



## Land Mines and Spatial Development

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*What happens to the economic performance of a region contaminated by explosive remnants of war (unexploded ordnance and landmines) when it is finally cleared? Which regions benefit the most? And what are the aggregate country-wide effects of landmine clearance? Our study is the first one to offer a systematic answer to these questions.*

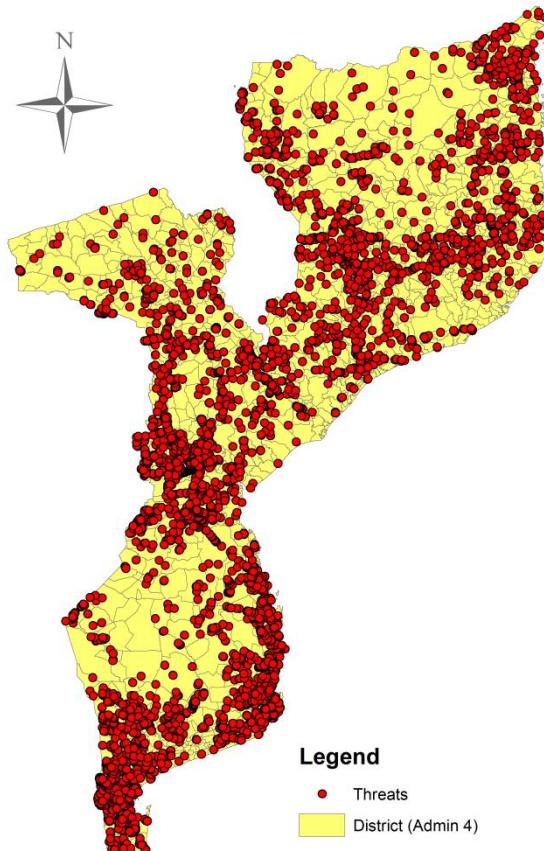
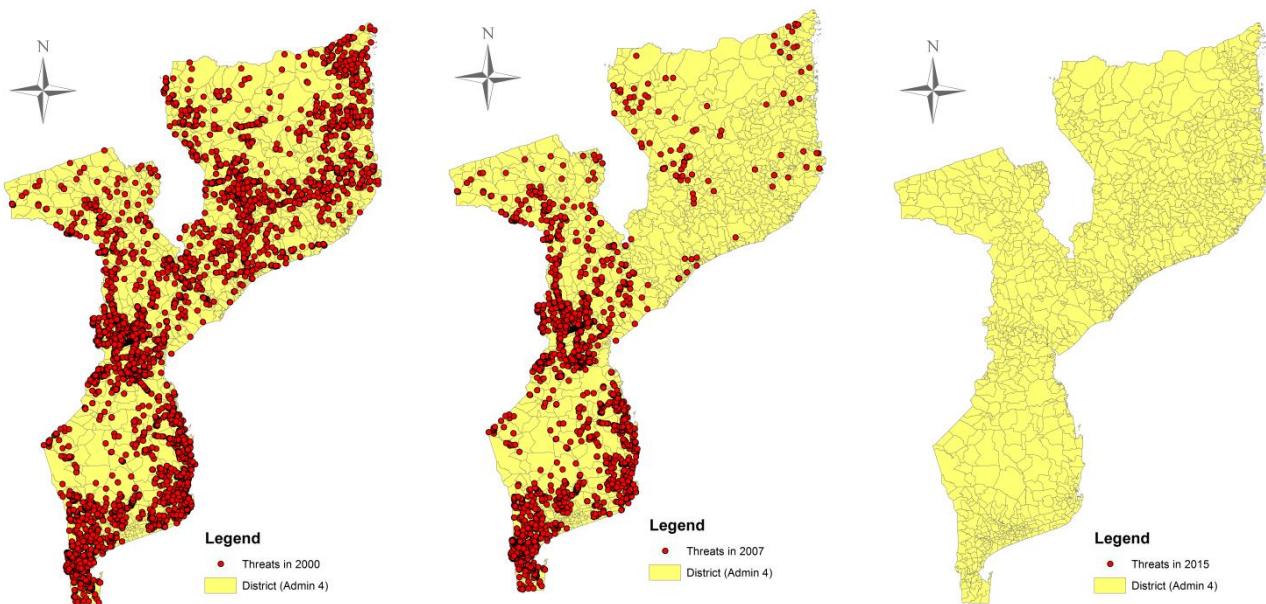
## Background-Motivation

Landmines are uniquely savage in the history of modern warfare remaining on the ground long after the cessation of hostilities. Currently, land mines affect the lives of people in around 50 countries, while a dozen or so countries are still classified as “heavily-impacted” by landmines. Despite the 1997 Mine Ban Treaty signed by 162 States Parties, rebels, armies, and militias use currently landmines and improvised explosive devices in Syria, Iraq, Libya and other civil-war torn countries. Twelve United Nations Specialized Agencies, Departments and Offices, funds and programmes play a role in landmine action around the world, while the international community spends close to one billion US dollars per year solely on clearance.

Nevertheless, little (if any) research exists on the consequences, economic and social, of landmine clearance. In this project, we explore the economic consequences of landmine clearance in Mozambique using self-collected data from various governmental agencies, NGOs, the UN and private firms covering close to the universe of landmine clearance operation. Mozambique is a particularly interesting country for this analysis as it is the only-so far heavily contaminated by landmines country officially declared landmine-free in 2015, 23 years after the end of the civil war and the war of independence.

## New data

In the first part of our analysis we describe the self-collected georeferenced data on landmine contamination and their subsequent clearance between 1992 and 2015. We are able to provide for the first time to the Mozambican government, the United Nations, the various NGOs involved in the demining process, and the international community an almost complete documentation of this gigantic and often chaotic process that lasted more than two decades. This is a non-negligible contribution, as there is no complete documentation of landmine clearance from any other heavily impacted country. Figure 1a below illustrates the distribution of land mines and unexploded ordnances (UXOs) at the end of the war, while figures 1b-1d portray the progress of demining during its three main phases (period 1: 1992-2000; period 2: 2001-2007; period 3: 2008-2015).

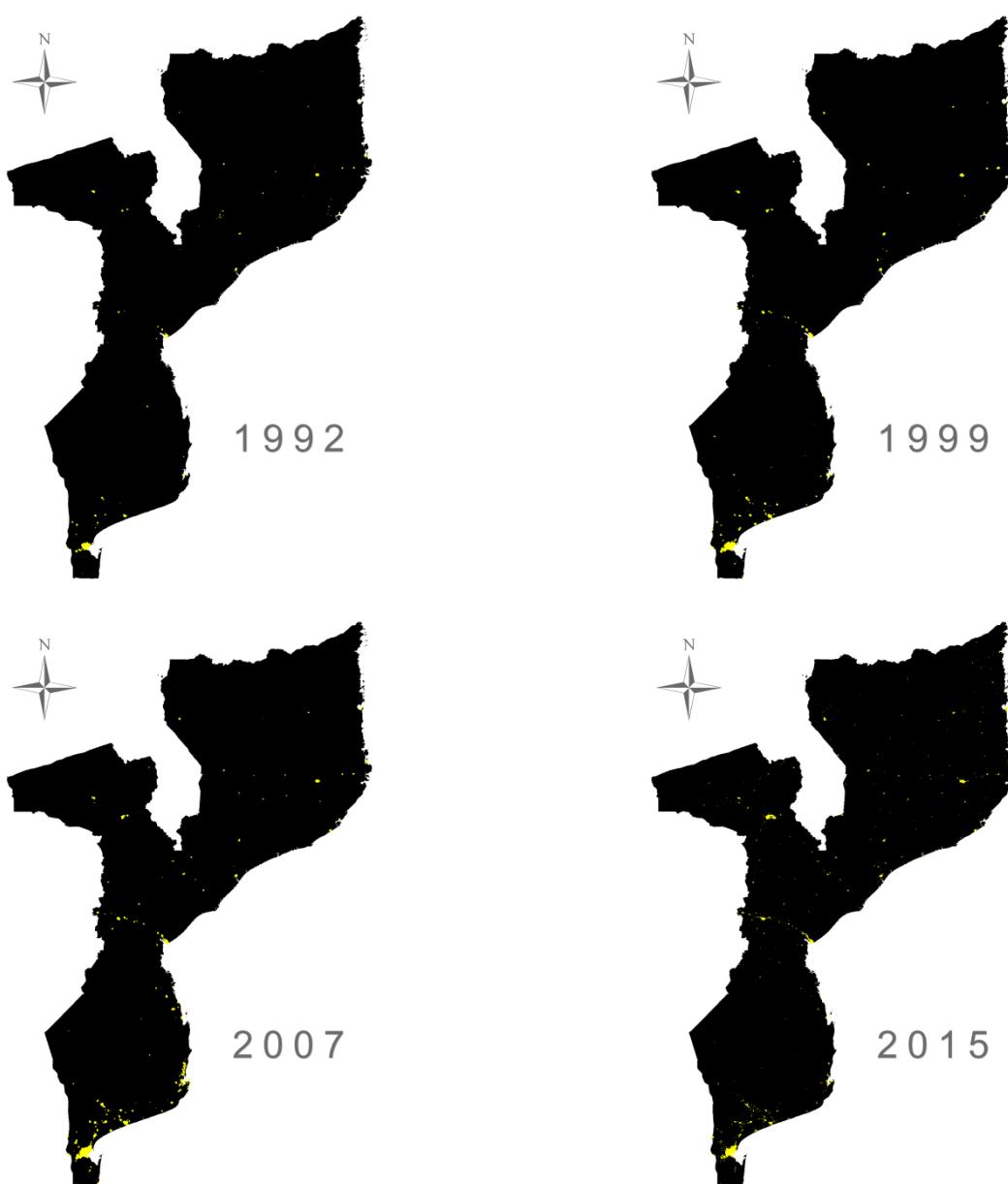

**Private Enterprise Development  
in Low-Income Countries**
**Figure 1a:** Distribution of land mines and unexploded ordnances (UXOs) at the end of the war**Figures 1b-1d:** Demining's progress during its three main phases



## Private Enterprise Development in Low-Income Countries

### Local effects of land mine clearance

Second, we exploit variation in the timing of demining across localities to assess its impact on economic activity. Given the chaotic situation in the country in the 1990s, this process was far from strategically planned. To bypass data unavailability on output statistics, we proxy regional development using satellite images of light density at night that are available at fine regional scale. We compare Mozambican localities, where demining took place in a given period, to those localities that either were not contaminated by landmines or were mined but not cleared yet. The specifications reveal statistically significant, but small-to-moderate economic magnitudes.

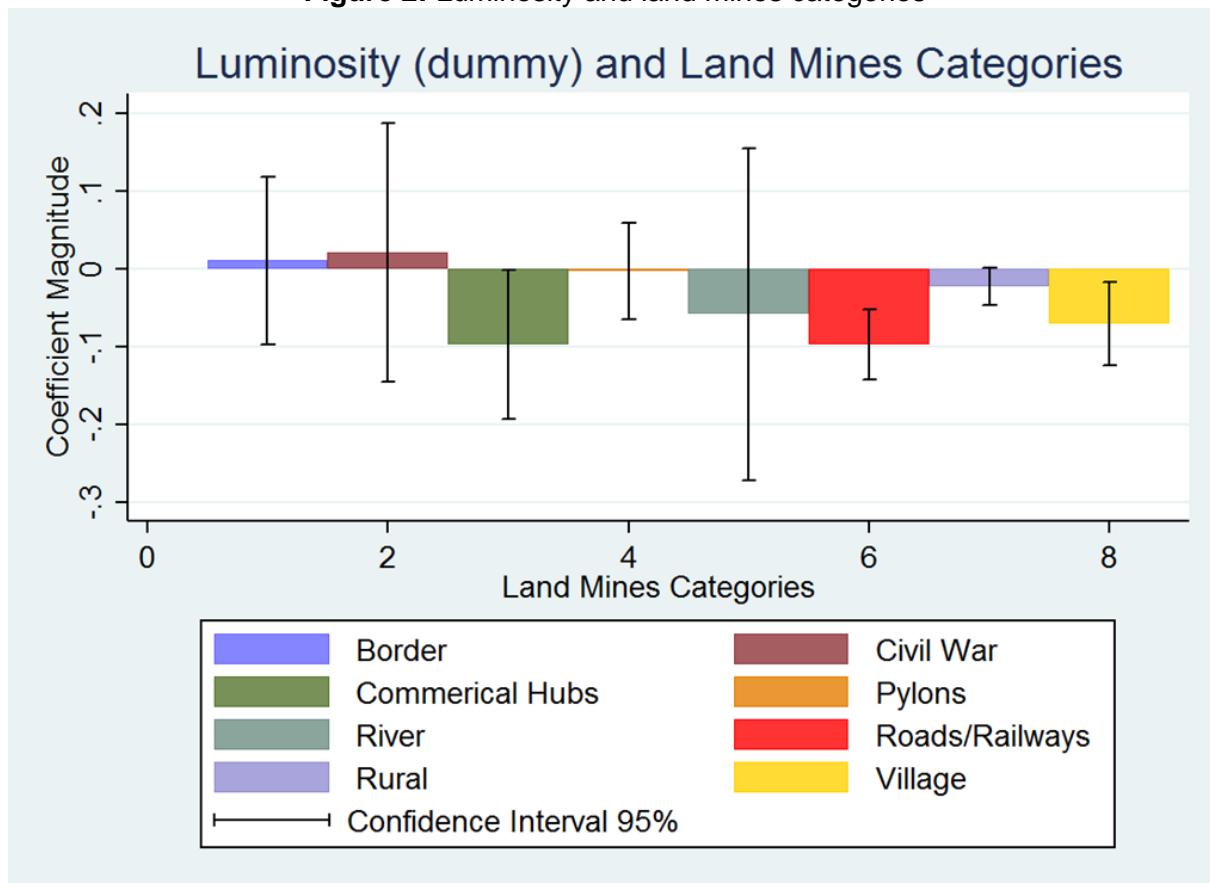


Third, in an effort to better understand the potentially heterogeneous impact of landmine clearance and offer guidance to ongoing demining activities in other parts of the world, we ask how clearing different categories of mines moderates the impact of demining on local development (as reflected on luminosity). Local trade hubs and relatively larger towns seem to benefit more from clearance, whereas demining rural



places, often close to the borders yield small and in general statistically insignificant estimates on local-level luminosity. Figure 2 below summarizes the main patterns<sup>1</sup>.

**Figure 2:** Luminosity and land mines categories



## Economy wide effects

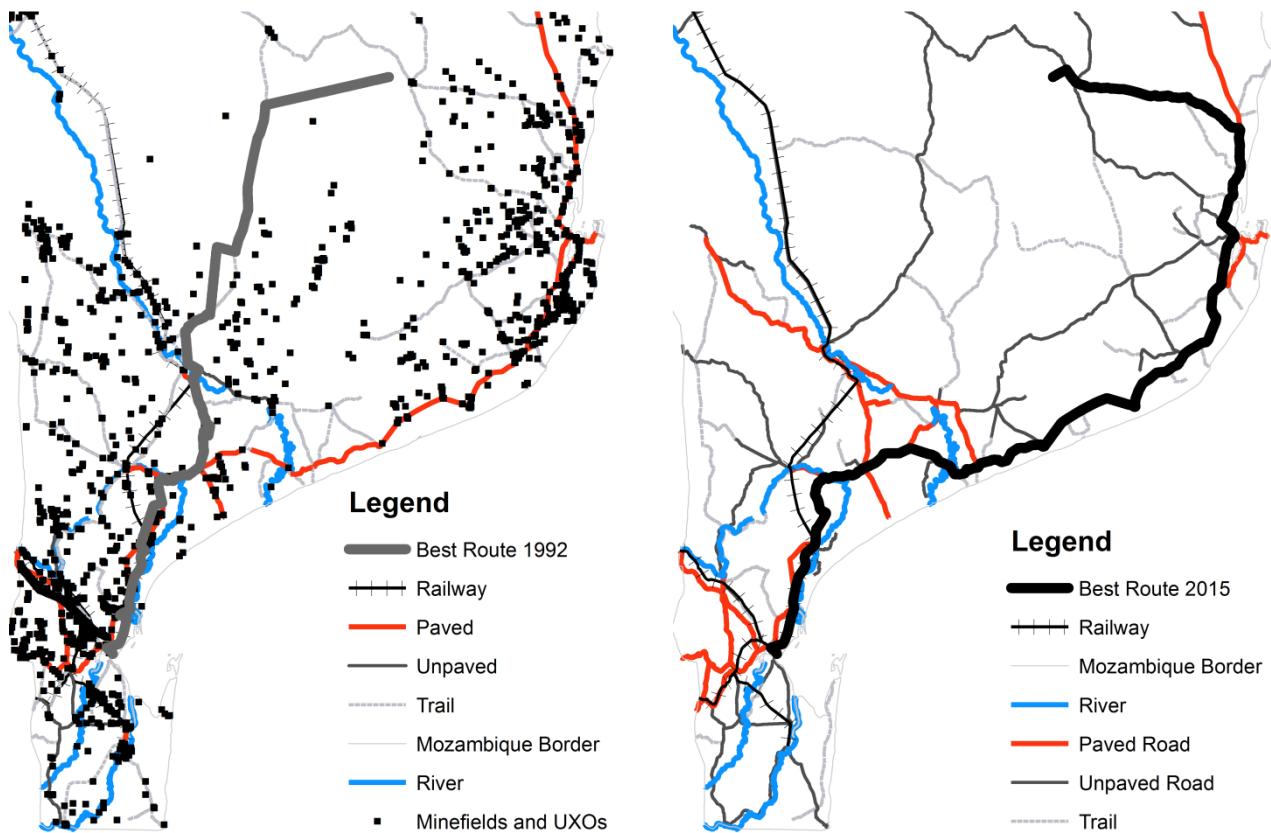
Fourth, we examine the economy-wide implications of landmine clearance recognizing the fact that removing landmines in one locality may indirectly impact economic activity in other regions through interconnections via the transportation network. To do so, we identify how the process of landmine clearance reconfigured the accessibility of the pre-existing transportation network (railroads and roads) over time. We apply a "market-access" approach, derived from general equilibrium trade theory that quantifies the aggregate effects of landmine clearance on spatial development. Applying a "google-maps" type algorithm that connects each Mozambican locality to all other localities in every year via the pre-war transportation network, we assess how the removal of landmines affects travel time across all pairs of localities. [Figures 3a-b below provide an example of travel from the town of Funhalouro to the capital Maputo in 1992 while the network was heavily mined and in 2015 when all contamination was removed]. We then associate regional luminosity to "market-access" changes due to demining across the country. The estimates reveal economically large and precisely estimated effects of landmine and UXO removal on aggregate economic activity. These results point out that due to positive spillovers, the economy-wide effects of landmine clearance are larger than the local effects.

<sup>1</sup> Negative values imply that a decrease in landmine contamination increases the probability of a given locality being lit.



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**Figures 3a-3b:** Optimal travel route and time from Funhaluro to Maputo in 1992 (40 hours) and in 2015 (8 hours)



Fifth, to improve on identification and mitigate concerns that the estimates reflect the strategic prioritization of high-growth potential regions (that does not seem to be the case), we repeat estimation focusing solely on localities, which were spared from any landmine contamination at the end of the civil war. For these places, changes in “market access” stem solely from landmine clearance in other regions connected via roads, rivers, and railroads. The results show that landmine clearance benefits areas that were not affected at all by landmines, illustrating the strong positive externalities and pushing crucially towards causality.

### Policy simulations

Sixth, we perform counterfactual policy simulations to approximate the likely economic gains of demining if the process, instead of taking place in the fragmented and uncoordinated manner that characterized mine clearance in Mozambique, was strategically planned and centrally coordinated. The policy simulations reveal significant economic losses in absence of central planning and strategic coordination among the various demining operators. This is because in the early years, Mozambique cleared border areas and rural regions rather than infrastructure-network-central localities or local urban hubs. It is important to keep in mind that conducting this counterfactual, we only take into account the economic growth benefits as reflected in the increase in luminosity due to demining. We anticipate that economic alongside humanitarian considerations are likely to be important elements in ongoing clearance efforts worldwide.

### Policy implications

Our results carry some immediate policy implications. First, by showing that landmine clearance boosts economic performance in relatively large towns, in areas close to roads and railroads, and in local trade



hubs, the results suggest that demining operators and governments should take this into account while setting their priorities. Clearly district prioritization is a complex in reality process that factors in various issues. We argue that economic potential –that is high in towns and cities- should be one of them.

Second, the decades-long effort of the international community to persuade governments to sign the Mine Ban Treaty on anti-personnel land mines should be expanded to cover anti-tank (and anti-vehicle) landmines. Their use by debilitating the transportation network, hinders economic recovery, as –to great extent- economic development is fueled by intra-region flow in goods, people and ideas.

Third, the stark comparison of “local” and “economy-wide” estimates and the associated counterfactual policy simulation point out that coordination and central planning would be clearly beneficial in heavily-mined countries where the international community is currently working on.

### Moving Forward...

Given the lack of research on the impact of land mines, we are currently extending our project in various dimensions. First, we are exploring the impact of land mine clearance on various socioeconomic aspects and entrepreneurship in Mozambique using a plethora of micro-level data that, however, cover the post-2000 period. This is crucial, as there is a strong humanitarian element on land mine clearance with a community reintegration focus, which goes well beyond a pure economics cost-benefit analysis. Second, we are assessing the impact of land mines, as well as other aspects of the Mozambican civil war (mostly related to refugees) to state capacity and political economy outcomes. Third, we have teamed up with researchers in engineering and landmine specialists from major demining operators to assess the impact of clearance in Asian countries.