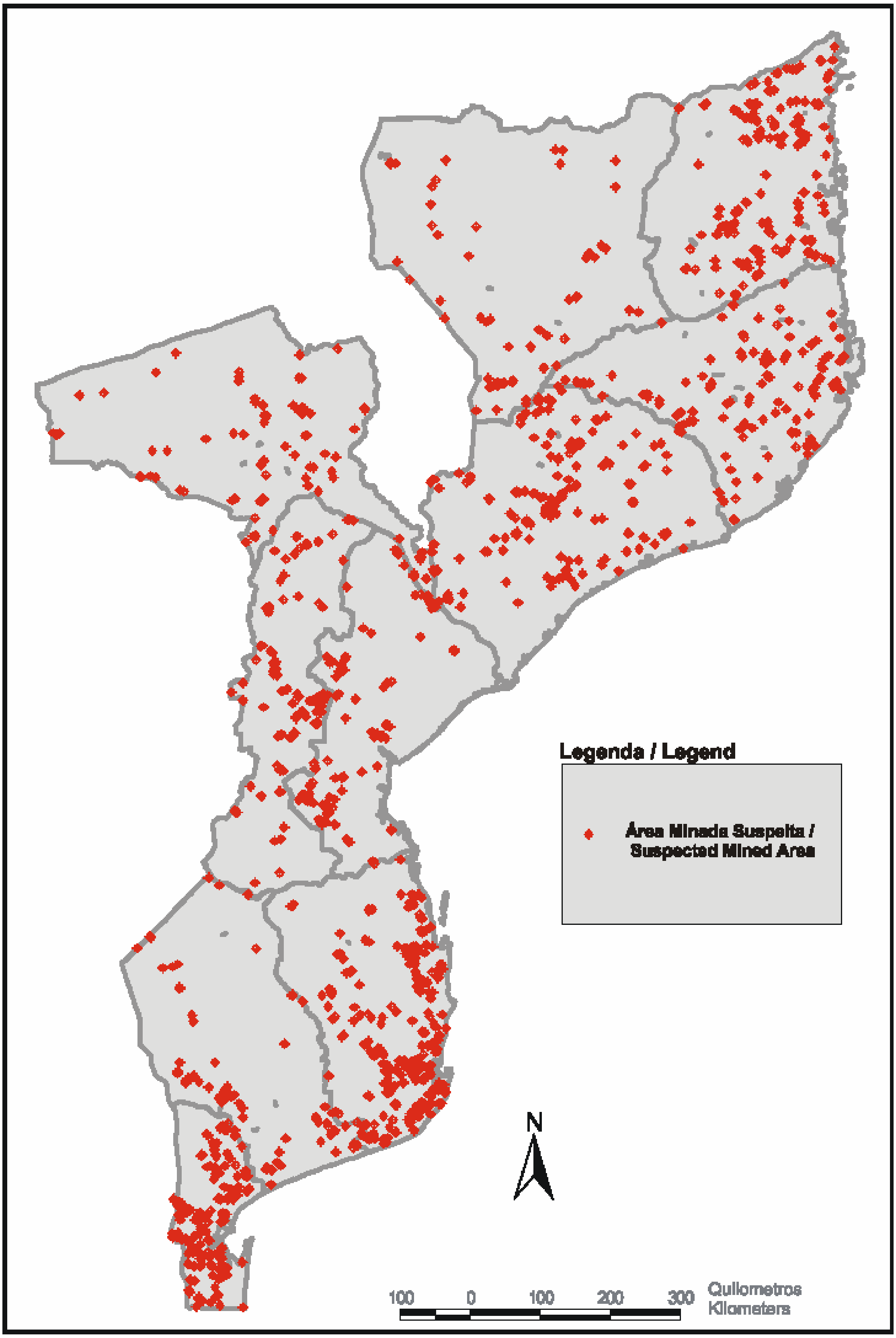
[6] Rosenzweig MR, Wolpin KI. (1988), "Migration selectivity and the effects of public programs", Journal of Public Economics Dec; 37(3):265-89.

[7] Simler, K., and V. Nhate (2002) ‘Poverty, Inequality and Geographic Targeting: Evidence from Small-Area Estimates in Mozambique’ mimeo, International Food Policy Research Institute: Washington DC.

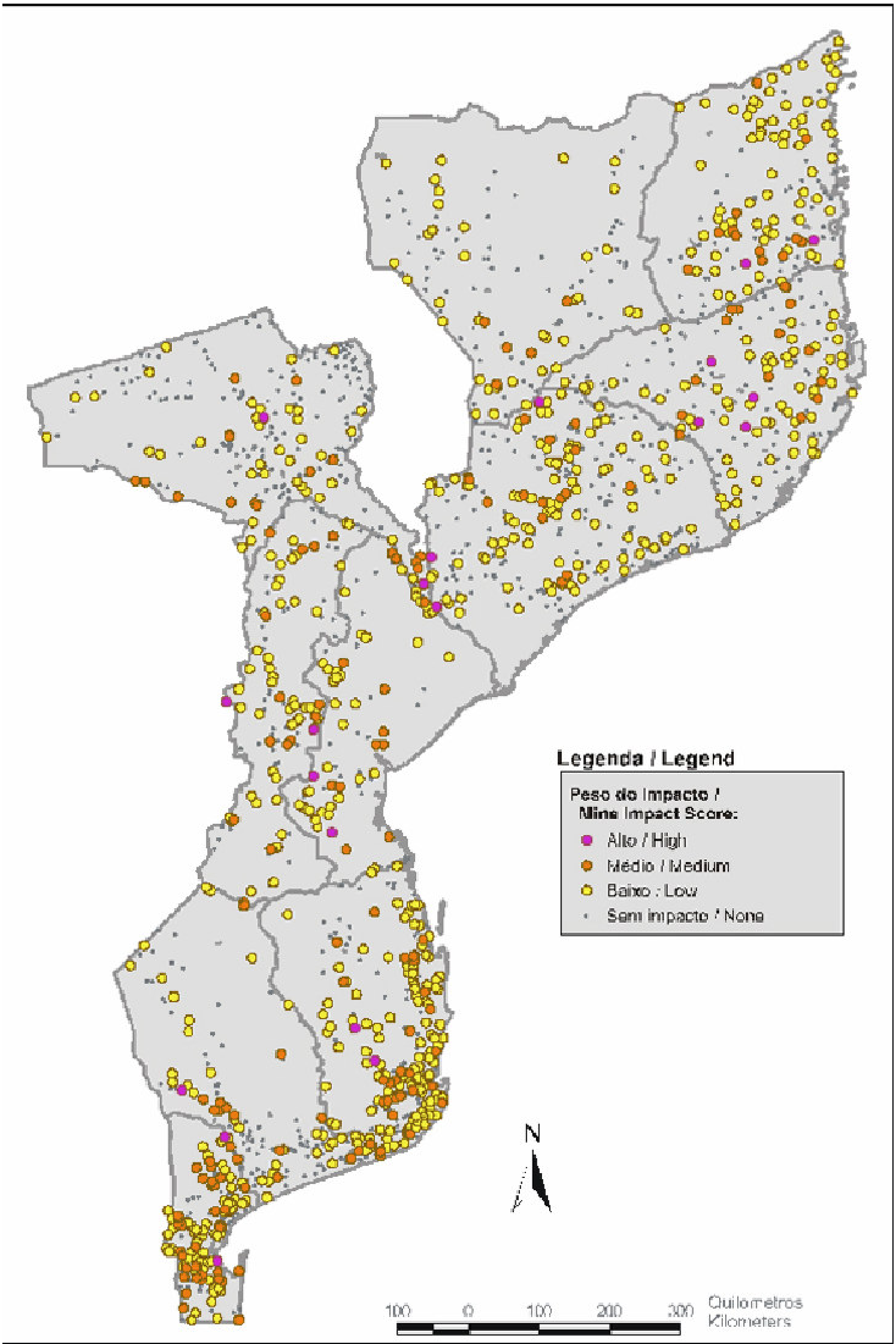
[8] Vines, A. (1994). Landmines in Mozambique. New York: HumanRights Watch.

[9] Vines, A. (1997). Still killing landmines in Southern Africa. New York: Human-Rights Watch.

[10] Willett, S. (1995). Ostriches, wise old elephants and economic reconstruction in Mozambique. International Peacekeeping, 2, 34–55.



MAP 1- Suspected Mined Areas



MAP 2-Landmine Affected Communities

Annexe 1- SMAs and Affected Population, By Province

Province	Number of SMAs	Affected Population
Cabo Delgado	166	170,566
Gaza	70	90,766
Inhambane	261	373,033
Manica	110	89,823
Maputo	184	126,592
Nampula	130	178,152
Niassa	62	60,379
Safola	102	134,156
Tete	89	93,596
Zambezia	200	171,527
Total	1374	1,488,590

Source: Landmine Impact Survey Report

Annexe 2- Functional Classification of SMAs

Functional Category	Number of SMAs
Military Installations	179
Well	45
Bridges	58
Village Perimeter	65
Trail	189
Road	177
Unknwon/Unclassified	661
Total	1,374

Source: Landmine Impact Survey Report

Table 1: Descriptive Statistics

Panel A: All Sample

Variables	Nbr.Obser.	Mean	Standard Deviation	Min	Max
Daily per capita Consumption (in Metical)	126	5 108	1 634,23	1534,82	13108,39
Headcount Index	126	70,5	13,7	22,8	98,6
Poverty Gap	126	32,7	12,3	6,9	72,6
$LC_{96\text{-}04/1000}$	126	120,4238	322,8	0	2491,72
$LC_{96\text{-}01/1000}$	126	72,73903	270,9	0	2491,72
$LC_{01\text{-}04/1000}$	126	48,06628	127,8	0	801,915

Panel B: Restricted Samples

	Areas Cleared Pre-2000	Areas Cleared Post 2000
Mean Poverty Rate	71,09	71,4
Mean Poverty Gap	33,05	33,1
Mean Consumption per cap	5121,5	5029,03

Table 2: Impact of Landmine Contamination on Consumption and Welfare

		Headcount Index	Poverty Gap	Daily Comsumption per capita
(1)	$LC_{96\text{-}04}$	0,01***	0,008***	-0,912**
		(0,003)	(0,003)	(0,433)
(2)	$LC_{96\text{-}01*}$	**0,011*** **	**0,009** **	**-1,166** **
		(0,004)	**(0,004)**	**(0,530)**
	$LC_{01\text{-}04}$	**0,0096**	**0,0067**	**-0,015**
		(0,0093)	**(0,0085)**	**(1,127)**
Nbr.Obser.		126	126	126

Table 2: Continued

(3)	***LC** 96-01**	**0,0144***	**0,0103**	**-1,832***
		(0,009)	**(0,008)**	**(1,017)**
		0,0027	0,0027	0,934
	LC 01-04	(0,013)	**(0,0115)**	**(1,456)**
	Nbr.Obser.	41	41	41

*Notes: Standard deviations in parentheses. *** means significant at one percent level, ** at fives per cent level*

Table 3: Transmission Mechanisms

		Female-to-Male ratio	Population Density	Average Family size	Number of Firms	Number of Employees	Business Size
(1)	*LC 96-04*	-0,004	-0,0115	0,0004***	0,017	-0,008	-56,4
		(0,002)	(0,009)	(0,0001)'	(0,028)	(0,555)	(282,5)
(2)	***LC** 96-01**	**-0,001**	**-0,0096**	**0,0004*** **	**0,013**	**-0,214**	**-42,02**
		(0,003)	**(0,011)**	**(0,0001)**	**(0,035)**	**(0,681)**	**(346,93)**
	LC 01-04	**-0,012***	**-0,0178**	**0,0002**	**0,0267**	**0,683**	**-114,65**
		(0,0063)	**(0,023)**	**(0,0003)**	**(0,075)**	**(1,446)**	**(736,81)**
	Nbr.Obser.	126	126	126	126	126	126

Notes: see Table 2

Table 4 A: Program Yearly Output and Cost since 1993

Years	Size of Land Cleared	Total Program Cost
1993-1999	2,683 million m2/year	62 cents/m2
2000	4.983 million m2	$ 17 million
2001	8.87 million m2	$ 15,1 million
2002	8.9 million m2	$ 16.9 million
2003	6.9 million m2	$ 17.5 million
2004	9.42 million m2	$ 18 million
2005-On	10 million m2/year	$ 18 million/year

Source: Landmine Monitor Report (several issues) and National Demining Institut.

Table 4 B: Cost-Benefit Assumptions and Results

Average Impact	***E(LC 96-01/1000)=-1,166***
Area Cleared 1993-2000	23,764 million m2
Cost in $ 1993-2009	277,63576 million $
Discount Rate	5%
Population	18,811,731
Exchange Rate $/Mt	11293,8
Discount Period	**50 Years**
Future Value	193 billion $
Discount Period	**25 Years**
Future Value	57 billion $