

Contents

1	War of Independence	3
1.1	The War	3
1.2	Independence	5
2	Civil War¹	6
2.1	Phase 1 (1977 – 1980)	7
2.2	Phase 2 (1981 – 1986)	8
2.3	Phase 3 (1987 – 1990)	9
2.4	Phase 4 (1991 – 1992)	10
2.5	Descriptive Patterns	11
3	The End of Civil War	13

¹See Emerson (2014) and Funada-Classen (2012) for a discussion of the civil war and its origins.

1 War of Independence

1.1 The War

The attacks of the Mozambique Liberation Front (FRELIMO) rebels on September 25th, 1964 against the Portuguese base at Chai in Northern Mozambique mark the onset of the Mozambican War of Independence against colonial rule. FRELIMO was founded in 1962 in Dar es Salaam with the help of the Tanzanian leader Julius Nyerere. It unified three regional anti-colonial movements from Mozambique's Northern Provinces (Cabo Delgado, Nampula, and Niasa) and Tete (the Central-West province neighboring Zimbabwe). FRELIMO was a set-up by expatriate "intellectuals", without strong ties to Mozambique. Although its three main leaders (Samora Machel, Joaquim Chissano, and Eduardo Mondlane) were all Southerners, it drew predominantly from the Makonde, an ethnic group straddling the border of Tanzania and Mozambique (Newitt (1995)). Its founder leader was Eduardo Mondlane, a well-respected anthropologist, who before returning to Africa had worked at the United Nations and at Syracuse University in the State of New York. After Mondlane's assassination in 1969, FRELIMO was presided over by a three-member committee, consisting of Uria Simango, Samora Machel, and Marcelino Dos Santos.

The first anti-personnel anti-vehicle mines were laid by FRELIMO in 1965 in Cobue (Niassa) and Muidembe (Cabo Delgado). Watch (1997) FRELIMO mined roads alongside the Lurio river in Northern Mozambique in the late 1960s; the area was nicknamed by the Portuguese colonial forces as "Minas Gerais" mimicking the name of the Brazilian mineral-rich state. In March 1970, FRELIMO initiated "Operation Estrada" in Cabo Delgado, close to Tanzania, which involved mining roads south to Rio Messalo. In spite of some initial military success, mostly in the Northern Provinces, the Portuguese contained the insurgency with the brutal Gordian Knot Operation of 1970 – 1973. At the same time, the colonial administration completed the construction of the Cahora Bassa dam, the fifth largest in the world, which aimed to show Portugal's development agenda for Mozambique and its commitment of maintaining its colony. Cahora Bassa was designed not only to secure Mozambique's energy autonomy but also to export energy to South Africa and Rhodesia (Zimbabwe). In a highly controversial move, Portugal relocated half to one million Mozambican peasants into fortified camps (*aldeamentos*) in an effort to prevent the spread of revolutionary messages, provide basic public goods, and promote some industrialization. This proved to be counterproductive, as thousands died from disease, starvation, and brutal penalties.

FRELIMO relied mostly on small-scale attacks and insurgency tactics. The Portuguese, thus, used landmines to protect infrastructure that was targeted from the rebels. To secure the Cahora Bassa dam the Portuguese colonial authorities planted 80,000 landmines, creating the "largest" minefield in Africa. Portuguese forces also placed mines to ring-fence Mozambique's border with Tanzania and block the rearmament of FRELIMO. They also placed landmines near the "development camps". At the same time, and in response to the Portuguese counterattack, FRELIMO used anti-tank and

anti-personnel landmines to terrorize Portuguese troops. FRELIMO guerrillas planted landmines with anti-prodding devices, making them way more dangerous and easy to explode. After 1973, FRELIMO used landmines for non-military purposes in an effort to demonstrate to the locals and international observers that the Portuguese had lost control of the countryside. In Tete, FRELIMO laid anti-personnel landmines on paths and trails used by the locals for water access, farming, and accessing main roads. Watch (1997)

1.2 Independence

Developments in Portugal were crucial for the war ending. The Mozambican Independence War ended with the successful overthrowing of the military dictatorship in Portugal by the Carnation Revolution on April 25th in 1974. The new Portuguese officials were determined to end colonial wars; besides Mozambique, liberation movements and anti-colonial wars were flaring across all Portuguese colonies, Angola, Guinea-Bissau, Cape Verde, and Sao Tome. On September 1974, the Portuguese government (controlled by Movimento das Forças Armadas, but nominally represented by President Spínola) signed the Lusaka Agreement with FRELIMO, setting the stage for an independent Mozambique. Yet, many critical issues, related to the legal position of white/Portuguese settlers and their property, colonial debt, and economic relations with Portugal were left unspecified. And the country was effectively handed over to FRELIMO, which after a brief interim period, took power in 1975 without elections.

After taking office, Samora Machel, the first President of the country, and FRELIMO tried to implement ambitious social and economic reforms, such as empowering peasants, investing in education, and promoting industrialization. Yet, the situation was chaotic (Newitt (1995)). The economy was weak, infrastructure was poor, illiteracy rampant, and global economic conditions unfavorable. White settlers, Indians and educated Mozambicans were fleeing the country, depleting their bank accounts, and moving vehicles, cars, and tractors to South Africa. The government embarked on a large-scale nationalization program regarding housing, health, and education; it slowly promoted the nationalization of private enterprises. The apartheid government in South Africa, strongly skeptical of FRELIMO's policies, started laying off Mozambican workers from South African gold mines, depriving the country of valuable remittances. Things got worse in 1977 as heavy rains flooded vital agricultural lands in the Limpopo Valley, close to the country's capital, Maputo. The government took over abandoned farms and factories, installing state managers who were assisted by foreign experts from communist countries. At the core of FRELIMO's plan was a compulsory communal villagization system, similar to Tanzania's *ujamaa* system pursued by Nyerere. Peasants were forced to abandon their very dispersed settlements in the countryside and move into communal villages (*aldais comunais*). By 1981, close to 2 million people had been moved into 1,266 communal villages (Watch (1992)). This policy proved to be highly ineffective, causing resentment among peasants. Violence was high, conditions dire, and the prospects of high productivity proved to be illusionary. According to some estimates, output fell by 40% in the years surrounding independence -if not more. Thanks to foreign aid, the economy

rebounded during 1977 – 1981, but inefficiencies were massive and poverty widespread. However, the key challenge of the new government was its inability to broadcast control over its large territory. As Weinstein (2007) put it "the socialist state suffered the same fate as the colonial government that has been unable to extend its authority to rural Mozambique".

2 Civil War²

In 1977 FRELIMO declared a one-party state rule, based on Marxist principles. FRELIMO's rise to power affected Mozambique's relationships with neighboring governments. The apartheid government of South Africa was very suspicious of Samora Machel and his government, due to its Marxist and anti-colonial ideology, as well as its support of the African National Congress.³ Relations with Rhodesia, that had declared independence from Great Britain in 1965, were even tenser and deteriorated sharply with FRELIMO's rise in power. Even before Mozambique's independence, the Zimbabwe African National Union (ZANU) and its armed militia, ZANLA were launching attacks in Zimbabwe against the Ian Smith's regime from Central-West Mozambique (Tete Province). After independence, FRELIMO was in a position to further assist ZANU, a party with similar nationalistic, anti-colonial, and socialist ideology. In its effort to destabilize Ian Smith's regime, FRELIMO sealed the borders with Rhodesia, depriving its landlocked neighbor of critical coastal access via the "Beira Corridor". Mozambique also helped with the UN-imposed sanctions against Rhodesia.

The Rhodesian armed forces and police -that were already conducting operations in Mozambique against ZANLA- backed a counterinsurgency rebel group, the Mozambican National Resistance (RENAMO, often referred as MNR, Mozambique National Resistance, though locals would refer to them as "bandidos armados").⁴ RENAMO was established in Salisbury, Rhodesia in 1977 by the Rhodesian Secret Service; according to some records South African Special Forces also played an instrumental role. The principal figures were Orlando Cristina, a prominent figure of the notorious Portuguese Secret Police; André Matsangaissa, a former FRELIMO official, who had been freed by Rhodesian forces during a raid in Mozambique; and Afonso Dhalakama, who led RENAMO for more than two decades. RENAMO members including former FRELIMO officials dissatisfied by the radicalization of the party, Portuguese and other European expatriates looking to recover their property and influence, and mercenaries that were mostly interested in looting. RENAMO also received support from *regulos*, traditional ethnic chiefs, who were displeased with the nation-building policies of FRELIMO that aimed to attenuate ethnic differences. Emerson (2014) In its infancy, RENAMO's army was around

²See Emerson (2014) and Funada-Classen (2012) for a discussion of the civil war and its origins.

³At the same time, South Africa was directly involved in the Angolan civil war that (as in Mozambique) started almost immediately after independence. South Africa was supporting the rebels of UNITA (National Union for the Total Independence of Angola) that were fighting the MPLA (People's Movement for the Liberation of Angola), the key anti-colonial movement that seized power at independence and with the military and economic assistance of communist countries managed to secure power during the three-decade-long Angolan civil war.

⁴Vines (1991) gives an eloquent description of RENAMO's formation and its activities in Mozambique during the civil war. Weinstein (2007) provides an in-depth analysis of the structure of RENAMO, its tactics, and recruitment methods.

300 hundreds and in 1979 did not exceed 3,000 members.

Most of the landmines in Mozambique were laid either by RENAMO or the FRELIMO-backed government troops between 1977 and 1990, though landmine usage went on till 1992 and according to some reports even beyond the war ending. Other militias, gangs, and even private agents used landmines for a plethora of reasons, to protect farmland, to terrorize the civilian population, for military purposes. And the armies of Rhodesia and then Zimbabwe, South Africa, and even Malawi and Tanzania also used landmines during their direct involvement in the war. According to Watch (1997), FRELIMO and RENAMO frequently disseminated landmines in an "arbitrary fashion". The international support of both actors was reflected in the landmines used on the ground: FRELIMO planted landmines produced in the Soviet block (e.g., Yugoslavia, Bulgaria, and the Soviet Union), while RENAMO mostly employed landmines produced in South Africa and in the Western world (e.g., Italy, Belgium).

2.1 Phase 1 (1977 – 1980)

During the first stage of the civil war, roughly from 1977 till 1980, RENAMO's operations were limited to the Rhodesian border and rarely affected areas close to the coast (see Panel A of Figure 2). According to the data of Domingues et al. (2011) and Robinson (2006), less than 10% of civil war's events took place during this initial phase. Rhodesian forces were in control; as Emerson (2014) puts it "RENAMO would be molded into a small, but well-trained commando unit groomed to play a very limited and tightly-controlled part of the Rhodesian war effort."

RENAMO's attacks in Mozambique were targeting military bases. RENAMO was also trying to disrupt communications and destabilize local communities in an effort to de-legitimize the power of the new Mozambican government. It was also assisting Rhodesian forces in special operations, the most important being the sabotage of the Beira oil storage depots in March 1979. Later that year and with the huge support of the Rhodesian army, RENAMO established its first major base in the country, in Gorongosa. According to some evidence (Magaia (1988)), there were around 350 RENAMO and Rhodesian attacks between 1976 – 1979. At the same time, FRELIMO was cracking down opposition using torture and capital punishment.

During this period landmines were placed on both sides of the Rhodesia-Mozambique border to prevent ZANLA's raids in Rhodesia and to protect RENAMO's bases. For example, in Mucumbura 20 kilometers of border areas were mined along the river. Rhodesian forces trained RENAMO's members to use landmines in combat. RENAMO's main strategy concerned the mining of major roads, supply routes, rural areas, and airstrips. Watch (1997) Landmine contamination took place in Tete, Manica, and Maputo provinces. Many roads in Magoe district (Tete) were mined by the Rhodesian forces (e.g., in Massapa where bridges and roads were mined). The transportation network in Massangena district (Manica) was also mined (e.g., Chingamane and Choane) due to Rhodesian activities. Mines were laid by both Rhodesian and FRELIMO forces to secure the border.

The fall of Ian Smith's government in Rhodesia in June 1979 coupled with the successful attack of FRELIMO on RENAMO's headquarters in Gorongosa (in October 1979) and the death of Matsangaissa in a counterattack weakened the rebels; it looked like that the civil war would be over. As Newitt (1995) puts it " *at this stage RENAMO was simply a mercenary unit of a white colonial army.*"

2.2 Phase 2 (1981 – 1986)

With Zimbabwe's independence and the rise of Robert Mugabe in power, RENAMO moved to South Africa in 1980. Its new leader, Afonso Dhlakama, secured assistance from the South African Defence Force (SADF). Having new bases in Transval, a Northern South African region close to Mozambique, RENAMO's strategy changed. With the strong military and financial backing of South Africa, it expanded its presence in Mozambique. The conflict reached Zambezia and Nampula in the North and Inhambane and Sofala in the Center-South (see Panel B of Figure 2). RENAMO attacks coincided with massive droughts in 1981 – 1982, leading to starvation and famine. Watch (1992) reports that RENAMO was even attacking tracks carrying food supplies and medicine. RENAMO managed to recruit some sympathizers, who were opposing FRELIMO's villagization policies and the suppression of ethnic leaders and customs. In its controlled territories, RENAMO returned local power to ethnic chiefs, who in turn were collecting supplies for the army. It also engaged on child soldiering in an effort to boost its numbers; according to some estimates, 40% of its army consisted of children recruited below the age of 18 (Weinstein (2009)). RENAMO seems to have also reached some form of agreement with the government of Malawi, and throughout the 1980s its army was getting supplies from the poor landlocked country (Robinson (2009)).

RENAMO now targeted infrastructure, dams, roads, and railroads. Roads in Morrumbala and Namroi districts in Zambezia became unusable because of mines. RENAMO placed mines on bridges in Rio Lingonia between Ribaue (Nampula) and Gile (Zambezia) in 1982; its most eminent "successes" were the destruction of oil storage tanks in Beira in December 1982 and the blowing of the Zambezi rail bridge in 1983, that effectively cut the country into two. RENAMO's operations spread even in the North, far from its base in South Africa and in Gorongosa (in Central Mozambique) and in areas where FRELIMO's influence was strong.

FRELIMO also deployed landmines. Several minefields were planted to defend villages in Inhambane (e.g., Funhalouro and Inharrime districts), Zambezia (Morrumbala), and Maputo (Moamba and Marracuene). RENAMO laid mines trying to isolate urban centers (packed by internally displaced people) from the countryside. In response to RENAMO's attacks in the early 1980s, FRELIMO planted protective minefields around the Komatripoort electricity power line (that runs in parallel to the main road connecting Maputo to Johannesburg). Ring minefields were laid around each of the 202 pylons, each with 200 – 300 AP mines. Watch (1997) The border with South Africa started to be mined around the same year in an effort to cut supplies from South Africa. FRELIMO also used landmines to destroy RENAMO's outpost in conquered villages in Zambezia (e.g., Mocuba district)

and Inhambane (e.g., Inharrime district). In their effort to secure key facilities across the country, FRELIMO patrols laid mines around their positions and camps when they stopped at night. When the troops moved on, mines were left behind and the population was not alerted, creating a lethal danger to civilians.

In response to the devastating conditions, Samora Machel made a political U-turn, signing a security agreement with South African President Pieter Willem Botha. The Nkomati Accord of March 16, 1984 mandated both countries to stop supporting each others' insurgent groups, RENAMO and the African National Congress, respectively. Machel abandoned the strong ideological ties with the Soviet bloc and also visited European capitals to persuade European leaders to commit much-needed aid and to show that he was not a hardliner. He was successful, as many European governments, including the United Kingdom, provided aid and humanitarian support. At the same time, the Mozambican government lifted price controls and changed the investment code making it easier for foreigners to invest in the country. Yet, the war continued as RENAMO was still being assisted by South African paramilitary forces, Malawi, and SADF agents.

Violence, if anything, intensified. In late 1982 Samora Marcel reorganized the military forces, decentralizing power to 10 provincial leaders, and with the assistance of Soviet countries established small counter-insurgency groups. Emerson (2014) With the help of Zimbabwe and Zambia's Presidents Robert Mugabe and Kenneth Kaunda, respectively, Machel managed to secure Malawi's neutrality in September 1986. But in his flight back to Maputo, his plane crashed. After his death, Joaquim Chissano became FRELIMO's leader and Mozambique's President and served till the end of the civil war and the transition to democracy in 1994.

2.3 Phase 3 (1987 – 1990)

The bloody phase of the war continues after Samora Marcel's death. RENAMO and other militias engage in widespread terror strategies and there are numerous reports in international media of atrocities. Although RENAMO had lost the official support of South Africa and most other allies, the third phase of the civil war was the most brutal (see Panel C of Figure 2). "*RENAMO augmented its financial base -hedging against a South African withdrawal- by systematically looting household property, trading in illegal goods, and extorting payments from private enterprise in exchange for protection*" (Weinstein (2007)). The United States and the United Kingdom refused to treat RENAMO as a *bona fide* anti-communist party, although they were pressed by ultra-right-wing groups to do so. "*RENAMO was also steadily weaning itself- not by choice but of necessity- from South Africa*" (Emerson (2014)). And in a private meeting in July 1988 with President Joachim Cissano, South African President P. W. Botha promised to cut off any assistance to the rebels. But these developments intensified -rather than attenuated- conflict. RENAMO's strategy during this period was to destroy people's belief in the ability of the government to protect them. Massacres were commonplace, as RENAMO embraced a strategy of terror. Abductions, kidnaps, child soldiering raids, rapes, attacks in villages

and mutilations, burning, and looting become widespread. The most infamous event took place in July 1987 in the town of Homoine, where rebels killed 386 – 424 unarmed civilians with knives and machetes, mostly children, women, elderly and patients in the local hospital. Given the coverage of international media (New York Times article of July 1986), accusations focused on South Africa, even from the United States and the United Kingdom.

A US State Department commissioned report by former US official Robert Gersony argued that such attacks were commonplace. Gersony (1988) writes "*it is conservatively estimated that 100,000 civilians may have been murdered by RENAMO.*" The report stated having credible information of "*killings, shooting executions, knife/axe/bayonet killings, burning alive, beating to death, forced asphyxiation, forced starvation, and random shooting of civilians in villages during attacks*" (Gersony (1988)).

RENAMO also established forced labour camps (Gandira System). RENAMO continued targeting infrastructure (especially bridges and roads in Sofala) using landmines extensively to also terrorize the local population. This was the case in Piquerra village Nampula where Renamo laid mines (even on a football pitch) to disrupt the community around 1987. Many of the landmines laid by RENAMO in southern Mozambique were intended to cause extensive social and economic disruption, with dissemination on roads and villages following a random fashion aimed at maximizing their lethal potential.

Its operations appeared successful and the government lost control of sizable parts of the country. Tanzanian and Zimbabwean troops intervened to contain RENAMO and eventually launched counterattacks in the mid-late 1980s. But RENAMO responded by staging war against Zimbabwe and launching a major counterattack that led to chaos in the border regions. It seems that FRELIMO and government troops also committed serious crimes during this period. They were also using forced labour and there were constant accusations of rape, killings, and looting, as the country was effectively lawless. Violence against the civilian population intensified as warring parties appeared unwilling to fight with each other, preferring plundering, stealing, kidnapping.

2.4 Phase 4 (1991 – 1992)

The war's final phase started when the South African public opinion shifted and with Frederik de Klerk's efforts for a smooth democratic transition in South Africa (with his secret negotiations with ANC's imprisoned leader Nelson Mandela). The South African political establishment also decided to stop the disaster in Mozambique. RENAMO had been weakened both militarily and financially. "New" armed groups emerged, offering protection to peasants and refugees. FRELIMO was also weak, unable to cope with the huge logistic challenges of running a war stretching across the vast country. The conditions were devastating and foreign support was dwindling. People were also tired and support for both warring parties dwindled. Spiritual military groups, like Naprama rose, illustrating the collapse of authority in the country. However, violence against the civilians continued and in some places even

intensified.

FRELIMO introduced a new Constitution in November 1990 allowing multi-party elections, freedom of the press, an independent judiciary, and civil liberties. While the United States and South African governments were pushing for an immediate cease-fire and a steady transition, RENAMO continued its operations. Other groups and scattered FRELIMO units also went on with terrorizing activities and fighting continued in 1991 and 1992 although negotiations were taking place since late 1990 (led by Archbishop Jaime Gonçalves and *Sant’Egidio*, an Italian-based Catholic lay movement). Both actors continued to use landmines during this period. A cease-fire agreement that ended the war and opened the way for elections was signed by the two parties in Rome in October 1992. With the United Nations Operations in Mozambique (UNOMOZ) deploying 6,400 soldiers and workers and foreign aid coming in from various Western powers, the transition took place and the 1994 Presidential and Parliamentary elections marked the beginning of a democratic era.

2.5 Descriptive Patterns

We gathered data on conflict during the civil war from Domingues et al. (2011) and Robinson (2006). As the authors themselves acknowledge, the data are noisy and incomplete; yet, they allow validating the historical narratives. The format of the data resembles that of the ACLED (Raleigh, Linke, and Hegre (2014)) and UCDP-GED dataset (Sundberg, Lindgren, and Pads kocimaite (2010), Sundberg and Melander (2013)). The authors distinguish between battles involving the fighting parties and one-sided violence against the civilian population (e.g., kidnaps, village burning, repression) perpetrated by both parties. We complemented this data with the widely-used UCDP-GED dataset (Sundberg and Melander (2013)) that however covers only the latest period, 1989 – 1992. Figure 3 illustrates the distribution of State-based violence (mostly between the FRELIMO-backed Mozambican armed forces and RENAMO) and One-sided Violence in the four periods: *i*) 1975 – 1980; *ii*) 1981 – 1986; *iii*) 1987 – 1990; *iv*) 1991 – 1992. In line with the historical background, violence in the country increased over time, spiking between 1987 and 1990. In these three years, the number of violent events was higher than in the previous ten years. In the final period, just before the Rome Peace agreement, state-based violence decreased. But the level of violence against civilians remained very close to the level reported during the third period.

Figure 4 presents the evolution of violence at the province level. In absolute terms, the most affected provinces throughout the period were Maputo, Sofala, Gaza, and Zambezia. Levels of violence were fairly stable in Gaza and Sofala (given their proximity to Zimbabwe and South Africa). The northern provinces of Cabo Delgado and Niassa were the regions in which conflict was lower.

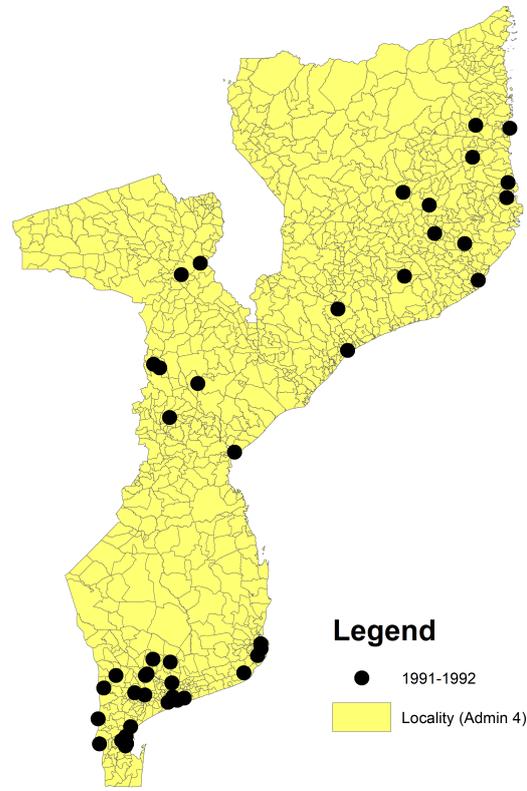
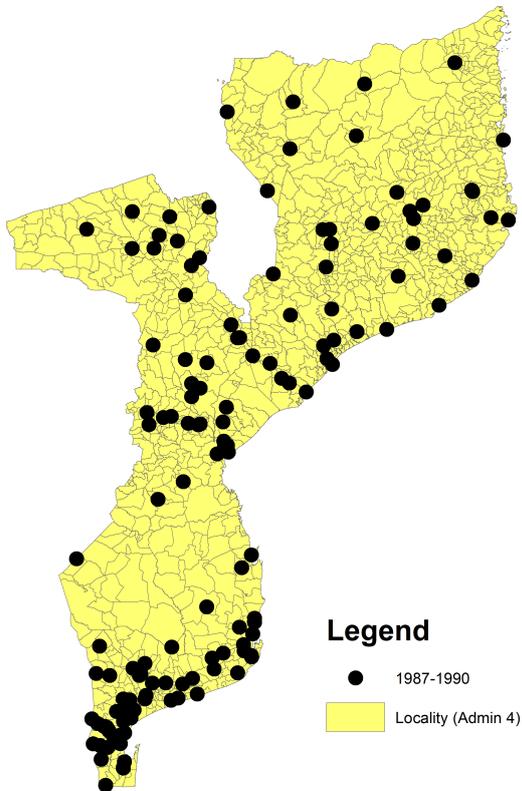
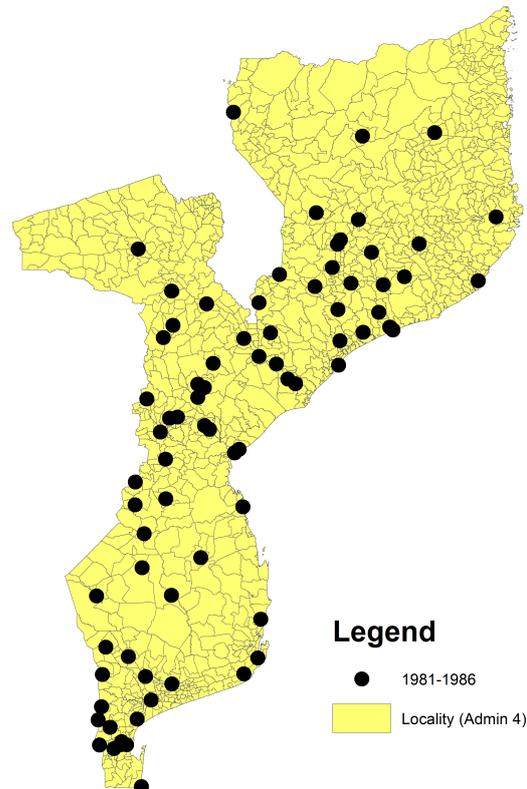
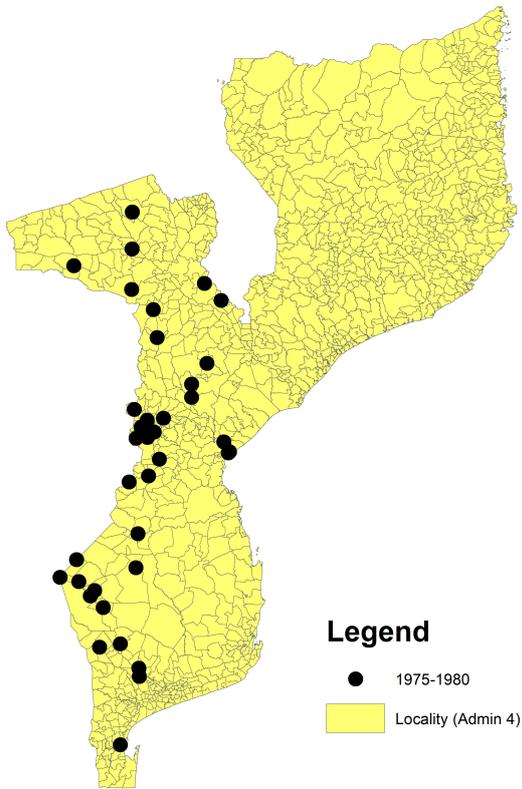


Figure 2: Civil War Spatial Distribution by Period

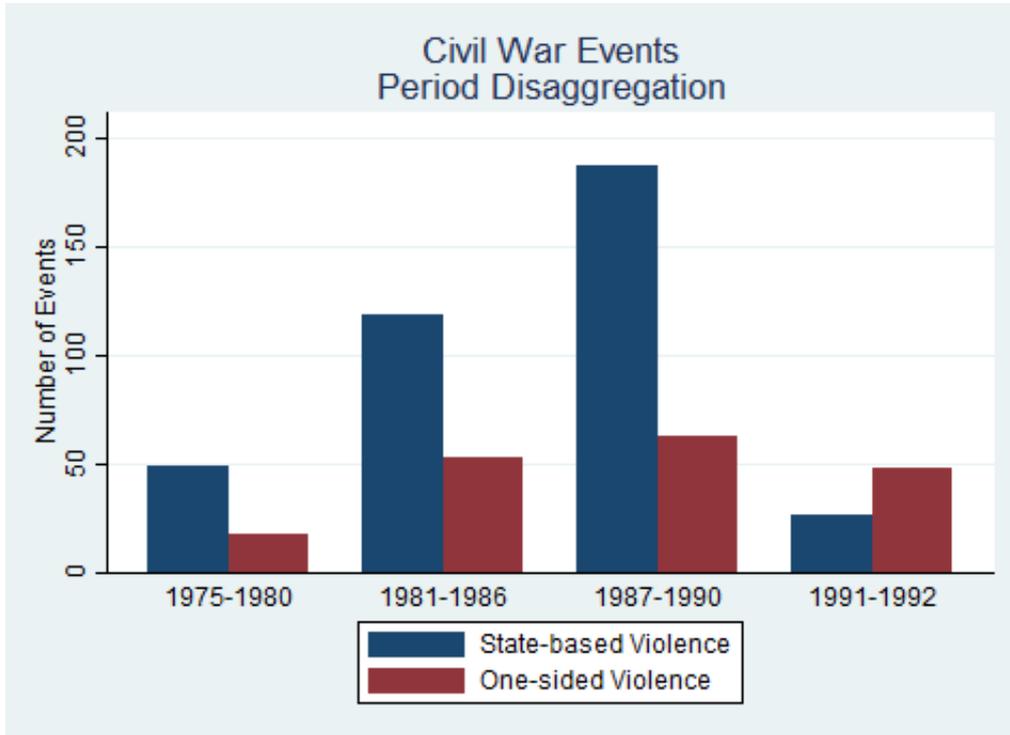


Figure 3: Civil War Evolution by Period

3 The End of Civil War

The toll of the war of independence and especially of the civil war appears, by all accounts, incalculable. RENAMO was mostly aiming to destroy state capacity, infrastructure, loot, kill and terrorize. And FRELIMO also committed serious crimes. A peculiar feature of the Mozambican civil war is the small number of battles between the fighting parties⁵; this was a war against the civilians. Human Rights Watch’s early report was eloquently titled *Conspicuous Destruction* (Watch (1992)). Approximately 100,000 – 150,000 Mozambicans died in rebel raids. While estimates vary, there were 7,000 to 15,000 fatalities from landmines during the war, placing the death and injuries rate to population at 1 per 1000 inhabitants (Roberts and Williams (1995)).⁶ Moreover, one million (and according to other estimates 2 million) people died from starvation, famine, and by lack of medical support. Four to five million Mozambicans (from a total population of 12 – 15 million) had to abandon their villages. Of those approximately 1 – 2 million fled to neighboring countries (mostly in Malawi) where they lived

⁵The two armies were relatively small (at its peak RENAMO had 20,000 fighters and FRELIMO’s army had 70,000 soldiers) and both were ill equipped. Thus, they were trying to avoid direct confrontation and resorting to the extensive use of landmines.

⁶It seems that there was severe under-reporting on landmines as both parties wanted to avoid international criticism. A 1994 Survey conducted by Physicians for Human Rights covering 7,000 respondents in Manica and Sofala estimate death and injury by landmine ratios per 1,000 people at 16.7 and 8.1 in Manica and Sofala, respectively.

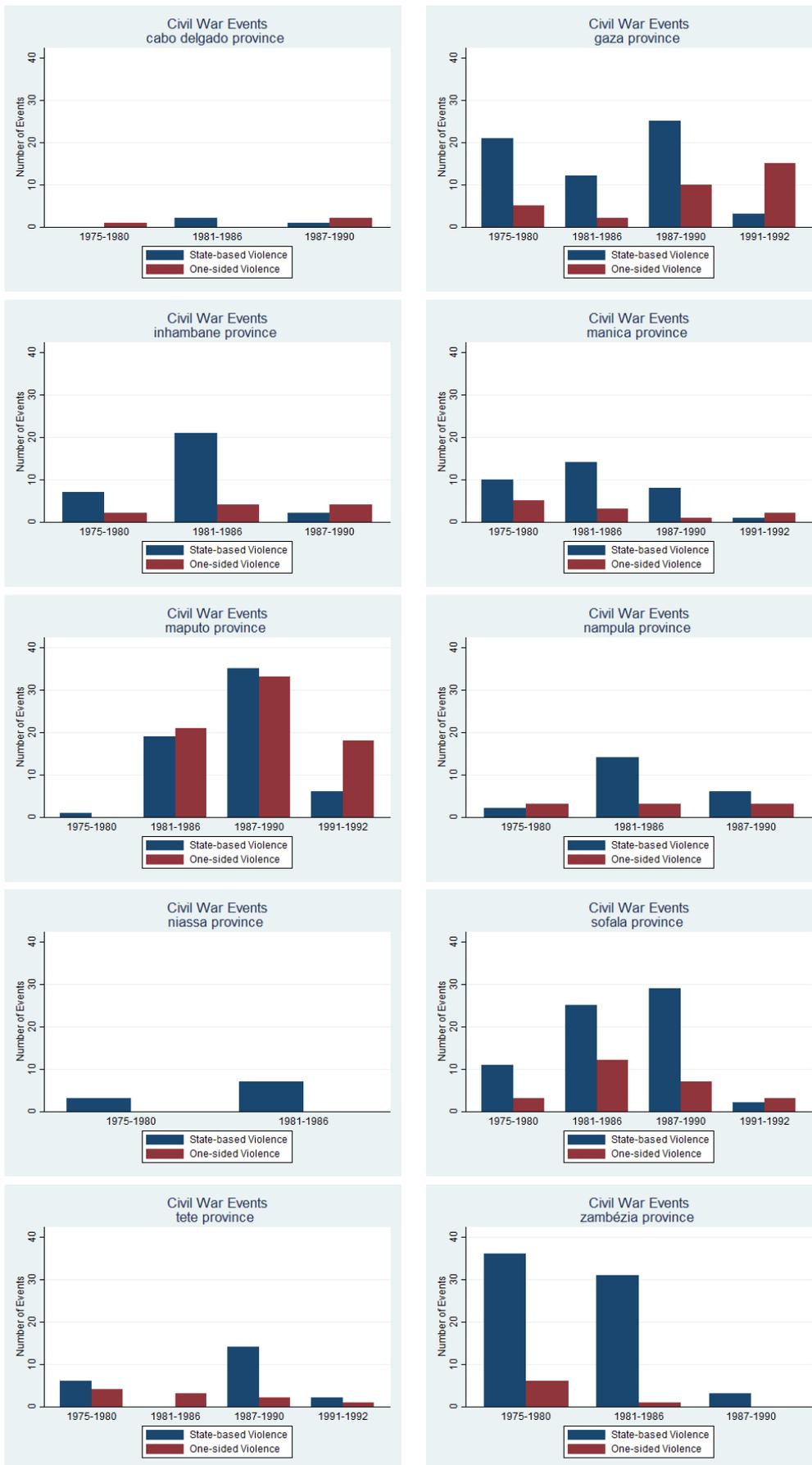


Figure 4: Civil War Evolution by Province

at bleak conditions, with the remaining 3 – 4 million flooding Maputo and domestic refugee camps.⁷ During the war, hundreds of thousands of displaced Mozambicans were put in special tortures camps. Thousands of children were taken hostage and recruited as child soldiers while tens of thousands of women suffered from rape and mutilations.⁸ Watch (1992) estimates that 200,000 children were left orphaned. The war also resulted in an environmental catastrophe; the population of cattle and other domesticated animals fell by more than 80% and wildlife also declined. The situation in 1993 and 1994 was devastating; Mozambique was arguably the poorest country in the world, kept afloat only with foreign aid (Ronco (1996)).

An appalling description of the Mozambican situation at the end of the world is effectively resumed by (Watch (1992)): *“Most of the country’s economic infrastructure is destroyed or inoperable, and much of the population is dependent on a massive international aid program. Hundreds of thousands of people are refugees in neighbouring countries or displaced inside Mozambique. Many rural areas have been reduced to a stone age condition, without trade or modern manufactured goods, education or health services, and suffering from constant insecurity. Mozambique needs to be built almost from scratch.”*

⁷UCDP places the number of refugees in neighboring countries to 1.5 million and the number of internally displaced people to 3 million.

⁸Watch (1992) writes: *“The mutilation of civilians, by cutting off ears, noses, lips and sexual organs, and by mutilating corpses, has been one of the most characteristic abuses of the war in Mozambique.”*

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Landmines and Spatial Development

Appendix II

History of Landmine Clearance ^{*}

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Abstract

This appendix presents a detailed account of the demining operations in Mozambique. Mine clearance in Mozambique was a difficult, 24-year-long task that involved the government, the main warring parties, several international NGOs, commercial operators, international agencies (United Nations), and donor support. The section is organized along the three phases of landmine clearance: *(i)* initial phase (1992 – 1999); *(ii)* limited coordination phase (2000 – 2007); *(iii)* completion phase (2008 – 2015).

^{*}Additional material can be found at www.land-mines.com

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Contents

1	First Phase (1992-1999)	3
1.1	Initiation (1992-1994)	3
1.1.1	Conditions in 1992	3
1.1.2	Demining Programmes/Operators	5
1.1.3	The HALO Trust/UNOHAC Mine Survey of Mozambique 1994	6
1.1.4	Demining	12
1.2	Consolidation Phase 1995-1999	12
1.2.1	Conditions after the 1994 Elections	12
1.2.2	Landmine Clearance	14
1.3	Summary	15
2	Second Phase 2000-2007	17
2.1	Conditions and Initial Developments	17
2.2	The Mozambique Land Mine Impact Study (MLIS 2001)	17
2.2.1	Key Findings	18
2.2.2	Criticisms	20
2.3	Progress on Landmine Clearance. First Mine Action Plan (2002-2006)	21
2.4	Set-backs	23
2.5	Summary	25
3	Third Phase 2008-2015	25
3.1	Conditions. Second Mine Action Plan (2008-2014)	25
3.2	Landmine Clearance	28
4	Timeline of Mine Action in Mozambique	30
4.1	First Phase (1992-1999)	30
4.2	Second Phase (2000-2007)	32
4.3	Third Phase (2008-2015)	35

1 First Phase (1992-1999)

1.1 Initiation (1992-1994)

1.1.1 Conditions in 1992

Demining planning and operations start with the signing of the General Peace Accord in Rome of October 4, 1992, ending conflict between FRELIMO and RENAMO. After more than thirty years of warfare (war of independence and civil war), dealing with landmine contamination was considered a pillar for the peace building process. The two warring parties, FRELIMO and RENAMO, agreed with the Peace Treaty that they would take an active role in landmine clearance activities. To implement the obligations of the agreement, the United Nations established an Operation in Mozambique (UN-OMOZ). This was a peace-building operation, involving 6,400 soldiers and UN workers, that oversaw the transitional period leading to the first elections in the fall of 1994 (United Nations Development Programme (2016)). *“UNOMOZ helped to monitor and verify: the cease-fire; the demobilization of armed forces and paramilitary groups; the collection, storage, and destruction of weapons; and the withdrawal of foreign troops” (United Nations (1995)).*

Among its other duties, UNOMOZ *“mandate was to work with the national authorities and coordinate the surveying of contaminated areas and clearance” (GICHD (2005)).* A preliminary landmine action plan, with funding from the international community (United States, France) was developed in late 1992; however, FRELIMO and RENAMO agreed with the plan’s provision almost a year later, in November 1993 (GICHD (2004)). And *“even after agreement with the plan, beurocratic tangles slows the preparatory phase.” (Roberts and Williams)* Conditions in the country were devastating; millions of refugees and internally displaced people were trying to return to their birthplace towns/villages, poverty was rampant, and the country’s countryside lacked any state authority. As an early Human Rights Watch (1992) report, put it *“parts of the country had returned to stone-age conditions.”* At the same time, there was still violence and insecurity. The peace accord looked fragile as militias, rebel groups, and thugs were still operational. Reports specified that RENAMO not only didn’t assist in landmine clearance (by providing information on the location of minefields), but it continued planting landmines close to their main bases in Gorongosa in central Mozambique (HRW (97)). UNOMOZ aim for the emergency operations was establishing a *“well-defined prioritization processes during the initial phases of demining, focusing particularly on clearance of transport routes” (OReilly, Friedman, Dinsmore, Storr, and MacPherson (2012))* for the repatriation of refugees and internally displaced people (Smith (1996), GICHD (2005)). The United Nations Organizations for Humanitarian Assistance Coordination (UNOHAC) estimated that, in the first years of demining operations, there were approximately 2 million landmines across the country (Millard and Harpviken (2000)), though this number was soon revised to 1 million.

1.1.2 Demining Programmes/Operators

Several international and African NGOs and commercial operators established bases in Mozambique to assist with landmine clearance (GICHD (2004)). After some back and forths, three main demining programmes morphed across the main Mozambique regions: The HALO Trust's programme in the Northern Provinces, the Norwegian People Aid (NPA) programme in Tete and other Central region, and the United Nations Development Programme (UNDP) in the form of the Accelerated Demining Programme (UNADP) in Maputo province and other Southern provinces.

- **South - United Nations.** Upon the conclusion of hostilities, UNOHAC established a mine clearance training centre in Moamba, between Maputo and the South African border (Komatiport), to train demobilized soldiers in demining. In July 1994, the UNDP initiated the Accelerated Demining Programme (ADP) modelled along the Cambodia's Mine Action Centre with German government's financial and technical support. The UN-ADP established itself as the main demining actor in the Southern provinces covering Maputo, Inhambane, and Gaza. UNADP focussed on training staff and by 1998, it appeared staffed (employing 500 deminers), funded and ready to proceed with clearance. The United Nations initially wanted to be directly involved with landmine clearance across the country. But donors appeared skeptical; and soon the ADP contracted with commercial firms to clear specific areas mostly in the South.
- **North - HALO Trust.** The HALO Trust, a Scotland-based British and American NGO, became the major demining operator in the Northern Provinces. With funding from Japan, the United States, and the British Overseas Development Administration, Halo Trust started operating in 1994 in Zambezia. The following years it expanded its operations northwards, in Niassa (1995), in Cabo Delgado (1996), and in Nampula (1997). By 1999 Halo Trust was employing close to 200 deminers and supervisors (United Nations Development Programme (2016)).
- **Centre - NPA and HI.** The NPA was the first operator to build demining capacity as early as 1992. The NPA had been running development programmes in the Tete province (bordering Zimbabwe) since the mid-1980s, well before it officially began demining operations. NPA's work was concentrated in the central regions of Tete though later it expanded to Manica and Sofala. The United Nations Human Rights Council (UNHRC) co-financed with the Norwegian government NPA's operations during their initial years, as clearance focused on facilitating the return of refugees from Malawi (around 1 million) and Zimbabwe (around half a million). By 1994, NPA had trained two 32-person teams (US Department of State (1994)). Handicap International (renamed in 2018 Humanity & Inclusion (HI)), an international network focusing on inclusion and assistance of people with disabilities, also played a key role in the Central provinces. HI started mine action in Mozambique in 1992 with a focus, however, on Mine Risk

Education (MRE) and victim assistance rather than on clearance. HI opened orthopedic centres with the Red Cross across the country (United Nations Development Programme (2016)). In 1994 – 1995, HI run large awareness campaigns across the country with funding from the US Army’s Humanitarian Demining Programme. Together with local organizations, it called for the destruction of stockpiles of landmines, as (at the time) it looked likely that their use will continue (HRW 97). HI started demining activities in 1998 in Inhambane.

- **Other Players.** A few commercial operators also established bases in the country after the end of hostilities (1993 – 1994). Commercial companies signed contracts with the government, the United Nations, and USAID and played a key role in the early stages. For example, Gurkha Security Guards (GSC), a British company, was awarded a pilot program to clear areas in Central Mozambique with the financial backing of the European Union (HRW 97). Mechem (Minerva), a South African firm began the clearing of roads in 1994 using vapor detection technology (with financial support from South Africa). MineTech, a Zimbabwean firm, cleared roads, powerlines and railroads in FRELIMO-controlled areas in Manica and Sofala (United Nations Development Programme (2016)). RONCO used canine detection to clear roads in Morrumbala in Zambezia and in Tete. *“From May 1994 through July 1995, RONCO cleared 2,177 kilometers of roadway in Central Mozambique with 84 deminers and 32 mine dogs/handlers”* (Ronco (1996)).

The geographical focus of the three largest players (with HALO Trust working exclusively in the North, NPA in the Center, and UNADP in the South) arose from a situation of non-coordination. HALO established itself in Zambezia to support British NGOs (Save the Children, Oxfam, and later Trocaire) and then expanded its activities to the other Northern Provinces, north of the Zambezi river that effectively cuts the country. NPA focused on the central Provinces, locating itself in Tete, as it was running already a development programme there during the civil war. Likewise, HI presence in the central provinces dates back to 1986, when they were providing orthopedic assistance, physiotherapy, and rehabilitation to landmine victims. UN ADP focused on the southern Provinces around Maputo because this is where the initial UN mission was located, as security concerns were not that high in the South. As observed by the Geneva International Centre for Humanitarian Demining (GICHD), *“the division of the country into three distinct regions complicated the task of national coordination, but it also minimized concerns over duplication and unhealthy competition among the three large “humanitarian” operators”* (GICHD (2005)).

1.1.3 The HALO Trust/UNOHAC Mine Survey of Mozambique 1994

The UN mission, donors, and development agencies soon realized that one of the main challenges was lack of information of the spatial distribution of landmines and unexploded ordnance (UXO’s). Hence, in late 1993, after numerous negotiations with RENAMO and the FRELIMO government that were delaying the process, UNOHAC contracted HALO Trust to conduct the first national,

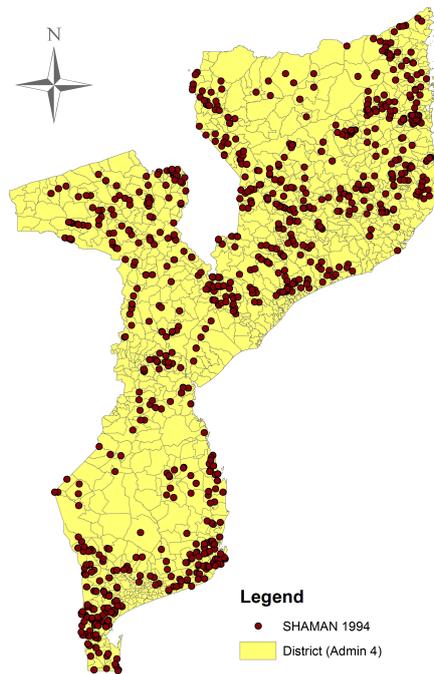


Figure 2: SHAMAN Survey

comprehensive survey of the extent of Explosive War Remnants (EWR) contamination. The United Nations Development Program (UNDP) provided funding (470,000 USD contract). The goal was to compile a list of suspected hazardous areas (SHA) that would be then used to target clearance operations.¹ In less than six months, “*six teams in a total of 55 vehicles covered over 110,000 kilometers of roads and tracks*” (Halo Trust (2007a)) in all 10 provinces. The HALO Trust team conducted interviews with locals, NGO workers, former combatants and civil administrators to assess the problem. The teams compiled a set of Impact Survey (IS) reports that gave details on suspected of contamination areas (SHAs); these geocoded reports were then stored in the SHAMAN (System for Humanitarian Assistance MANagement) database.²

Key Findings The HALO Trust team detected 981 SHAs. The suspected hazardous areas ranged from small stretches of tracks enclosed by a single (suspected) mine, to large minefields with hundreds (perhaps thousands) of mines and unexploded ordnances (UXOs). The survey revealed that land mines were widely dispersed across Mozambique. However, details of the extent of and exact location remained unclear. Figure 2 depicts the spatial distribution of the SHAMAN survey across the country, while Figure 3 zooms in the Niassa (North) and Sofala (Center) provinces. The reports recorded information about location characteristics, person(S) interviewed, and GPS information about the

¹The main objective was to “provide an overall assessment of the landmine situation in Mozambique for the benefit of all organizations and agencies”.

²We are thankful to HALO Trust for providing us the original data of the 1994 report.

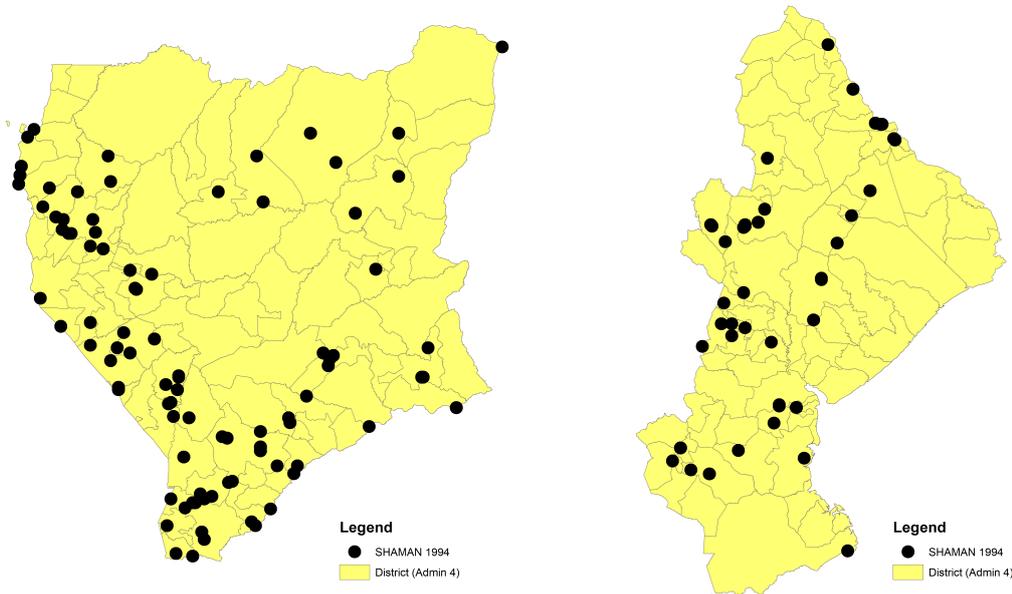


Figure 3: SHAMAN Survey: Niassa and Sofala Province

suspected of contamination area. Figure 4 reproduces a page of the entries in the Halo Trust Report. In some instances, a hand-written map was attached. However, even the HALO Trust that conducted the survey have not kept track of these maps. However, going over the United Nations archives (in New York City) we managed to extract the hand-written maps, as well as retrieve the original reports that in some instances provide more details. Figure 5 and Figure 6 give two examples. Typical entries from the HALO Trust (SHAMAN) dataset read as follows:

- *Chibabava, Chibabava District, Sofala Province*: “Information reported by Mangude RAA camp commander. AP and Anti-Group (AG) mines known to have been laid beside and on N1 road (main highway). Many exploded during rehabilitation but many more are left. Laid by FRELIMO.”
- *Machado, Mandiba District, Niassa Province*: “Sapper Agistnho Nimala (resident). Abandoned school with one AP in front of each of the doors facing the road. RENAMO used to sleep in school while waiting to ambush traffic on the road.”
- *Murraca, Caia District, Sofala Province*: “Information provided by MSF (Doctors without Borders). A mine accident was registered around the Air Strip of Murraca. Number of mines is unknown.” (see map in Figure 5).
- *Chioco, Changara District, Tete Province*: “Information from Diogo dos Santos (RENAMO

SOPALA

District	Location	Date	Reported by: MSF CAIA
CAIA	CAIA	12/01/94	Map Sheet: 60 Grid Reference: 36K 7-48-4 E 80-28-1 N Latitude: 17° 49.20' Longitude: 35° 2.40'
Types: UNKNOWN			Date Laid:
No of Mines: UNKNOWN			
Laid by:			

Source: MSF - Caia

Reported Mines: Chemba - main road Sena - military area Caia

Suspected Mines: Suspected area are Chemba - Murraca - Sena

District	Location	Date	Reported by: MSF - CAIA
CAIA	CAIA	12/10/93	Map Sheet: 60 Grid Reference: 36K 7-48-8 E 80-27-5 N Latitude: 17° 49.80' Longitude: 35° 3.00'
Types: AP			Date Laid:
No of Mines: UNKNOWN			
Laid by:			

Source: MSF France - Caia

Remarks: About 20 metres from the main road, around the Rio Zungue bridge entry of Caia sede

District	Location	Date	Reported by: HALO TRUST (TF-B)
CAIA	CAIA	01/05/94	Map Sheet: 60 Grid Reference: 36K 7-48-8 E 80-27-5N Latitude: 17° 49.80' Longitude: 35° 3.00'
Types: UNKNOWN			Date Laid: UNKNOWN
No of Mines: UNKNOWN			
Laid by: FRELIMO			

Source: Locals on site. UN Assembly Area.

Reported Mines: Strip of mines on west side of town.

Suspected Mines: Suspect area near the new ferry terminal.

Remarks: May be more locations here, but ongoing security situation prevented clarification.

District	Location	Date	Reported by: HALO TRUST (TF-B)
CAIA	CASA DO JOEL	02/05/94	Map Sheet: 60 Grid Reference: 36K 7-38-2 E 80-40-2 N Latitude: 17° 42.60' Longitude: 35° 3.00'
Types: AP POSS AG			Date Laid: UNKNOWN
No of Mines: UNKNOWN			
Laid by: FRELIMO			

Source: Local villagers on site.

Reported Mines: Small broken outbuilding reported to be surrounded with AP mines.

Suspected Mines: Locals suspect area either side of road near large church at this grid.

District	Location	Date	Reported by: MSF - CAIA
CAIA	MURRACA	23/10/93	Map Sheet: Grid Reference: Latitude: 0° 0.00' Longitude: 0° 0.00'
Types: AP			Date Laid:
No of Mines: 1			
Laid by:			

Source: MSF - Caia

Reported Mines: Anti Personnel mine accident staff of GSG foot injured

Remarks: On the road Murraca - Sena few metres from Murraca

Figure 4: SHAMAN Original Dataset

representative). One Anti-Personnel (AP) mine found at the building site [old hospital] and one AP mine close to the administration building. Locals and Renamo avoid the area due to suspicion of mines around airfield. Laid by Rhodesian forces.” (see map in Figure 6).

The majority of SHAs were located in the south and centre of the country. The most seriously affected provinces were Maputo, Inhambane, Manica, Zambezia and Tete (Halo Trust (1994)). The survey corroborated UN’s earlier assessments that all 28 major road segments were mined (US Department of State (1994)). For example, the HALO Trust report verified the heavy mining of the main highway connecting Maputo the Centre (EN1) in Inhambane. The Survey also revealed that bridges, schools, clinics, and local townhouses were mined. The report suggested that the majority of dams, railway lines, electricity substations and powerlines should be assumed to be contaminated (Halo Trust (1994)). HALO Trust’s survey reduced the initial UNOHAC estimate of millions of land mines to a few hundred thousand (Millard and Harpviken (2000)). The survey rightly stressed that the issue is not the actual number of mines, as even a few mines can be hugely detrimental to economic and social activity (see also Vines and Thompson (1999) and HRW (1997)).

Criticisms The HALO Trust report provided an overview of the problem of contamination in the demining community. However, it was heavily criticized for a number of reasons. First, the survey arguably underestimated the extent of contamination. This was inevitable, as the HALO Trust did not claim to cover every area in Mozambique nor did it suggest that every piece of information was reliable (Halo Trust (1994)). Although the survey teams covered over 110,000 km of roads and tracks, some areas were inaccessible. For example, the Chinde district in Zambezia could not be reached by vehicle. Second, given the size of the country, the team was evidently understaffed. The United Nations pushed for a quick completion of the survey, making it even harder for the surveying team. Third, conditions were truly chaotic, marked by millions of refugees and internally displaced people trying to return home, violence, and insecurity. Fourth, many organizations that had laid mines (notably RENAMO and other militias) were not particularly collaborating. This was especially the case in Central provinces, close to RENAMO main military bases, as the rebel organization was afraid that after clearance the government will move forces. Hence, the quality of provincial reports varied. Fifth, the availability of relevant people to interview with knowledge of landmine placement hindered the quality of the findings. In many instances, landmines were placed ten or even twenty years before the surveying team visited the areas; as such it was close to impossible to get accurate information on the exact location of contamination.

Despite these limitations, the HALO Trust survey and the associated SHAMAN database provided a preliminary assessment of the problem, though “*the survey did not, despite its intention, form the basis of a long-term landmine programme for Mozambique*” (HRW 97). In line with this assessment, a follow-up assessment, funded by USAID, concluded that “more detailed surveys of affected areas were needed to work out a priority list for humanitarian clearance.” However, the report shifted attention

from the total number of mines (“intensive” margin) to the impact on the local community which was considerable even when there were a couple of mines (HRW97).

1.1.4 Demining

Actual demining in the initial phase was limited. On top of the challenges posed by poverty, refugees, and insecurity, clearance operations were delayed as the United Nations Agencies, the government, and RENAMO were involved in tedious negotiations on priorities. Some limited “*uncoordinated mine clearance from both sides occurred across the country during 1993 and the first half of 1994*” (HRW (97)). Data on funding is scant, but HRW estimates that 31.3 million USD was spent for landmine clearance during this period.

The most controversial demining operation was the one awarded by the United Nations to a consortium of Lonrho, Mechem, and Royal Ordnance in May 1994 to clear roads for a cost of 4.8 million USD. The “*Project Caminho*” was heavily criticized internationally, as it involved operators that were manufacturers of landmines and small weapons themselves (HRW (97)) Figure 7 gives a mapping of these interventions using self-collected data from the United Nations Library in New York City (these data were not recorded by national or other authorities as at the time the country lacked any capacity to even monitor developments).

Some demining was completed by RONCO in the central provinces of Sofala and Zambezia under US financial backing (of roughly 4 million USD). 7 below gives the maps provided by RONCO to USAID on its clearance operations in 1993 – 1995. [Again these data were not recorded by the Mozambican authorities and were retrieved from archives].

1.2 Consolidation Phase 1995-1999

1.2.1 Conditions after the 1994 Elections

The first democratic Presidential and Parliamentary elections took place on October 27th – 29th, 1994. The warring factions transformed into political parties in a nascent democracy. It was the first time the country had multiparty elections since independence (in the 1977 elections only FRELIMO participated). The electoral race between Joaquim Chissano, FRELIMO leader, and Alfonso Dhlakama, RENAMO’s leader, brought to the polling stations 88% of the voting-age population. FRELIMO won both the Presidential (53%) and the Parliamentary (44.33%) elections; Dhlakama obtained 33% of the presidential election votes and RENAMO reached a 37% share of the parliamentary votes. The electoral results revealed a divided country. RENAMO managed to secure the relative majority of votes in Manica, Nampula, Tete, Sofala, and Zambezia; while the remaining Southern provinces and Maputo city gave a strong victory to FRELIMO. The newly-elected government highlighted mine action as essential to Mozambique’s recovery. Nevertheless, the effectiveness of the government was curtailed by the weakness of its administrative structures, especially at the local level, and by the

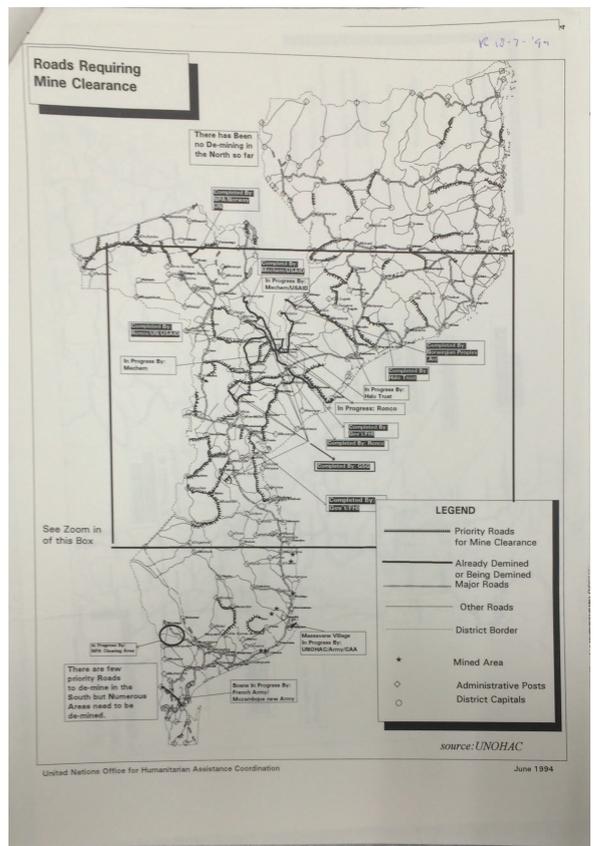
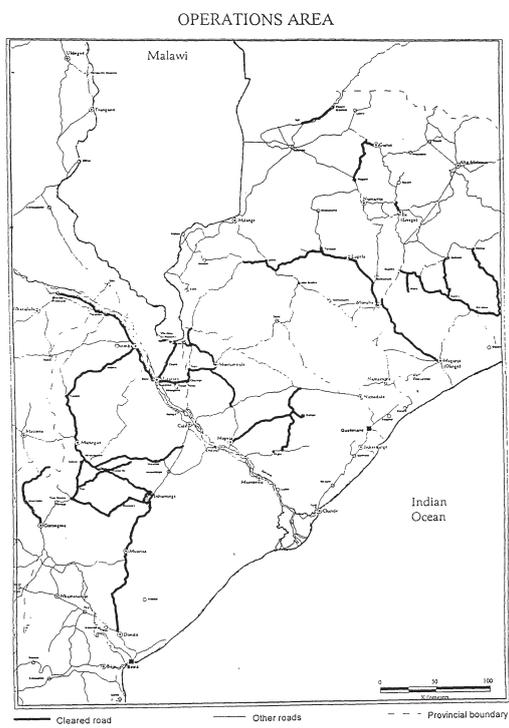


Figure 7: RONCO and “Project Caminho” Maps

termination of the UNOMOZ's mandate.

In 1995 the government established the National Demining Commission (CND). Its mandate was to “*collect, process and analyze information and data relevant to demining, elaborate a strategy and action plan for mine clearance, and establish procedures for setting priorities at the local and national level; monitor and coordinate all ongoing demining activities; act as the approval and licensing authority in respect of a new operator; adjudicate public tenders for service contracts; and promote and oversee the implementation of a national programme to improve public mine awareness*” (GICHD (2005)). The UNDP partly funded the CND (1995 – 1999) by providing 3 – 5 technical demining advisors in addition to US\$ 1 million. Moreover, the UN earmarked US\$ 12 – 14 million for mine related activities (?). However, it took more than a year for the commission to meet; and it was apparent that it had virtually no capacity (GICHD (2004)). It began operating in 1996, but its workers, though less than 10, first got paid in 1997. CND was unable to establish its oversight role. A July 1996 US diplomatic cable states “*the CND has failed to develop, as expected, is poorly led, and has yet to produce a long-awaited national demining policy.*” (HRW (97)). Donors were dissatisfied and the CND was eventually closed.

Some progress was made by the signing of the Anti-Personnel Mine Ban Convention in 1997, a milestone global treaty that required signing parties to stop manufacturing and using antipersonnel landmines (though anti-tank mines were excluded from the ban). According to Article 5, Mozambique committed to remove all known landmines within 10 years. Article 5 mandates each state party to make every effort to identify all areas under its jurisdiction in which anti-personnel mines are known or suspected to be and ensure the destruction of all anti-personnel mines.

1.2.2 Landmine Clearance

Landmine clearance operators proceeded to work with low levels of coordination, reinforcing the regional and provincial divide. The size of the country (more than twice the size of Germany) and the lack of infrastructure isolated demining actors even further.

HALO Trust expanded in all northern provinces; Niassa in 1995 with funding from the Irish Government, Nampula in 1997 with Dutch and US financial assistance, and Cabo Delgado in 1998 with financial backing from the Swiss government (UNDP, 2016). By 1998, “*The HALO Trust was the only humanitarian demining operator working in the north of Mozambique and its programmes stretched across each of the four northern provinces. At its peak HALO Mozambique employed 550 staff*” (Halo Trust (2007a)).

In 1998, the NPA launched a two-year Integrated Demining Programme (NORAD (2009)).³ Handicap International (Humanity & Inclusion) began demining in Inhambane in 1998 after predominantly

³The programme allowed for “small-scale development activities to be performed together with demining to make the side effects of having a large demining team present more positive. Activities could be community education, rehabilitation of infrastructure, construction of improved traditional latrines and drilling of wells” (Knudsen (2006)).

focussing on MRE. It established a tactic of Proximity Demining, focusing in the most-heavily mined province of the country. Proximity Demining entailed the clearance of small sites under 15,000m², aiming at ensuring safe access to land and paths for small communities (GICHD (2012)). Given limited funding, 4 HI teams of 8 deminers were deployed in 1999 to small demining areas close to communities rather than the large-scale action that was commonplace in the North and the South.⁴

The UNADP began operations in Inhambane and Gaza around 1998, deploying 10 to 50-men platoons (United Nations (1998)). Commercial operators' involvement also increased in 1997. Two local NGOs, AfroVida and Necochaminas cleared areas in the South; other international agencies, such as Krohn Demining Enterprise (a German firm) and MAG, a British NGO, got involved. By 1997, 45% of total funding had been assigned to commercial companies (Millard and Harpviken (2000)).

Arguably the most important of the smaller operators was Mine-Tech, a Zimbabwe-based firm, that worked together with the German Development Agency, GTZ, in the Central provinces. In its initial operations, Mine-tech cleared pylons connecting the Cahora Bassa damn to South Africa and then cleared mostly border villages and secondary roads in the border with Zimbabwe. Figure 8 gives one of the operation reports (as provided to us by GTZ director Ulrich Weyl) with an associated map of GTZ-Mine-Tech operation in 1997 in Sambazoka village, Machaze district, in Manica, close to the border with Zimbabwe.⁵

1.3 Summary

Despite all efforts, the progress of clearance during the first period was not meeting initial expectations, partly due to the lack of precise information on the actual degree of contamination, partly due to government's weak state capacity, conflict between the UN and donors (and also between UN agencies), and ensuing violence and insecurity. In spite of donor support and international assistance, it was clear in the late 1990s that the country could not meet its ambitious 10-year deadline to clear all confirmed hazardous areas (CHA) and investigate all suspected hazardous areas (SHA).

The lack of coordination coupled with the desire of the international community and donors to assist brought into the country dozens of NGOs and commercial demining operators. And while some demining did take place, most operations were conducted in an ad hoc manner and without much consideration of the general implications and the big picture. A national demining plan was still missing (GICHD (2005)). The United Nations had left and the National Commission proved unable to centralize the process and accelerate the process of surveying and clearing contaminated areas. The government and NGOs had a fragmented, at best, picture of the problem. According to the director of Mozambique's mine clearance operations in 1997: *"First, we must have a clear idea of what the landmine situation in Mozambique is. We are in the dark about that, and without a sound knowledge*

⁴We are grateful to Aderito Ismael and his colleagues at HI, who provided very useful information and data on HI operations in Inhambane.

⁵We are grateful to Ulrich Weyl for kindly sharing his personal archives detailing GTZ-Mine-Tech's operations and also for patiently explaining the challenges of demining teams at the time.

CONFIDENTIAL

CPD/GTZ/IHD/MARRP DEMINING PROJECT

FINAL REPORT: IHD OPERATION PHASE 2: DEMINING:
SAMBAZOKA VILLAGE: MACHAZE DISTRICT:
MANICA PROVINCE: MOCAMBIQUE.

September 1997

CONFIDENTIAL

(D207)

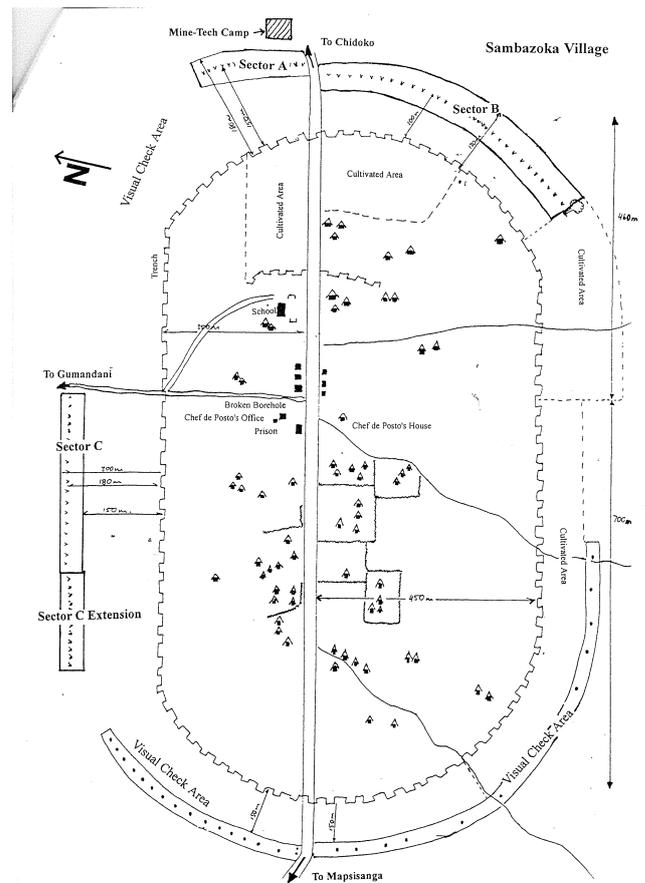


Figure 8: GTZ-Mine-Tech report of Sambazoka operation

of the situation, it is impossible to define a strategy, let alone determine the cost and resources needed for clearance operations” (Human Rights Watch (1997)). In the meantime, other related projects on raising awareness, assisting the wounded, and improving health facilities proceeded. Though data is scarce and not much reliable, all evidence suggests that the number of deaths and injuries from landmines and UXOs declined considerably from 1992-1994 to 1999.

2 Second Phase 2000-2007

2.1 Conditions and Initial Developments

In late 1998, the National Mine Clearance Strategy Approach suggested that a new governing body of the mine action programme should replace the CND to enable greater coordination (United Nations Development Programme (2016)). The National Demining Institute (IND) replaced the CND after the council of ministers approved decree 37/99 in June 1999 (GICHD (2004)). The IND had some autonomy and could bypass cumbersome procedures and red tape. It established two provincial offices (on top of the headquarters in Maputo), one in Nampula in the north and the other in Sofala in the centre to coordinate with the HALO Trust and NPA teams, respectively.⁶ IND aimed at *“successfully establishing and developing coordination, supervision and management mechanism, in close cooperation with all other relevant organizations and agencies, to ensure the cost-effective execution of a national mine-action plan”* (GICHD (2005)). Donor funding increased (from approximately 6 – 8 million per year in 1993 – 1996) to more than 14 million during 1999 – 2004. The IND started coordinating the demining efforts and it is no coincidence that landmine clearance accelerated during the early years of the second phase, 1999 – 2003 (GICHD (2005)).

2.2 The Mozambique Land Mine Impact Study (MLIS 2001)

However, the true extent of contamination was yet to be known with certainty. The SHAMAN database was not used by demining operators, as it entailed various flaws and shortcomings (for example the hand-written maps were lost). In an attempt to address this issue and meet the requirements of the Anti-Personnel Mine Ban Treaty of 1997, the IND (with funding from the Canadian International Development Agency) commissioned the Canadian International Demining Corps (CIDC) and Paul F. Wilkinson & Associates to conduct a nationwide survey of the landmine situation and its impacts. Fieldwork began in March 2000 and the survey was completed in August 2001.

During this period the survey teams collected expert opinions and conducted group interviews with 6,772 locals aiming to *“collect, records and analyze information on the location of known or suspected mined areas throughout the country and provide an overview of their social and economic*

⁶The IND’ mandated was to “coordinate and oversee the implementation of all mine action program, including quality assurance and information management (data gathering, mine action database maintenance and information dissemination)” (National Institute of Demining (2008)).

impacts as perceived by the residents of landmine- affected communities” (Canadian International Demining Corps (2001)). The survey findings were stored in the Information Management System for Mine Action (“IMSMA”). This database “*constituted the basis for Mozambique authorities to define priority targets for mine action*” (Canadian International Demining Corps (2001)).

2.2.1 Key Findings

In a broad sense, the MLIS reaffirmed the main message of the 1994 SHAMAN Report. Landmine contamination was more extensive than intensive; most importantly landmines were having substantial adverse impact on local communities almost a decade after the civil war ending (Canadian International Demining Corps (2001), Scan Team (2003), GICHD (2013)). Figure 9 shows the spatial distribution of suspected and confirmed hazardous areas recorded in the MLIS survey; Figure 10 zooms on Niassa and Sofala provinces. Landmines affected all 10 provinces and 123 out of the 128 districts (admin-2 units). The MLIS identified 791 landmine-affected villages and 1,374 suspected hazardous areas (SHAs) spanning an area of 562 square kilometers. The majority of affected villages and towns (768) were in the south-east of the country. The provinces of Inhambane, Maputo and Zambezia were found to have above average landmine-affected villages. SHAs affected 1.5 million people (approximately 9% of the 1997 population). Inhambane alone accounted for one quarter of all affected persons, recording also the highest number of affected communities (157 villages). Gaza, Niassa, Sofala and Tete tended to have numbers below the national average. Niassa reported the lowest number with only 40 affected villages. The data illustrated that, while an overwhelming number of landmines was discovered, their contamination was not as intense as previously suspected. Over half of landmine-affected communities reported only one SHA. Only 63 reported more than 4 SHAs, demonstrating that the sheer presence of landmine contamination outweighed the importance of the actual number of mines in an area. A typical entry from the MLIS dataset contained information on the location (e.g., GPS), the reason why the location was affected (civil war incident or developments during the war of independence), the population of the affected village, and an assessment of the impact of contamination. For example:

- *Ponte Nova in Mecutine, Nampula Province.* “The suspected area is located 3 km away from an area known as Ponte Nova, along the N8 road. Several mine accidents were reported and a mine is visible. It is consider of Medium Impact and agriculture blocked. 1081 people affected.”
- *Antigo Quartel in Catuane, Maputo Province.* “Rodrigues Ossomane, who mined the area, informed us about the presence of land mines. It is judged of Low Impact, affecting a population of 96 people. Road and agriculture were blocked.”
- *Unsicane in Matiquiti, Cabo Delgado Province.* “Interviewers saw a mine. Impact considered high. 3,493 people affected. Agriculture blocked.”

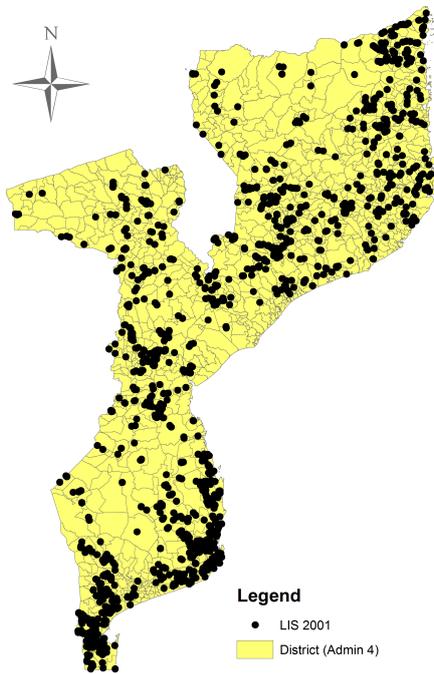


Figure 9: LIS 2001 Survey

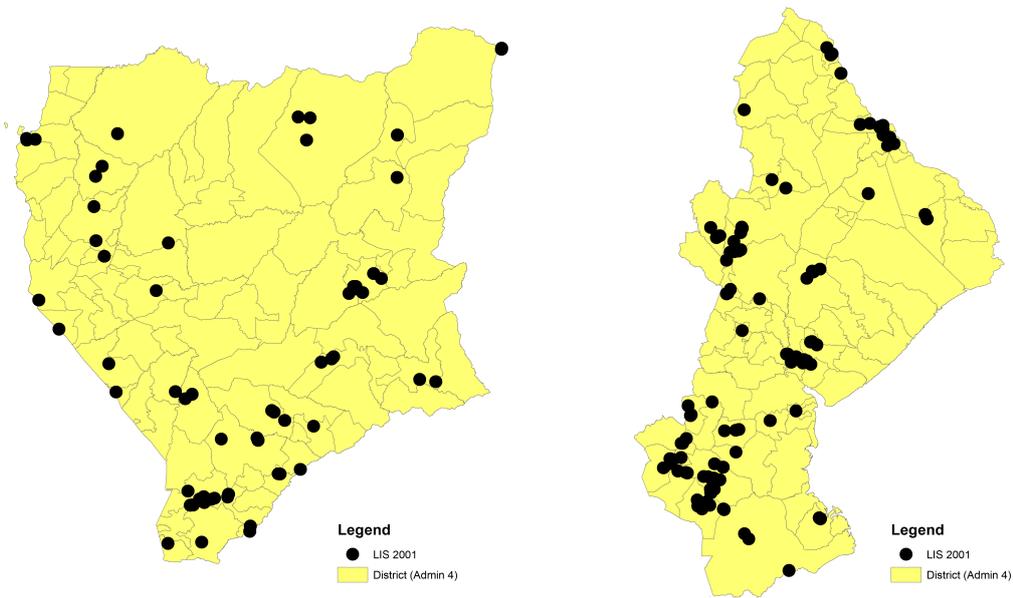


Figure 10: LIS 2001 Survey: Niassa and Sofala Province

- *Rio Djuni in Maubica, Niassa Province.* “Informed by HI about land mines contamination. Access to water blocked. Low impact and 1,401 people affected.”
- *Thomo in Ressano Garcia, Maputo Province.* “Several mine accidents. During survey, landmines were spotted and danger signs were present. Agriculture was judged to be blocked. Impact considered Low. People affected 7,345.”

The MLIS identified blocked land access in all provinces. Agricultural land was inaccessible for 464 villages/towns. For example, in Maciana (Maputo province) and Meculane (Cabo Delgado) contamination during the civil war was preventing the development of agricultural activities. Blocked access to non-agricultural land, such as land for hunting, firewood collection was widespread with the exception of some areas in western Nampula, northern Niassa and Gaza and north-western Inhambane. 180 villages were impacted by this restriction. Restricted roads and paths were evident in 231 villages across all provinces. In addition, access to infrastructure was blocked in landmine-affected communities. This occurred mostly in Zambezia, Inhambane and Maputo. Access to drinking water was generally sufficient; only 55 communities in Maputo and Inhambane reported restrictions to their access.

The landmine-affected communities were assigned a landmine-impact score, as a means to prioritize areas for mine action. The scores were established through consideration of a number of factors, including blocked access to facilities, the number of victims and whether SHAs were clearly marked. Landmines in the vast majority of affected villages (76.7%) were considered to have a low impact affecting 1.1 million persons, the majority of which were located in Inhambane. 164 affected villages identified landmines to have a medium impact affecting 393,000 people. Maputo had the largest number of modestly affected villages. With the exception of Niassa, every province had an affected village with a high impact score accounting for 2.5% of all affected communities. The SHAs in these 20 villages impacted 36,000 persons.

2.2.2 Criticisms

The MLIS has been criticized on a number of accounts. The representativeness of the survey compromised the validity of the findings. The MLIS did not survey all areas of Mozambique, as survey teams were not able to access many communities (Wilkinson and Masella (2003)). Villages in Niassa and Sofala were inaccessible, and thus, landmine-affected communities may have been present, but their plight was not recorded.⁷ Mozambique suffered the largest flooding in 50 years during 2000 – 2001.⁸

⁷Discrepancies between the MLIS and the HALO Trust survey emerged after publication particularly in the areas where HALO Trust was active (GICHD (2004), Scan Team (2003)). A difference of a factor of three between the number of SHAs identified by the HALO Trust and the MLIS was discovered. For example, in Zambezia, the HALO Trust reported a total of 46 SHAs while the MLIS recorded 200 (GICHD (2004)).

⁸Cyclone Eline in late February 2000 and Cyclone Hudah in mid-April 2000 affected the lives of close to 2 millions of people in the Southern provinces of Gaza, Maputo and Inhambane. The cyclones killed about 600 and displaced more than 200,000. A major flood also occurred early 2001 in the Central-East.

The floods disrupted demining momentum, stressed the capacity of government, and significantly impacted the MLIS. The independent report by Government of Mozambique (2008) summarizes the key challenges: “*The large size of Mozambique and the absence of a functional road network in much of it, extensive flooding in parts of the country in 2001, the widespread distribution of mine-affected communities, the absence of an accurate national gazetteer (i.e., official listing of communities and their geographic coordinates), the lack of accurate maps in appropriate scale, the impossibility of applying in its entirety the SAC protocol for false-negative sampling, and, the nature, availability and quality of expert opinion.*”⁹

2.3 Progress on Landmine Clearance. First Mine Action Plan (2002-2006)

Despite its limitations, the MLIS was considered the most comprehensive landmine survey across the world at the time. The MLIS data enabled the IND to design the first National Mine Action Plan (NMAP 2002–2006). Its main objective was to achieve a “landmine-free” Mozambique within 10 years, by 2011 (GICHD (2005)); the NMAP also envisioned the clearance of all high-to-medium impact areas by 2006. MLIS setup 6 main objectives; increasing demining coverage, conducting nationwide technical surveys, implementing quality assurance, increasing landmine clearance capacity¹⁰, and improving victim assistance (GICHD (2004), GICHD (2005)). Figure 11 shows the distribution fo HALO Trust intervention on the Tanzanian border between 2003 and 2006.

As a result of improved information and a more efficient institutional structure, the main operators accelerated their operations. The HALO Trust continued its clearance operations in the Northern provinces. In 2003 the US government funded HALO Trust’s three-year operation to clear large Portuguese-laid minefields from the colonial era. “*This project would ultimately lead to the clearance of more than 80,000 mines and would be successful in clearing the country’s biggest barrier minefield*” (Halo Trust (2007a)).

The NPA had also expanded to around 500 deminers, employing, among others, workers with foreign expertise (United Nations Development Programme (2016)). “*NPA’s work in the province as a whole has gradually shifted from the emergency aid required in the initial years after the Peace Accord (1992-1997), when thousands of people returned to their homes with little to live on, to development assistance designed to equip the people with the means and capacity to fend for themselves on a sustained basis*” (Norwegian Peoples Aid (2002)). Figure 12 shows the distribution fo NPA interventions between 2002 and 2004.

Smaller players also continued demining, mostly in the Southern provinces contracting with the

⁹The IND “*stated as a priority from 2003 to get a better picture of the mine problem in the country. By this, it acknowledged that the survey from 2001 did not reveal the true picture*” (Knudsen (2006)).

¹⁰A Danish government-funded project enabled the UNDP to assist Mozambique in capacity-building (GICHD (2004), United Nations Development Programme (2016)). Handicap International (Humanity and Inclusion) also participated in indigenous capacity building, passing many of its victim assistance responsibilities to the IND (United Nations Development Programme (2016)).

Accelerated Demining Program. Afrovita continued with road clearance, MgM, a German NGO began mine clearance of electricity pylons close to Maputo in 2000 – 1 and Mechem was assigned clearance of the Massingir Dam in Gaza. The armed forces of Mozambique (FADM) also undertook humanitarian demining operations in Niassa, Nampula, Sofala, Gaza and Maputo (National Institute of Demining (2013)). APOPO, a Belgian-Tanzanian organization started working in 2004 initially testing its rat-based survey approach and subsequently assisting HI.

2.4 Set-backs

The period of perceived progress came to a halt in 2004.¹¹ The mine action programme suffered a blow of confidence due to scandals, a depletion of funding and the withdrawal of the main demining operators. In 2003 – 4 the Adopt a Minefield charity, established in 1999 with the aim to engage the US civil society in landmine clearance in Mozambique, was involved in a major corruption scandal, implicating, among others, the head of the NPA and officials from the UNDP and IND (GICHD (2012), United Nations Development Programme (2016)). A further scandal involving IND funds and its director erupted leading to donor fatigue for mine action. Furthermore, criticisms of the IND undermined its credibility: *“although performing far better than the former NMCC/CND, IND has as yet been unable to establish fully adequate coordination to ensure the activities of the humanitarian operators are consistent with an overall national plan for mine action”* (GICHD (2005)).

In 2005, UNDP’s capacity-building programme with the IND terminated without being renewed; this weakened considerably IND’s capacity, at a time when its operations were improving. Corruption coupled with the evident inability of IND and the administration to meet the targets of five-year Mine Action plane by 2006, led to donor fatigue (United Nations Development Programme (2016), GICHD (2012)). At the same time, the IND was receiving reports from operators and local administrators of highly contaminated areas and uncovered by the MLIS contaminated sites. *“All of these factors contributed to failing donor support for mine action -from almost US\$ 23 million in 2002 to US\$ 17 million, 7.5 million and 4 million in 2005, 2006 and 2007, respectively”* (GICHD (2012), GICHD (2012)).

Central Provinces As a consequence of the donors’ withdrawal, demining operators began to cease activities. The NPA that was the major demining operator in the Central provinces announced

¹¹By 2005, a report reviewing 10 years of mine action in Mozambique accredited the achievements made thus far. The Geneva International Centre for Humanitarian Demining suggested that *“significant progress has been made in terms of clearance and, more broadly, in generating a better picture of the extent and precise location of suspected hazard areas”* (GICHD (2005)). According to the GICHD (2005) report, although the humanitarian impact of landmines had been greatly reduced, Mozambique would not be free of mines in the near future. It suggested that *“there is a need for greater leadership on the part of the Government of Mozambique to address the underlying issues that might lead to donor fatigue by formulating a national strategy for long-term mine action, increasing accountability and transparency”* (GICHD (2005)). This was evident in the execution of the NMAP 2002-2006. It exaggerated its predictions and was therefore largely ignored by the main operators; the *“independent operators have not always adhered to the government’s plans”* (O’Reilly, Friedman, Dinsmore, Storr, and MacPherson (2012)).

that it would close operations in 2005. “NPA started discussing how to perform a phase-out of the programme and whether to leave something behind. Among the alternatives discussed was a small fire brigade-like organization with a capacity of some 50 deminers or a larger one including mine-detection dogs. An Exit Strategy 2003-2007 was formulated in late 2003, planning for the termination of operations by late 2006” (Knudsen (2006)). “By the end of August 2005, all remaining manual deminers were dismissed as part of the phase-out” (Knudsen (2006)) and the operator left in 2006 “leaving a hole in the centre of the country” (GICHD (2012)). Before its departure, the NPA conducted a Task Impact Assessments (TIA) of all the provinces it had worked on.¹²

The IND requested Handicap International (Humanity and Inclusion) to expand its operations from Inhambane to Manica and Sofala. In spite of its limited capacity, HI surveyed all three central provinces (Inhambane, Manica and Sofala) to confirm or cancel suspected hazardous areas; it also identified new SHAs (GICHD (2013), United Nations Development Programme (2016)). Over a period of two years, HI worked in roughly 750 sites, in which many mine clearance tasks were cancelled due to insufficient evidence of contamination. The majority of sites that required clearance were newly reported ones, suggesting that the up-to-that-point survey data were incomplete. The survey “identified nine million km² of 651 previously unknown suspected hazardous areas plus roads” (GICHD (2012)).

Southern Provinces Things were not better in the South, as ADP entered a severe crisis. ADP workers struck over unpaid wages. “In the summer of 2005 UNDP ceased its Accelerated Demining Programme. This had been imagined as the only large actor to remain active upon departure of the international NGOs. The ADP staff made an attempt to create a new organization, but did not obtain funding” (Knudsen (2006)). The UNDP terminated its capacity-building project with the IND and consequently the IND lost trained and educated staff (GICHD (2012), GICHD (2012)). As donor support dwindled, commercial operators terminated activities in the mid-2000s. For example, MgM closed their activities in 2003 and RONCO in 2006 (Government of Mozambique (2008)).

Northern Provinces In contrast to the negative developments in the Southern and the Central provinces, the second phase of demining concludes with good news from the North. HALO Trust had progressed with landmine clearance and managed to conclude its operations by 2006. As the task of freeing the Northern Provinces was in sight, HALO Trust announced plans to leave Mozambique in the end of 2006 (Halo Trust (2007a)). Before leaving, on request of the IND, the HALO Trust conducted

¹²While it was not a comprehensive survey, it re-surveyed the MLIS-identified suspected hazardous areas in districts it had worked in. Information on the “local communities and the history of the area is collected from villagers, landowners and land users, the municipal and county authorities and other humanitarian and development actors through interviews and discussion. This helped governments, donors and operators to make more informed decisions about prioritizing mine clearance activities” (NORAD (2009)). After an increase in funding, the TIA expanded to Gaza and Maputo despite never having cleared mines there. Similar to the methodology of the MLIS, the TIA examined the situation in affected communities rather than areas with minefields (GICHD (2012)). The “NPA gave IND detailed reports on each site, classifying them as high, medium, low and negligible impact. NPA would consider the province to be “mine impact free” if all sites in high, medium and low categories were cleared” (GICHD (2012)).

Mine Impact Free Surveys in all Northern provinces. Teams visited communities to ask residents if they were aware of known mines, contaminated areas or threats from UXOs. “*Any suspected area identified during the process was investigated and if necessary cleared*” (Halo Trust (2007a)). The HALO Trust teams visited 6,395 communities and interviewed 401,007 people. 74 new suspected hazardous areas were identified and eventually cleared (Halo Trust (2007a)). The tasks identified by the surveys “*were in addition to the 478 tasks that had been identified over the years by HALO survey teams and subsequently cleared by HALO demining teams*”, the majority of which were located in Cabo Delgado (Halo Trust (2007a)). This village by village “*process achieved a state as close to every single square meter of the country to verify the fact*” (Halo Trust (2007a)). At the end of the process, all interviews had confirmed that all known areas were cleared and that there were no areas they would not use or fear mines. This was confirmed by each community leader signing the paperwork to acknowledge that no mine threats remained and all known mined areas had been cleared.

2.5 Summary

Demining accelerated during the period 1999 – 2007. The establishment of the autonomous and decently-funded National Institute of Demining, coupled with learning from past mistakes enabled the acceleration of landmine clearance that was quite limited in the earlier phase. The Landmine Impact Survey of 2001 was also useful, as for the first time, officials, international agencies, and demining operators obtained a decent overview of landmine contamination across the country. However, progress was slow and by the end of 2007 more than half of the suspected hazardous areas were cleared. This was due to a combination of many issues. First, IND’s capacity was far from strong and weakened when the United Nations Development Program stopped assistance in 2005. Second, The MLIS had many flaws and as such the country still lacked a thorough, analytical, and in-depth description of the problem. Third, the massive floods of 2000 and 2002 removed landmines and unexploded ordnance in the much-contaminated central provinces making detection even harder. Fourth, corruption allegations in 2004 stopped the earlier momentum. Fifth, donors became frustrated with the challenges and corruption and aid fell considerably in the period 2004 – 2007. In 2007 it was clear that in spite of the clearance of the Northern provinces, there was still a lot of work to be done for the country to achieve landmine-free status.

3 Third Phase 2008-2015

3.1 Conditions. Second Mine Action Plan (2008-2014)

The final phase of demining starts with the second Mine Action Plan (2008 – 2014) and the subsequent request of the Mozambican government for an extension of the deadline to destroy the stockpiles of landmines and clear all suspected hazardous areas (Government of Mozambique (2008)). The request

for extension built on the “Baseline Assessment”, a survey commissioned by the IND and conducted by the HALO Trust, using all records and survey data from other operators (like HI and NPA) from the 6 central and southern provinces that remained contaminated. Additionally, the HALO Trust survey teams visited over 1,800 sites in Inhambane, Manica, Sofala, Gaza, Maputo and Tete and confirmed that all were still contaminated (National Institute of Demining (2009)). Figure 13 illustrates the spatial distribution of suspected hazardous areas according to the “Baseline Assessment” in 2007.

A key finding of the assessment was that, despite the progress made, contamination was still prevalent as new minefields and UXOs were discovered. The survey teams confirmed a total of 541 mined areas covering approximately 12,164,401 m² across the country. A total of 1,192 sites suspected of contamination were cancelled after non-technical surveys. Cancellation was mainly due to duplication in databases, insufficient evidence for contamination, and because the threat had been already cleared but the information had not been passed to the authorities.¹³ The confirmed tasks were classified into high, medium and low priority. The vast majority of SHA was identified to be of medium priority for clearance, whereas 169 tasks were categorized as low and 84 were listed as high.

Inhambane contained approximately half of all suspected hazardous areas (252 confirmed minefields) which concurs with findings of the earlier MLIS survey (2001) and the HALO Trust survey (1994) that it was the most affected by landmines province. Figure ?? depicts the distribution of suspected hazardous areas in Inhambane. The survey identified Inhambane as having the most SHAs listed as high-impact.¹⁴ New minefields were identified, including the Chicamba Dam, power-lines in Sofala, and new areas in the border with Zimbabwe. In addition, the survey “*also revealed that the four northern provinces still had 146 locations with UXO problems and some cases of suspected mined areas (Niassa 49, Cabo Delgado 44, Nampula 16, and Zambezia 37)*”.

The second Mine Action Plan 2008 – 201 was designed to provide a strategic, district-by-district clearance scheme outlining key objectives and priorities (GICHD (2012), United Nations Development Programme (2016)). Past criticisms of poor coordination (Millard and Harpviken (2000)) were addressed as “*coordination meetings and information sharing increased among stakeholders. As a result mine-action donors and partners regained confidence in the programme’s leadership*” (United Nations Development Programme (2009)).

The findings of the “Baseline Assessment” were a crucial input in the mine-action planning (GICHD (2013)). The increased coordination, and the evidence that landmine contamination was still severe, helped to reignite donors’ interest. “*Between 2008 and 2012 the State provided the equivalent of \$8.8 million USD. The international community contributed about USD \$41.1 million most of which was transferred directly to international humanitarian demining organizations*” (National Institute of

¹³In line with this, going over the original reports provided to us by Halo Trust, NPA, and HI, we detected dozens of completion reports that were not stored by the electronic system of the IND. Moreover, we did detect in the IMSA datasets many duplicate observations.

¹⁴Previous survey findings suggesting that Gaza was of the least contaminated were also corroborated by the Baseline Assessment as only 13 confirmed tasks were recorded.

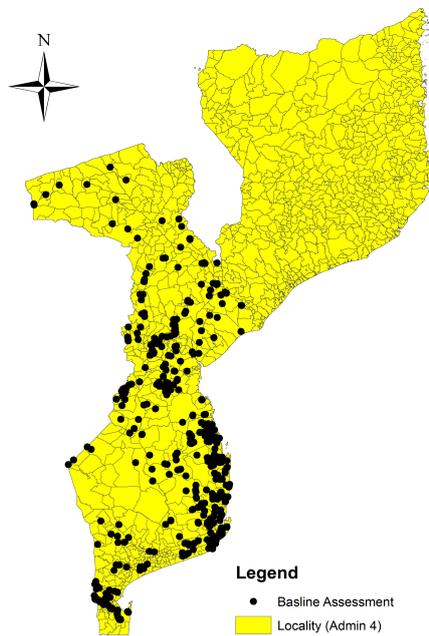


Figure 13: Baseline Assessment 2007

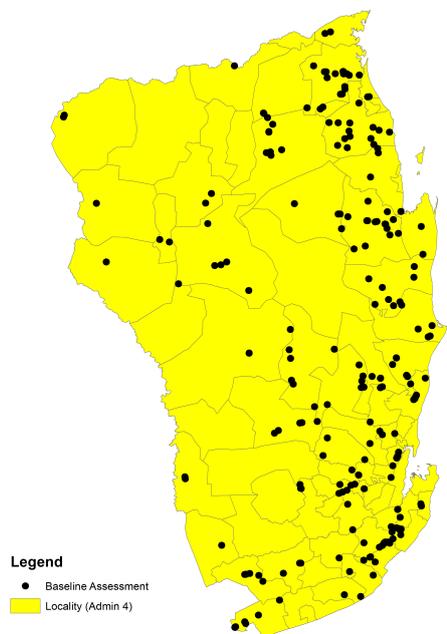


Figure 14: Baseline Assessment 2007: Inhambane Province

Demining (2013)).¹⁵ Following these developments, the Anti-Personnel Mine Ban Treaty Extension Request was finally approved during the 9th Meeting of the states parties in November 2008 in Geneva (National Institute of Demining (2009)). The new deadline for Mozambique to achieve mine-free status was set to 2014. The IND, with further funding and a new director in 2009, tasked the remaining operators beyond their initial regional dominance. The new plan, unlike the first MAP, which was largely ignored by operators (GICHD (2005)), was respected and time-frames were generally adhered to.

Besides clearance, the plan highlighted assurance, mine risk education (MRE), and victim assistance (GICHD (2012)). The plan's priorities were "*population resettlement, demining areas destined for agricultural activities, social infrastructure (schools, hospitals, commercial areas, areas around or within human settlements), areas of socio-economic interest, such as roads and bridges, railway lines, dams, electricity transmission lines and industrial infrastructure*" (National Institute of Demining (2013)).

3.2 Landmine Clearance

At the beginning of the final phase of demining, clearance activities accelerated as a result of the expanding databases of landmine contamination.

Demining Operators Belgium funded, rat-based operator, APOPO, was accredited as a demining operator and subsequently tasked with the clearance in Gaza and Inhambane in 2007/2008. APOPO, from 2008 to 2012 cleared a total of 4,970,832 m² destroying 2,425 landmines (APOPO (2012)).

The HALO Trust cleared additional suspected mined areas that were reported to the IND by the local governments, in which 43 SHAs were cleared with 34 UXOs in the North, and continued demining in Maputo, Tete and Manica working along Help Age International (WYG International (2013)). The IND requested HI to clear half of the SHAs, approximately 6 million m², in Sofala, Manica, and Inhambane, by December 2014 (Handicap International (2014)). The NPA, after departing from Mozambique in 2006, returned in 2011 to complete works in Tete and Manica in 2013 (National Institute of Demining (2013)). Between 2008 and 2012, the Government of Mozambique classified 96 districts out of 128 districts in Mozambique as mine free.

Progress By 2010, 50 of Mozambique's 128 districts were freed from mines, with the prospect of a further 42 in 2011 (GICHD (2012)). In 2012, Gaza was declared mine free by APOPO, a huge

¹⁵The UNDP "pledged funds to directly support the demining operations of three NGOs, namely the HALO Trust in Maputo, APOPO in Gaza and Humanity & Inclusion in Inhambane" (United Nations Development Programme (2009)). The "Mozambique Government allocated a substantial amount of funding in 2009. In addition, there is a genuine boost of donor interest and support to the programme, including: Norway, Belgium, Ireland, Japan, UK, Italy, USA and UNDP. With the Government and donor contributions financial resources for 2009 mine action activities (9 million US Dollars) have been secured" (National Institute of Demining (2009)).

breakthrough in mine action in the Centre-South. Despite these tremendous efforts by operators and the IND, the remaining 5 provinces (Inhambane, Manica, Maputo, Sofala and Tete) were not at a similar stage as these provinces were not able to “*reach the original deadline established by the mine-ban treaty; therefore, a further extension request was approved with a new deadline set for 2014*” (National Institute of Demining (2009)). As of 2012, 32 districts were still considered as mine affected (National Institute of Demining (2013)) with 82% of the mine-contaminated areas located in the provinces of Sofala and Inhambane (Handicap International (2014)).¹⁶

During January and February of 2014, APOPO and the HALO Trust concentrated on clearance in the Maputo province. Demining in the province was completed in March 2014. The HALO Trust, the NPA and APOPO proceeded to conduct demining in Sofala and Manica. Mozambique’s demining activities, however, outside Maputo briefly stalled in 2014. In addition to the heavy rains in central provinces, Sofala and Manica suffered military insecurity due to the re-emergence of conflict between RENAMO and the government.

In Manica, the operators faced operational difficulties. The Zimbabwean border remained considerably mined and clearing mines on this border were expected to cost much more than planned due to the dense mine patterns. A joint survey “*led by the National Institute for Demining in July to August 2013 with the involvement of the Mozambican Border Authority and the four international demining NGO operators, concluded that eight of the original thirteen border minefields were in fact located inside Zimbabwe*” (Norwegian Peoples Aid (2014)). The NPA completed demining of the Messambuzi border minefield in Sussendenga, bringing the total number of border minefields remaining on Mozambican territory to five: Kahira Luaia, Mucodo, Mudododo, Nhamacuarara, and Nsoluwamunthu. In Tete, the HALO Trust expected to finish the Cahora Bassa Dam demining by June 2014 and border minefields in the fourth quarter of 2014. At the end of the year, the province was declared landmine free. HI, working in Inhambane, expected to complete the province by September 2014 (Government of Mozambique (2015)). Manica was declared free of all known landmines by late 2014, followed by Inhambane.

In 12 September 2015 Mozambique declared itself free of known mined areas with the last mines exploded around the Dondo Bridge in Sofala.

¹⁶Between 2013 and 2014, it was estimated that “*USD 17.5 million [would] be required to fund the demining capacity required to clear all areas by the March 2014 deadline*” (National Institute of Demining (2013)). It was “*expected that USD 2.6 million [would] be provided by the Government through the state budget and USD 15 million [would] come from contributions by cooperation partners*” (National Institute of Demining (2013)). As of May 2014, however, “*it appeared uncertain whether it would meet the deadline*” (Norwegian Peoples Aid (2014)).

4 Timeline of Mine Action in Mozambique

The following section presents a detailed chronology of the main events and developments during the Mine Action Program in Mozambique. The information is based on the United Nations Development Programme (2016) report (“Evaluation of the UNDP contribution to Mine Action”).

4.1 First Phase (1992-1999)

- 1992: Peace agreement is signed between FRELIMO and RENAMO; responsibility for demining is assigned to the UN peacekeeping mission (UNOMOZ)
- 1992: UNOHAC estimates there are 2 million landmines in Mozambique
- 1992: HI begins nationwide mine risk education programme
- 1992-1994: UNOMOZ trains and manages clearance by Mozambican deminers
- 1993: UNOHAC establishes a mine clearance training centre in Moamba for former soldiers; it eventually results in ADP
- 1993: Mine clearance begins
- 1993: NPA establishes a demining programme in Tete province and soon expands to two other central provinces, Manica and Sofala
- Late 1993: UNOHAC contracts with HALO Trust for an emergency nationwide survey. Although coverage is incomplete, it finds 981 mined areas and assigns high priority to road clearance for peacekeeper access, refugee return and distribution of humanitarian assistance by road rather than air drop
- 1994: Absence of effective donor coordination and need to start operations leads to demining assignment of HALO Trust in the north, NPA in the centre and ADP in the south
- 1994: Mechem begins road clearance, financed by UNOMOZ
- 1994: HALO Trust establishes demining programme in Zambezia province in support of United Kingdom NGOs. It soon expands to three northern provinces: Niassa, Nampula and Cabo Delgado
- July 1994: UNDP initiates Accelerated Demining Programme (ADP) Phase 1 MOZ/93/801 to employ demobilized soldiers trained as deminers by UNOHAC, modelled on Cambodia’s experience; initiative operates in southern provinces of Maputo, Gaza and Inhambane
- 1994: HI and International Committee of the Red Cross establish and run modern orthopedic centres in all provinces

- Oct 1994: Elections are considered the end of the peace process and of UNOMOZ
- 1994 onward: HALO Trust, NPA and ADP manage independent demining programmes in the north, centre and south of country, respectively
- 1995: At consultative group meeting in Paris, the Government of Mozambique documents its economic and social development goals and key policies highlighting demining as an essential priority for development
- 1995: The National Demining Commission is created, beginning operations in 1996. Staff are first paid in 1997. CND is unable to establish oversight role and is understaffed (fewer than 10 staff); donors are dissatisfied. CND is eventually replaced by IND (1999)
- 1996-1999: UNDP supports CND with 3 to 5 technical advisers and 1 USD million; staff is weak, counterparts are lacking; 85% of funds go to expatriate salaries; little indigenous capacity building takes place
- 1996 onward: UNDP does most of the legwork to convene donors periodically in Mine Action Support Group, to share information, mobilize resources and develop a unified message in policy dialogue with the Government
- 1996: UNDP/DHA/ADP database records 1,721 mined areas divided into six categories depending on severity
- 1997-2000: Consolidation of the Accelerated Demining Programme
- 1997: DHA study on development of indigenous mine action capacity case study on Mozambique cites problems due to diverse mandates of multiple UN agencies: peacekeeping, relief, development etc.
- 1997: Anti-Personnel Mine Ban Convention (APMBC) opens for signature; Mozambique is among first countries to sign
- 1998: Mozambique ratifies APMBC
- 1998: HI starts small area demining in Inhambane
- Sep 1998: Study: with Specific Reference to Mozambique to identify mined areas)
- 1999: Canadian International Development Agency commissions, a firm without mine action experience, to prepare Mozambique Landmine Impact Survey; completed in 2001
- Feb 1999-July 2000: Preparation project for IND capacity building begins
- 1999: APMBC enters into force, including for Mozambique

- 1999: Mozambique hosts first meeting of States Parties to the APMBC
- 1999: Interministerial Committee for Mine Victim Support is established
- June 1999: Government replaces CND with IND under Ministry of Foreign Affairs, with more autonomy

4.2 Second Phase (2000-2007)

- 2000: Decree 39/2000 approves IND establishment with 120 employees. Most are never recruited as Government provides no funds and donors disapprove. As of 2001 staff is around 13
- 2000-2005: UNDP mobilizes resources for IND and ADP
- 2000: German NGO MgM starts demining in Mozambique
- March 2000: Preparatory assistance for project funded by Denmark, (MOZ/00/001) to run 2000 to 2003, extended to December 2006”
- Oct 2000 Dec 2001: UNDP Flood Related Mine Action project MOZ/00/004 delayed due to flooding in early 2000. By the time project starts the main flood relief effort is over; TA works on capacity development of IND
- 2000-2001: LIS is conducted but not integrated with IND; provides first national report on extent of landmine problem and socioeconomic impact
- 2000: MSMA is installed during LIS; first capacity building CTA”
- 2000-2005: Second UNDP ADP project provides funding for ADP 2000-2002 support for capacity building to IND (nationally executed)
- 2001-2004: Transformation of ADP into an NGO project (MOZ/00/012) (11.3 USD million) with objective to support national capacity development by producing a fully operational NGO. Minimal progress is made regarding the NGO and UNDP continues to provide demining funds. No real transition effort is in effect
- 2001: IND regional delegation established in Nampula (followed by Beira)
- 2001-2006: UNDP provides IND with four TAs, a CTA and advisers for finance and administration, operations and information
- 2001: MLIS report is issued, identifying 791 mine-affected communities in all 10 provinces and 123 of 128 districts; 80% are low impact; 1,374 suspected mined areas total 562 sq km
- 2001: HI hands over entire role in mine risk education to IND (supported by UNICEF)

- 2001: First National Mine Action Strategy is approved by Council of Ministers
- 2001: First Plan of Actions for the Reduction of Absolute Poverty (PARPA) (2001-2005) does not include mine action
- 2002: IND produces first National Mine Action Plan 2002-2006 using LIS data although operators mainly ignore it
- 2002-2003: First set of Mozambican national mine action standards is written by expatriate technical advisers in English (translated in 2004)
- 2002: Capacity building ProDoc is revised to include creation of socioeconomic research and evaluation unit, QA unit under operations, expansion of mine risk education, capacity building of Nampula and Beira delegations, new management for Adopt-a-Minefield”
- 2002: Consultancy concludes that NGO option for ADP is not viable. Donors agree at November meeting and decide to continue same”, i.e. UNDP, IND and ADP will develop proposal for a nationally executed project under Ministry of Foreign Affairs” 2003: DP continues with two TAs and 2.1 USD million for operations”
- 2003: After using LIS as basis for its 2002-2006 plan, IND starts receiving operator reports of excessive numbers of contaminated areas and many unrecorded sites. IND has no real picture of contamination and thus how long clearance will take”
- 2003: Final destruction of remaining landmine stockpile on time for APMBC
- 2003: Most bilateral donors announce intent to end funding for mine action
- 2003: New director of IND is appointed: Gamiliel Munguambe
- 2003: MGM closes operations and leaves Mozambique
- 2003: Evaluation of global landmine survey process. Mozambique country study (by Scanteam) is critical of MLIS
- 2004: IND QA teams are deployed to each regional office; they have insufficient equipment and resources; Austria and Switzerland each support one region (Sofala and Cabo Delgado, respectively)
- 2004: Corruption accusations are made over use of donor funds to purchase expensive car for IND national director
- July 2004: ProDoc 0039146 Transformation of the Accelerated Demining Programme (ADP) July 2004-June 2005 (3 USD million); establishing ADP as a non-profit-making demining operator, setting up the Governing Board, staff and strategy for ADP

- 2004: APOPO starts clearance testing with rats
- 2004: Mozambique hosts first review conference of APMBC
- 2004: Review: Support to Humanitarian Mine Action in Mozambique COWI for Danida
- 2004: HALO Trust announces it will conclude work in four northern provinces and close programme by end 2006
- 2004-2007: HALO trust conducts mine- impact-free district survey in the four northern provinces to document completion; process is largely ignored by IND; NPA and HI each conduct surveys of their areas of operations; all three result in update and reduction of areas estimated by LIS
- 2004: NPA announces it will close operations in Mozambique based on Norwegian Embassy recommendation, based on 2002-2006 IND strategy with all high- and medium-impact sites cleared by 2006
- 2004: HI announces it will close demining at end of 2006, with conclusion of all small area tasks in Inhambane
- 2005: IND annual plan refers to 2002-2006 plan and what provincial governments were reporting; henceforth priorities to start from districts and provinces
- Apr 2005: ADP employees strike over unpaid wages; director resigns; Government shuts down ADP operations.
USD million. Whereabouts of ADP database and clearance reports is unclear
- 2005: GICHD review of 10 years of assistance to mine action in Mozambique (based on fieldwork mid-January to mid- February 2005)
- 2005: UNDP capacity building programme ends; IND loses its best educated and trained local staff on UNDP project payroll; others not paid for months while awaiting admission to civil service
- 2005-2007: Donor funding plummets amid accountability and management concerns; donor support falls from 15 USD million in 2005 to 2.5 USD million in 2007
- June 2005: UNDP hires local consultant to help IND outreach to government departments and represent mine action in preparation for second PARPA
- 2006: Second PARPA (2006-2009) includes mine action as one of eight cross-cutting issues
- Jan 2006: Price Waterhouse produces of a Business Plan for the Accelerated Demining Project UNDP, but it is never heard of again

- 2006: NPA closes programme and leaves country after conducting task impact assessment of all centre-south provinces (Tete, Manica, Sofala, Inhambane; plus Gaza and Maputo, where it never worked)
- 2006: APOPO is accredited as demining operator
- 2006-2007: HI conducts comprehensive village-by-village surveys of Manica, Sofala and Inhambane provinces
- Feb 2007: Mozambique is one of three African countries to participate in launch of Oslo process, which produces Convention on Cluster Munitions
- June 2007: HALO Trust concludes a mine- impact-free assessment of the four centre-north provinces where it had been operating and declares no known mined areas remain
- 2007: Norway funds a seminar involving operators, GICHD, UNDP and IND to discuss National Mine Action Plan, challenges and strategy

4.3 Third Phase (2008-2015)

- 2007-2008: On behalf of IND, HALO Trust undertakes baseline assessment of remaining six provinces using records, LIS, pre- and post-LIS reports in IMSMA, and surveys by HI and NPA in their areas
- 2008-2015: The only remaining long-term advisers are individual CTAs funded by UNDP
- 2008: Evaluation of Canadian Land- mines Fund Phase II (mainly HI)
- 2008: For the first time the financial table in IND annual report contains government contribution (1.5 USD million)
- 2008: Socioeconomic impact assessment (UNDP-funded consultancy) is undertaken to determine performance against PARPA indicators. It is superficial but finds positive linkages
- 2008: Most ambassadors decline to attend annual IND director briefing
- 2008: Article 5 extension request is prepared, involving operators and other stakeholders under leadership of IND, using baseline assessment
- 2008-2012: National Mine Action Plan, based on baseline assessment, adopts district-by-district approach to prioritize remaining demining, approved by Council of Ministers
- 2008: Donor funding begins to recover, based on credibility of mine action strategy and Article 5 extension request, with UNDP support (full recovery by 2011)

- 2008-2011: Weapons Risk Mitigation and Mainstreaming Mine Action, Small Arms and Light Weapons Controls project
- 2008: IND strengthens QA operations
- 2008: IND performs district-by- district verification of provinces demined by HALO Trust in four northern sites; identifies 43 suspected mined areas and 34 unexploded ordnance sites.”
- 2008: Government requests Ottawa Treaty extension to 2014”
- 2008: Article 5 extension request is approved by States Parties
- Dec 2008: Government signs Convention on Cluster Munitions
- 2009: National Mine Action Strategy 2009-2014 is adopted, aimed at mine-free Mozambique by 2014 (amended following Article 5 extension approval)
- 2009: New IND director appointed: Julio Braga
- 2009: IND/SAC workshop held on land release; IND develops land release standards (not accepted by operators)
- 2009: APOPO begins demining work in cooperation with HI in Inhambane 2010 onward UNDP mobilizes resources for IND and operations within national programme, channelling funds to all operators according to IND priority
- 2010: In Five Year Plan 2010-2014 mine action is one of seven cross- cutting issues with nine priority actions, reflecting baseline assessment
- 2010: Classification of provinces as mine-free effort begins and progresses
- 2011: District police trained and equipped to respond to EOD tasks in four northern provinces
- 2011: PARP 2011-2014 challenges include eliminating landmines to free land
- 2012: Government ratifies Convention on the Rights of Persons with Disabilities
- 2012: National Disability Plan 2012-2019 is approved
- 2012: NPA returns to Mozambique demining operations
- 2012: Ravim and HI undertake survey of 300 mine/ERW survivors
- 2013: Government makes second request for extension of Article 5 deadline, to December 2014
- 2014: Mozambique hosts third review conference of APMBC

- June 2014: Government announces development of national victim assistance plan at third review conference
- 2014-2015: Police in Gaza and Maputo provinces are trained and equipped in EOD
- 2014-2015: IND plans transition of core EOD and database functions to long-term institutional basis in context of post-demining residual problems”
- 2015: Government Five-Year Plan 2015-2019 identifies landmines as one of several perennial issues for attention”
- 2015: Mozambique declares itself free of known mined areas (17 September)”

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Landmines and Spatial Development

Appendix III

Landmine Database *

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June 18, 2018

Abstract

This Appendix describes the construction of the database recording the close to universe of landmine clearance operations in Mozambique over 1992-2015. First, we present the new dataset, giving examples, and detailing cross-validation. Second, we give descriptive and summary statistics of clearance operations, by area cleared, operator, duration, number of mines and unexploded ordnance, and categories. Third, we provide graphical illustrations and a more detailed account of clearance operations across each of Mozambique's 10 provinces.

*Additional material can be found at www.land-mines.com

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Landmines and Spatial Development

Appendix IV

Validation Luminosity-Development *

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Abstract

This Appendix first briefly reviews works showing that satellite imagery on light density at night is a good proxy of aggregate economic activity both across and within countries. Second, the Appendix presents tests illustrating a significant association between luminosity and proxies of well-being (public goods, household assets, and education) across African and in particular Mozambican regions.

*Additional material can be found at www.land-mines.com

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Contents

1	Luminosity and Development	3
1.1	Literature	3
1.2	Elasticity between Luminosity and GDP	4
2	Luminosity and Well-Being across African Regions	5
2.1	DHS and Luminosity: Africa	5
2.2	DHS and Luminosity: Mozambique	7

1 Luminosity and Development

1.1 Literature

The increasing availability of big data with a spatial dimension has opened a way to the “meso-approach” in the empirical literature of comparative development and growth (see Michalopoulos and Papaioannou (Forthcoming)). Among such geo-referenced data, satellite images of light density have been widely used to capture economics activity at the local level. Building on Elvidge, Baugh, Kihn, Kroehl, and Davis (1997) and Doll, Muller, and Morley (2006), Henderson, Storeygard, and Weil (2012) first showed the potential of luminosity data to economics, uncovering that light density at night is a strong proxy of economic activity across and within countries. Many empirical works have since used satellite data on light density at night to study a plethora of questions. Pinkovskiy and Sala-i-Martin (2016a) use luminosity to construct revised data on poverty rates across countries, finding that global poverty has been falling considerably in most parts of the world, including Africa. Michalopoulos and Papaioannou (2014) and Pinkovskiy (2017) use luminosity to examine whether national institutions correlate with regional development close to the borders. Michalopoulos and Papaioannou (2013) aggregate the luminosity data across ancestral ethnic homelands to explore the link between contemporary development and deeply-rooted precolonial political organization. Alesina, Michalopoulos and Papaioannou (2016) use luminosity data to construct proxies of regional inequalities across ethnic homelands and administrative regions and explore the association between spatial inequalities and development. Hodler and Raschky (2014) use luminosity to examine regional favoritism. Campante and Yanagizawa-Drott (2018) use city-level luminosity data to assess the role of long-distance flight on the spatial allocation of economic activity. Henderson, Squires, Storeygard, and Weil (2017) use finely disaggregated luminosity data to explore the role of geographical features on the spatial distribution of economic activity. Michalopoulos and Papaioannou (Forthcoming) review this body of research, while Donaldson and Storeygard (2016) review the wider research agenda that used satellite data in economics.

While not problem-free, luminosity data entail some advantages. First, cross-country comparability is high, as the information is measured in a consistent way and does not reflect biases from statistical institutions (Michalopoulos and Papaioannou (Forthcoming) and Henderson et al. (2012)). Second, coverage is global (with the exception of the poles). Third, satellite data are able to capture a sizable portion of economic activity and urbanization at a fine resolution, of roughly 1 km^2 (in the equator), thus allowing meaningful within-country spatial analyses. Fourth, luminosity data are available at the yearly frequency from 1992 to 2015 and thus permit for meaningful within-country over time analyses.

Taking advantage of the disaggregated nature of the data, the literature has used various transformations of luminosity at different levels of analysis. These include the sum of total night light in a given region, province, or country, the share of lit pixels, the average night light, and the log of average night light, either per square kilometer or per capita (sometimes a small number is added

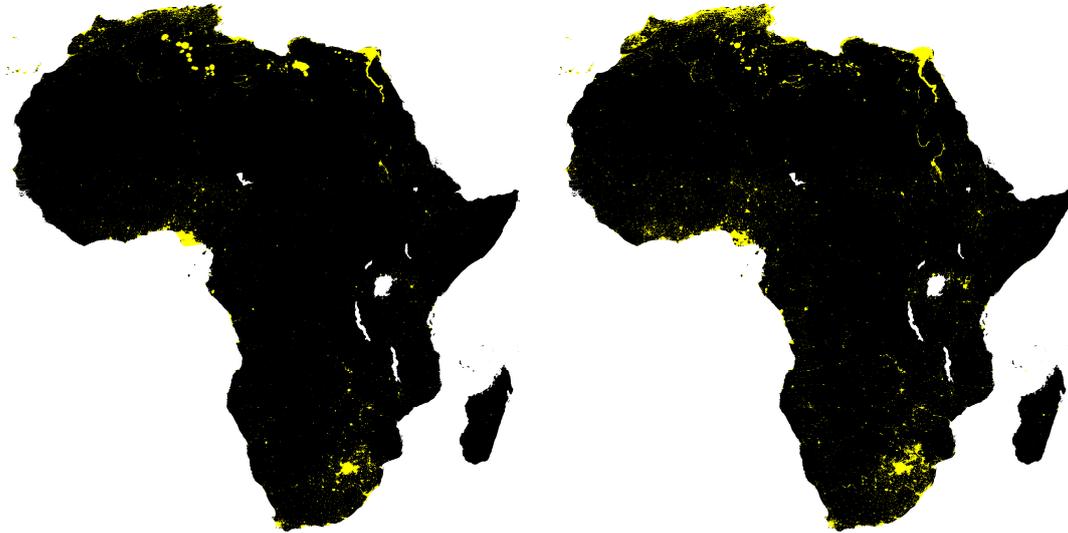


Figure 1: **Luminosity in Africa: 1992 and 2013**

before taking the log to account for the presence of zeros). Many high-resolution studies also employ a binary, 0 – 1, transformation that accounts for the highly nonlinear nature of the data. Even if there is a discussion on whether the correlation between lights and development is stronger in levels or growth rates, luminosity is a powerful proxy of development for regional analyses in conflict-ridden regions and those with poor-quality national statistics. And these are the places where understanding the causes of underdevelopment is more important (see Chen and Nordhaus (2011), Henderson, Storeygard, and Weil (2012), and Nordhaus and Chen (2014)). Figure 1 and Figure 2 illustrate the distribution of luminosity in 1992 and in 2013 for Africa and Mozambique, respectively.

1.2 Elasticity between Luminosity and GDP

The association between luminosity and GDP is strong. Henderson, Storeygard, and Weil (2012) show that a robust correlation emerges when estimating the association between luminosity and GDP in log differences over the period 1992 – 1993 to 2005 – 2006 across 170 countries. They uncover an elasticity of 0.32 and an R^2 of around 0.28.

Thanks to its fine resolution, luminosity allows comparisons of economic activity across regions within countries. Estimates at the subnational level reveal that the correlation between luminosity and GDP holds when controlling for nationwide common factors. At a global scale, Hodler and Raschky (2014) show that log luminosity and log output are related at the regional level. Similarly, Gennaioli, La Porta, De Silanes, and Shleifer (2014) in a sample of 1503 regions across 83 countries, estimate the

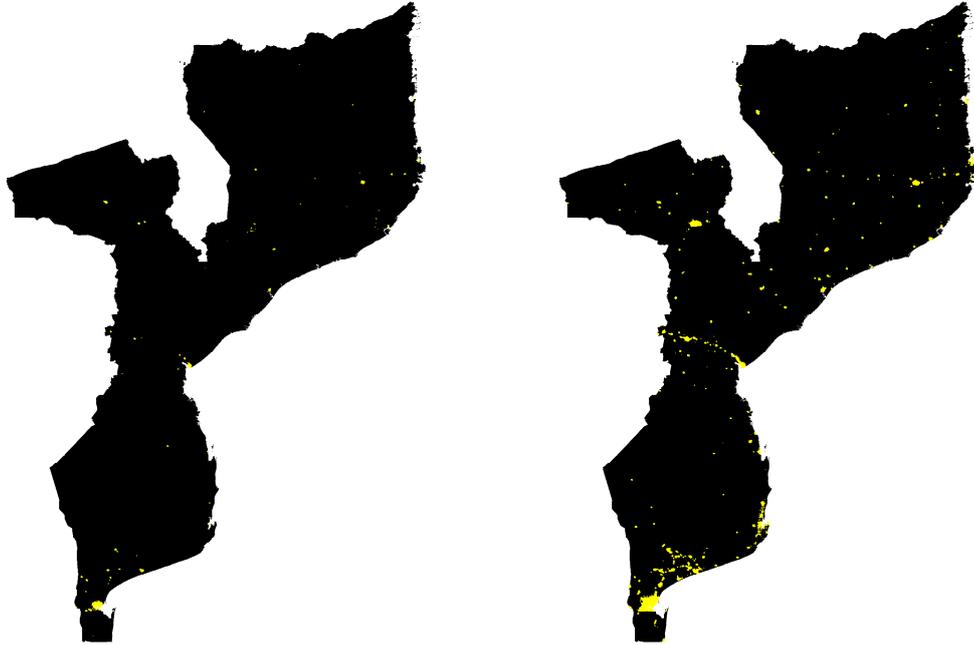


Figure 2: **Luminosity in Mozambique: 1992 and 2013**

elasticity to be around 0.25.

Following Henderson, Storeygard, and Weil (2012), we estimated the elasticity between luminosity and GDP in log differences over the period 1992 – 1993 to 2013 – 2012 for 180 countries. We uncover an elasticity of 0.45 (with a standard error of 0.04) and an R^2 of 0.30 (see left panel of Figure 3). We then explored the relationship for a subset of 50 African countries. The estimated elasticity is 0.46 (with a standard error of 0.08) with an R^2 of 0.20 (see right panel of Figure 3).

2 Luminosity and Well-Being across African Regions

While many works have shown that luminosity is a good proxy of local economic activity, especially in under-developed and war-prone countries (e.g., Henderson, Storeygard, and Weil (2012), Chen and Nordhaus (2011), Michalopoulos and Papaioannou (2013), Pinkovskiy and Sala-i Martin (2016)) we tried to cross-validate luminosity using data from the Demographic and Health Surveys (DHS); these surveys have been widely used in development economics to proxy individual well-being, household wealth, and access to basic public goods.

2.1 DHS and Luminosity: Africa

We collected data from 69 geo-referenced surveys covering 31 Sub-Saharan African countries over the period 1999 – 2015. We aggregated the data at the second-level administrative unit level using

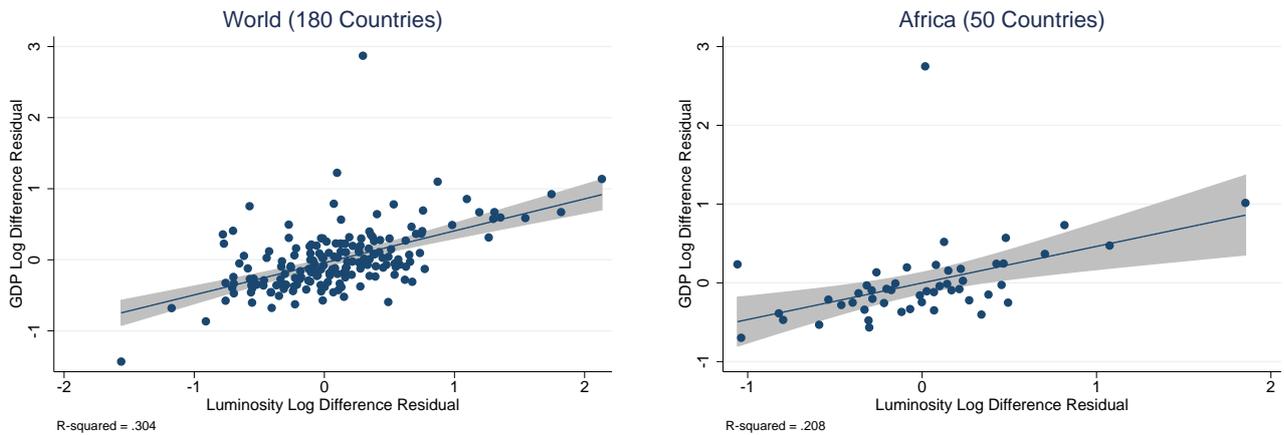


Figure 3: **GPD and Luminosity. Log Differences 1992-1993 and 2012-2013: World and Africa**

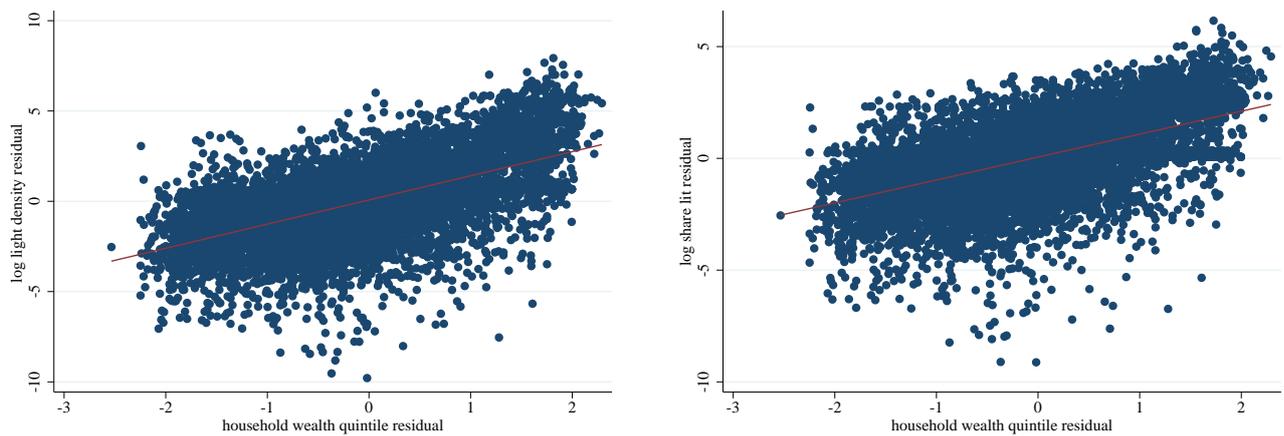


Figure 4: **Luminosity - DHS Wealth Index Association across African Regions**

the boundaries from GADM (Global Administrative Areas).¹ GADM delineates Africa into 6,157 sub-national (admin-2) regions; of these regions, 2,455 contain at least one DHS enumeration area (village/town) with data on household wealth. The DHS wealth index is a composite measure of household's assets and utility services. The wealth index is calculated using household's ownership of selected assets, such as televisions and bicycles; materials used in the housing construction; and types of water access and sanitation facilities. It is generated via a principal component analysis. The resulting DHS composite wealth index places individual households on a continuous (or quartile) scale of relative wealth within a country for a given survey.

Overall we use data from approximately 743,000 households.

plots regional luminosity against the DHS composite wealth index, netting out country-survey

¹GADM provides only admin-1 boundaries for Comoros, Cape Verde, Lybia, Lesotho, Mauritius and Seychelles.

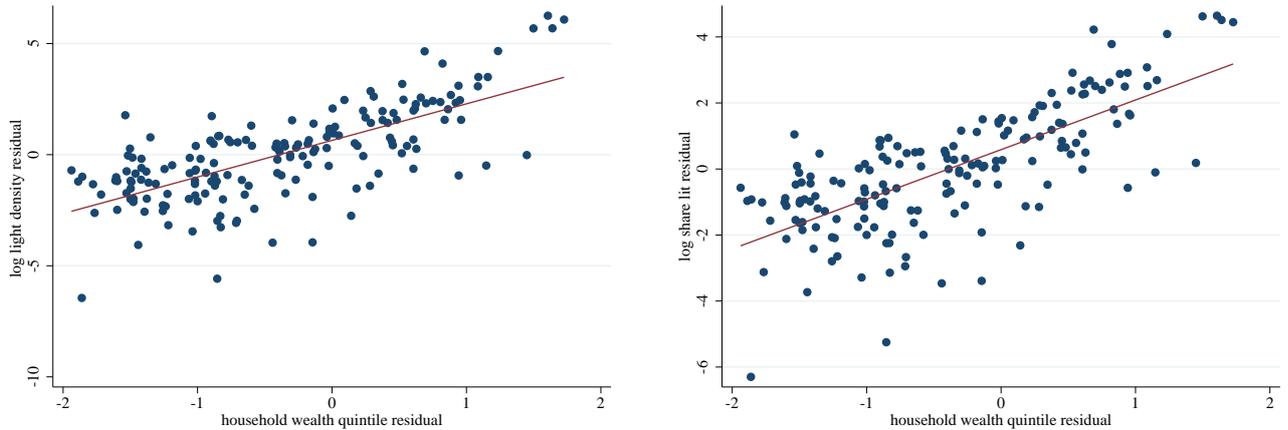


Figure 5: **Luminosity - DHS Wealth Index Association across African Regions**

fixed effects. In the left panel we employ a logarithmic transformation of the luminosity data (that range from 0 to 63). In the right panel, and since admin-2 units are typically large, we use the log share of lit pixels. There is an evident strong, and highly significant correlation between the wealth index and both transformations of luminosity. This correlation is similar to Weidman and Schutte (2017) and Bruerdele and Hodler (2017) who also report strong associations between luminosity and DHS-based proxies of well-being. And as can be seen, the relationship is not driven by outliers. The regression R^2 is around 0.30 – 0.35. The coefficient on the DHS wealth index is around 1.6 – 1.7 implying that 10 percent increase in luminosity is associated with a 0.6 increase in the wealth index (that ranges from 1 to 5).

2.2 DHS and Luminosity: Mozambique

In Figures 5 we plot luminosity against the DHS composite wealth index across the 124 Mozambican admin-2 districts using the 2011 survey (that covers 13,919 households) and the 2009 survey (that covers 6,097 households).² The correlation is quite strong (with an R^2 of around 0.49 – 0.51); while far from perfect, luminosity does reflect regional development. The estimate on the DHS wealth index is 1.6, suggesting that a 10% increase in cross-district luminosity is associated with a 0.62 points increase in the DHS composite wealth index ($1/1.6 \simeq 0.625$).

In Figures 6 we report the means of the deviation from the sample mean of the DHS composite wealth index for the unlit and lit Mozambican admin-3 units (391 postos administrativos), respectively, pooling together the 2009 and 2011 surveys and partialling out survey fixed effects. The mean of DHS composite wealth index is always larger for the lit administrative units compared to the unlit ones.

²Since the year of interview varies within the survey, we assigned to each household the corresponding value of luminosity of their admin-2 district of residence in that year. We then construct the average luminosity at the admin-2 level for both surveys.

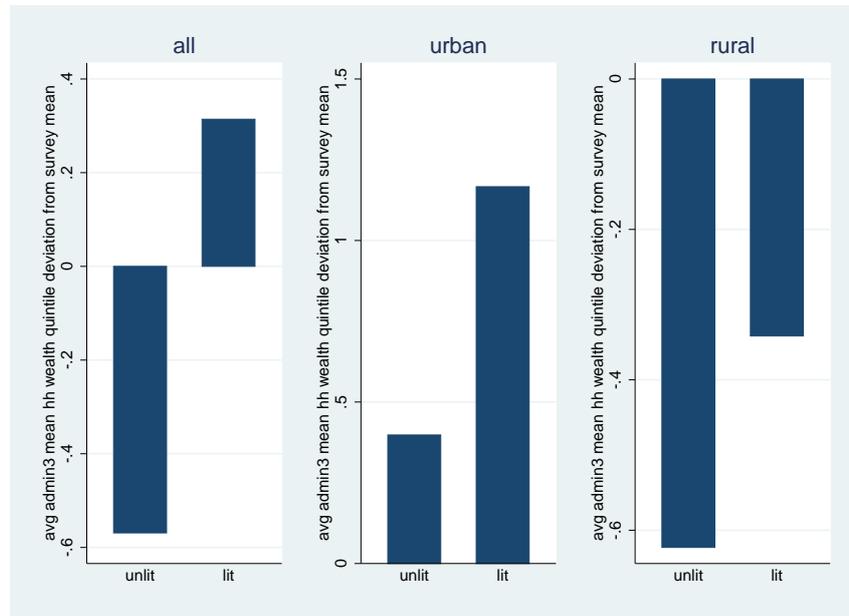


Figure 6: Luminosity - DHS Wealth Index Association across Mozambican Admin 3

The difference is particularly pronounced for urban regions where the average DHS wealth index is almost three times larger than the unlit counterpart. A similar pattern applies in rural units. A regression analysis corroborates the graphical illustration. Being lit maps to an increase in the DHS composite index by 1.5, that is almost half of its sample mean (3.21). As the graphs suggest, the effect differs between urban (an increase of 2) and rural (an increase of 0.32) administrative units.

In Figures 7 instead of looking at the composite wealth index, we report the means of the deviation from the sample mean of individual years of schooling for the lit and unlit units separately. In lit districts, individuals report on average 1.8 more years of schooling, which is around 40% of the sample mean (4.67). As the graphs illustrate, the association is stronger for urban (a 2.9 years increase) than rural (1.1 years increase) units.

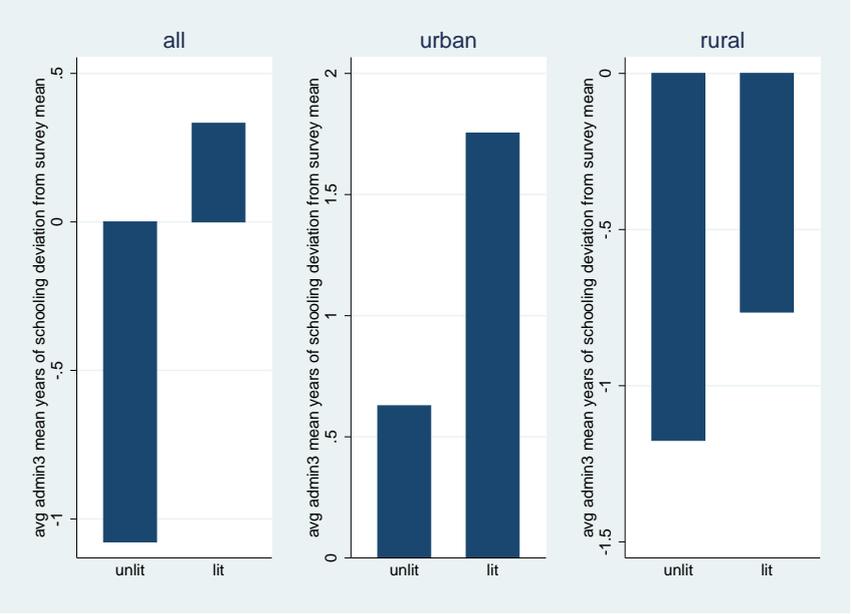


Figure 7: Luminosity - Education Association across Mozambican Admin 3

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Contents

1	Data Collection	3
1.1	Land Release Process	3
1.2	Data. IMSMA database	5
1.2.1	Introduction	5
1.2.2	IMSMA post 2008	8
1.2.3	IMSMA pre 2008	8
1.3	Additions and Validation from Original Data	9
1.4	Validation from Secondary Sources	17
2	Summary Statistics	17
2.1	Operators	17
2.2	Duration of Interventions	26
2.3	Area of Interventions	26
2.4	Items Removed	27
2.5	Heterogeneity Categories.	28
2.6	Report Based Categories	28
2.6.1	Example of Road Category	29
2.6.2	Example of Border Category	30
2.6.3	Example of Protection Ring & Residential Category	30
2.6.4	Example of Military Category	31
2.6.5	Cross-Tabulation of Report-Based and GIS-based Categories	31
3	Disaggregation by Provinces and Periods	33
3.1	Cabo Delgado Province	33
3.2	Niassa Province	36
3.3	Nampula Province Summary	39
3.4	Zambezia Province Summary	42
3.5	Tete Province Summary	45
3.6	Gaza Province Summary	48
3.7	Sofala Province Summary	51
3.8	Manica Province Summary	54
3.9	Inhambane Province Summary	57
3.10	Maputo Province Summary	60

1 Data Collection

In this section, we present the various steps involved in the landmine dataset creation. Reconstructing the universe of demining operations from 1992 to 2015 has been a complex task. As it is apparent from the history of demining, reviewed in Appendix II, the process to clear Mozambique from landmines was fraught with serious challenges; among others, lack of coordination, imperfect information on the location of minefields, as most were not laid by professional armies, little -if any- information-sharing across actors, absence of best practices before 2007 on data management, and the weak state capacity. These features rendered the reconstruction of a comprehensive database of clearance operations a complicated and often daunting task. Thankfully, the Geneva International Centre for Humanitarian Demining (GICHD), the main demining operators (e.g., HALO Trust, Humanity and Inclusion, NPA, and APOPO), and Mozambique’s National Institute of Demining (IND) offered generously their expertise and resources. Many individuals, former deminers, officials of the United Nations (UN) and national authorities (IND) helped us a lot in various phases of the data collection. Figure 8 shows the conditions of the archive at the National Institute of Demining, we encountered in the beginning of our attempt to reconstruct the clearance database in 2015.

1.1 Land Release Process

Before jumping to the data creation, it is useful to describe the land release process in case of suspected by landmines contamination. Mines are usually buried within 15 centimeters of the earth’s surface, which makes verification a difficult task. Even for mines laid on the ground, detection is difficult, as vegetation grows; moreover floods and rock-slides reshuffle landmines, making detection even more challenging. Gathering reliable intelligence is complicated by the fact that landmines were placed years ago by actors that are not around anymore and because in Mozambique dozens of actors used landmines (FRELIMO, RENAMO, other rebels and militias, the armed forces of South Africa, Rhodesia, and Malawi, the colonial administration, private agents).

Over time, the mine-action community has come to realize that attempting to clear all areas suspected of contamination (known as “suspected hazardous areas” - SHA) is impossible. This is because the initial classification of a SHA is usually based on word-of-mouth typically under insecure conditions. Hence, cancelling “false positive” SHA or updating their status to confirmed hazardous areas (CHA) is an essential task, typically done via non-technical surveys (NTS). NTS gather and



Figure 1: Warehouse $\frac{1}{4}$ ND in Maputo 2015

analyze information by visiting the area, interviewing landowners, farmers, village leaders, and (ex) military personnel. In cases of sufficient evidence of contamination, a technical survey (TS) that collects more precise information follows. Usually, a TS concludes with the clearance of the hazard(s) and the issuing of a completion report.

These practices first came into place at the end of 2001 with the issuance of the Handbook of International Mine Action Standards (IMAS), last revised on February 2016. IMAS is produced and sponsored by the United Nations Mine Action Service (UNMAS), with the support from a variety of organizations, including the Geneva International Centre for Humanitarian Demining (GICHD). It is in the absence of best practices and little coordination among demining actors that one needs to understand clearance operations in Mozambique during the 1990s and early/mid-2000s. Mozambique starts implementing best-practices in the beginning of the third phase of landmine clearance in 2007 – 2008.

1.2 Data. IMSMA database

1.2.1 Introduction

We started our data collection accessing the Information Management System for Mine Action (IMSMA) database stored at the National Institute of Demining (IND) in Maputo. IMSMA is currently used by around 80% of mine-action programmes around the world; it is also the United Nations’ preferred information management system for mine action.¹

Thanks to GICHD and IND officials, we managed to understand the functionality of the IMSMA software and data format. The three key dimensions in the IMSMA dataset are: *i*) Location (the relevant administrative division); *ii*) Hazard (the parcel of land where the threat is identified); and *iii*) Activity (the operations performed on the hazard). Hazards are classified as Confirmed Hazardous Area (CHA) or as a Suspected Hazardous Area (SHA). Among the activities listed in the IMSMA, we have:

- **Technical Survey Report:** Technical Surveys refer to the collection and analysis of data, using appropriate technical interventions, regarding the presence, type, distribution and surroundings of mine contamination, in order to define precisely where mine contamination is present, and to support evidence-based land-release prioritization and decision making processes.

¹We are grateful to the Mozambican authorities and the IND director, Alberto Maverengue Augusto, for enabling access to the data.

- **Impact Survey Report:** These reports contain information collected by the surveyor. The purpose of these reports is to collect evidence to support decision-making about where hazards are present and where they are not. Impact survey reports are also useful to understand impacts on affected communities.
- **Clearance Report:** These reports are typically used to record a formal clearance task. Clearance reports store GPS information of the contaminated area and in some instances even report the exact location of mines.
- **Progress Report:** Report containing progress data for a reporting period, usually, the number of mines cleared, area cleared and hours worked on a given task (either attached to a hazard or activity). Progress reports do not contain GPS coordinates.
- **Completion Report:** These are the final reports that summarize information stored on the Progress Report and the Clearance Report. The Completion Report is the final document of clearance that serves also as a certificate for Land Release.

In the most complete entries in IMSMA database, Location, Hazard and Activity are linked. For example, one or more Confirmed Hazardous Areas (e.g., minefield A and minefield B) or Suspected Hazardous Areas are located in a given location (e.g., locality). The hazardous areas are then linked to one or more activities. SHAs are linked to Impact Surveys only; while CHAs are linked to a Technical Survey, a Progress Report, a Clearance, and a Completion Report. High-quality information also come with a polygon for both the Hazard (which represents the area affected by the CHA or the SHA) and the Activity (area on which the clearance has been performed). Figure 2 shows an example of the linkage between these three elements. The Location of this entry is Marenga village, north of Inchope on the N1 road that connects capital Maputo with the Central and Northern Provinces along the Indian Ocean. Panel A shows the Confirmed Hazardous Areas (in blue color) linked to this Location. We registered three Hazards with polygons delineating contamination. Attached to these Hazards are three activities for which polygons are available. Panel B shows the three activities polygons in green. But this is not the universe of activities and interventions in Marenga village. As Panel C illustrates, there are other two activities (in 2003 and in 2007 indicated black dots) for which only the centroid of the activity is available. Due to the limited information on polygons (as shown below), we perform our analysis employing centroid of intervention on Confirmed Hazardous Areas (as shown in Panel C).

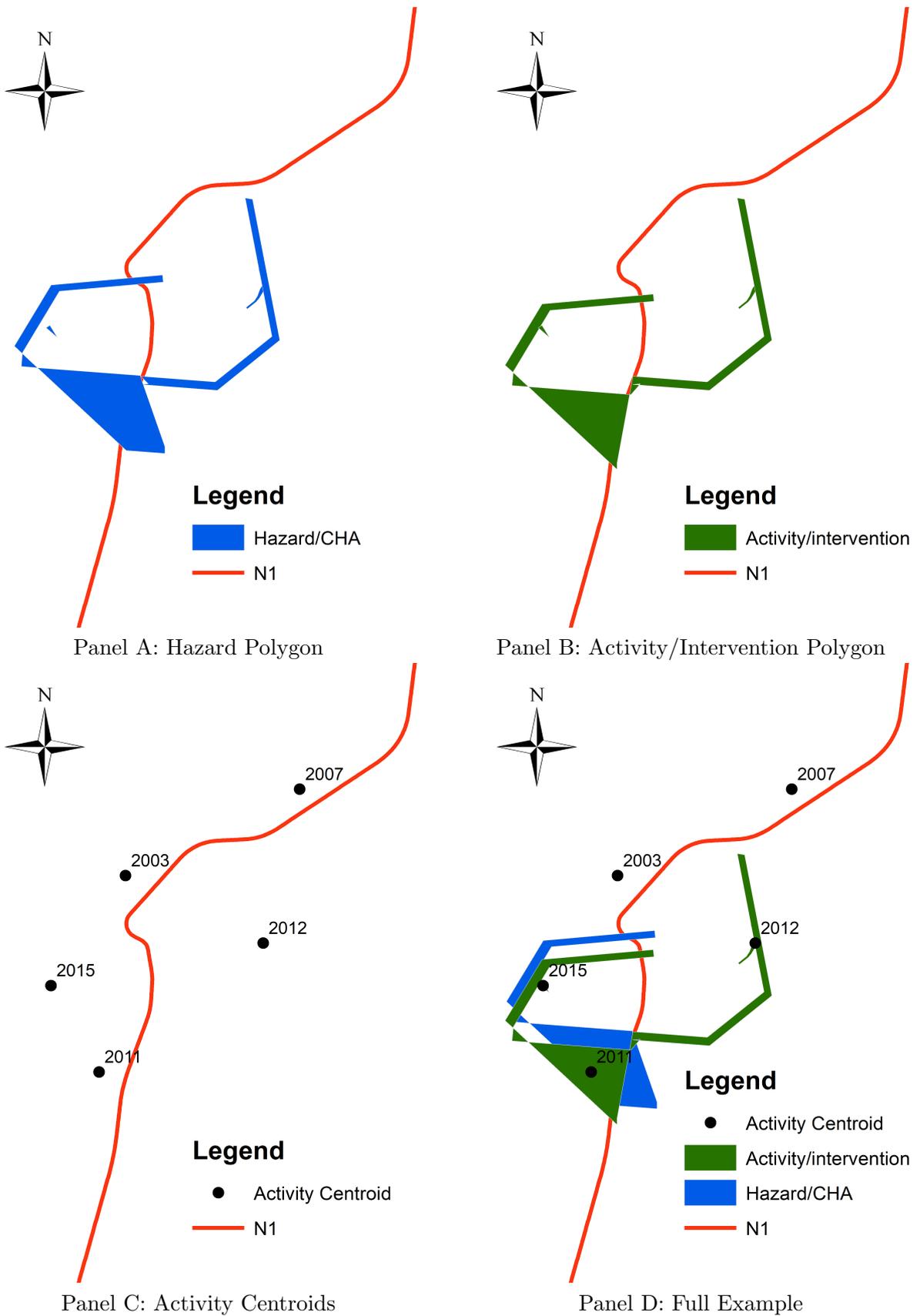


Figure 2: Harzard and Activities: Polygons and Centroids example in Marenga village (north of Inchope)

There are two IMSMA databases for Mozambique. The first stores information on demining activities from January 2008 to October 2015. According to IND officials and the GICHD experts, this dataset is reliable, as it was assembled following best practices. The second dataset, called “Legacy Dataset”, contains information on landmine clearance from 1993 to 2007. The original pre-2008 dataset was lost; so the available dataset is a copy of the original data. On top of this problematic issue, while data from 2001 to 2007 were originally collected by the IND, the data between 1993 and 2000 were migrated from different data storage systems depending on the individual operators and are evidently of lower quality.

1.2.2 IMSMA post 2008

The post-2008 IMSMA dataset includes 3,374 entries. The quality of the dataset allows us to identify 3,148 demining interventions and 226 Suspected Hazardous Areas that were deemed “false positives” and got cancelled. Each intervention is linked to a hazard and a location: the 3,148 interventions are distributed over 2,853 Confirmed Hazardous Areas. All 3,148 activities are based on Completion Reports, summarizing relevant information from the Progress and Clearance reports (e.g., Start date, End date, Operator identity, Area Cleared, Number of items cleared, etc.). Despite the high quality of the post-2008 database, only 1,026 (32% of the total) interventions have information on the polygon of the contaminated area. Below we discuss the validation of the post-2008 dataset.

1.2.3 IMSMA pre 2008

We took several steps to improve the quality and coverage of the “Legacy dataset”. The raw IMSMA data record 16,343 entries. There were three patterns/ways of data storage:

- 5,668 activities that were not linked to a hazard, but only to a location.
- 8,346 activities that were linked to a hazard and an associated location.
- 2,329 hazards with the corresponding location, to which no activities are reported.

As a first step and to avoid redundancies, we linked each activity to a hazard and a location. To this end, we created for each entry an identifier using information on the activity code, operator identity, and location. We then used this identifier to match each activity to either another activity or a hazard or both. This allows us to match information contained in a Progress Report regarding the

timing of interventions and the number of landmines cleared. We end up assigning information from 7,458 Progress Reports to 2,468 Clearance and Completion reports. The resulting pre-2008 dataset includes 8,885 activities/hazards.

The second step involved the identification of Confirmed Hazardous Areas (CHA) and Suspected Hazardous Areas (SHA). Specifically, we proceeded as follows:

- We drop all operations before 1998 that erroneously coded as having been done by Handicap International (Humanity and Inclusion). We drop them, as HI started its operations in the country as early as 1998. This leads to the exclusion of 566 entries. We also dropped an intervention from ADP, whose timing of end of operation was 2009 (well after ADP ceased activities).
- We went through each entry in the Impact Surveys identifying two categories: i) SHAs which were cancelled according to level-1 (Mozambique-wide) surveys (namely the 1994 SHAMAN HALO Trust and the 2001 MLIS); overall there are 1,511 cancelled SHAs. ii) Impact surveys in locations that subsequently clearance operations took place. Overall there 1962 entries. We dropped them as we were able to track them through the subsequent reports of demining activities.
- Using the “Baseline Assessment” Survey of HALO Trust in 2007 – 2008, we dropped SHAs that did not result in a CHA in the post-2008 period. These are classified as ”cancelled” SHA. This led to the exclusion of 45 entries.
- We also deleted (duplicate) entries that have the same operator, GPS coordinates, and timing of interventions. We dropped 758 duplicate observations.

Figure 3 (right panel) portrays the spatial distribution of cancelled suspected hazardous areas (SHA). These are areas that were initially thought of being contaminated, but eventually no clearance operations were carried. For comparability, the figure also portrays the distribution of all CHA.

After these steps, we are left with a dataset of 3,083 CHA from 1993 – 2008.

1.3 Additions and Validation from Original Data

After processing the IMSMA dataset (both post and pre 2008), we are left with 6,231 interventions.

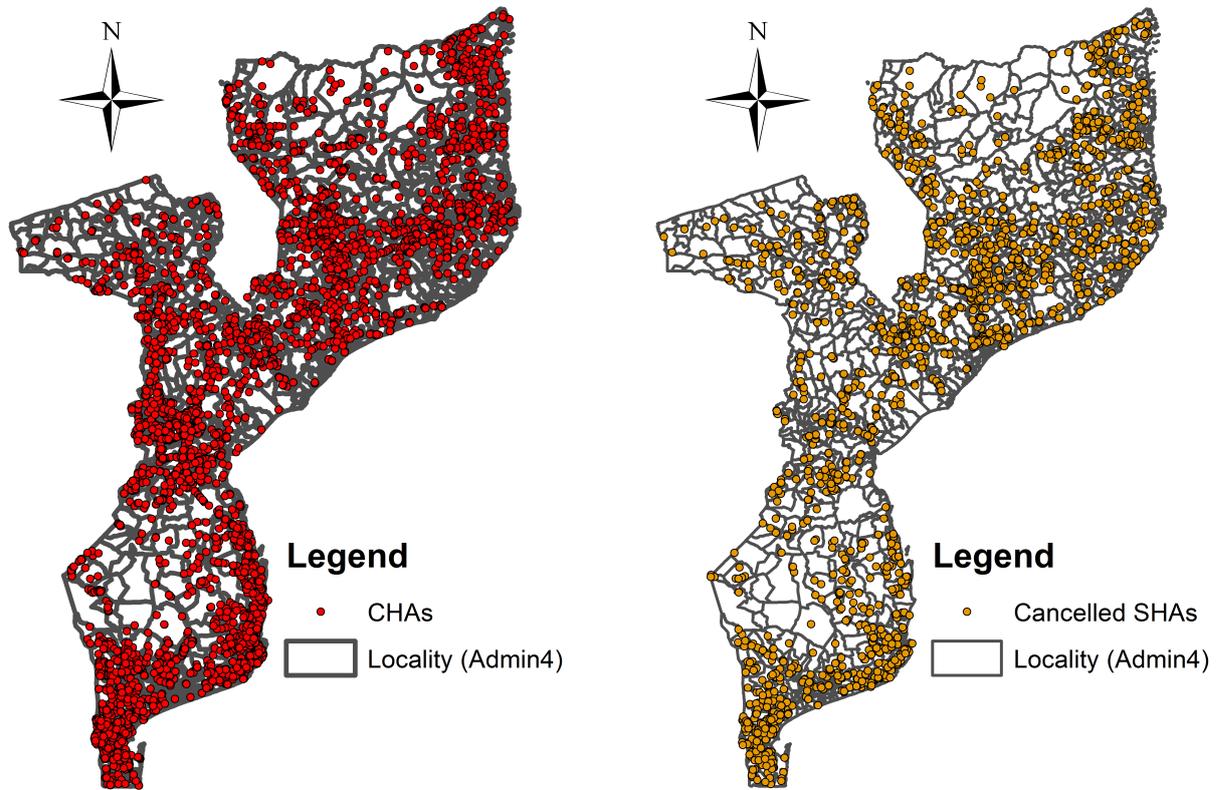


Figure 3: **Panel A: Location of CHAs** **Panel B : Cancelled SHAs across Localities**

We then collected, processed, and digitized data from the Halo Trust, Humanity and Inclusion (HI), the Norwegian People’s Aid (NPA), and APOPO, using these organizations’ internal records. All these data are at the Completion Report level.

- **HALO Trust.** We accessed the two original datasets (in Microsoft Access format) from HALO Trust. The first contains all operations performed by HALO in the Northern provinces before 2007. The second dataset stores all activities of HALO Trust in the Center-South of the country, post-2008.
 - **North Operations HALO Trust dataset.** We cross-checked the IMSMA entries with the HALO trust original data. As HALO Trust data and IMSMA followed different labeling criteria, we used ArcGIS to perform the following selection criteria. We impose a buffer of 1000m radius and erased those GPS location that overlap with a HALO Trust interventions from the IMSMA dataset. We retrieve 827 interventions that were not present in the IMSMA dataset, increasing the coverage of HALO Trust by 39% in the pre-2008 period.

- **Post-2008 HALO Trust Dataset.** Regarding the post-2008 IMSMA database, using the original HALO Trust data we validated all 1,623 HALO Trust activities. Reassuringly for the post-2008 IND data all HALO Trust interventions were properly recorded.
- **Handicap International (Humanity and Inclusion).** From HI we received MS Excel files containing summaries of operations for various years starting in 2002. Unfortunately, Handicap International does not have report/data at the hazard/intervention level for its 1998 – 2002 operations. We accessed information for the universe of HI operations for 2002, 2003, 2006, 2007, 2009, and from 2010 to 2015. We are thus able to validate around **627** HI operations (49% of the total interventions). For the pre-2002 period, we worked with Aderito Ismael, one of HI experts who worked at the time in Central Mozambique and we checked the pre-2002 entries in the IMSMA dataset.
- **Norwegian People’s Aid.** With the help of NPA directors, we visited the NPA warehouse in Tete, centre-West Mozambique, and accessed all reports covering the 1993 – 2000 period. Figure 4 shows the summary of total operations performed by NPA until 2000. We went over 70 clearance reports. The IND’s dataset did not have an entry for 27 interventions that were thus stored as new data. 43 interventions matched the IND database and thus allowed us to validate the accuracy of NPA data in the IMSMA database. We also accessed 53 original reports for the years 2003 – 2005. We end up adding 12 new interventions and validated the remaining 41. We did the same for original reports covering the 2013 to 2015. We validated all 43 NPA’s interventions for this period. Overall we increased NPA coverage by 20%.
- **UN Accelerated Demining Program (ADP).** We reached out and interviewed deminers and a field supervisor working with ADP in the mid 1990s. We retrieved 41 interventions from the ADP covering the period 1994 – 2000. We added 35 interventions from the ADP program that were not present in the IMSMA database. We validated that the remaining 6 interventions were accurately stored in the IMSMA database.
- **GTZ/Mine-Tech.** We accessed information on the operations performed by GTZ/Minetech from Dr. Ulrich Weyl with funding from the German Development Agency. Using Dr. Weyl personal archive, we were able to validate all the 64 interventions of Mine-Tech for the period 1997 – 1999 and 10 interventions of Armor SCS. Figure 5 illustrate an example of such a report.

NPA MINE ACTION PROGRAMME IN MOZAMBIQUE - OUTPUT SUMMARY DISPLAY - 31.08.93-31.03.00

MINECLEARANCE TASKS

MINE/NAME OF AREA	PROV.	GRQ/IT	LONG. (E)	LAT. (S)	SOM	KN ROAD	STARTED	FINISHED	LAP. MINES	AT MINES	LV. NO.	AUDIT	DIV. INFORMATION
Minefield - Chuanica-centrum	Tete	J	33°17'46"	16°49'56"	8086		30/09/93	30/09/93	123	1	1		Ref. Res. rep. 1 91
Minefield - 4km north of Chuanica	Tete	1	33°17'41"	16°48'34"	1716		01/09/93	16/09/93	1	60			Ref. Res. rep. 2 93, Fin. rep. 1 94
Minefield - Vila Nova Fonteira	Tete	1	33°13'35.5"	17°00'58.04"	83980		23/09/93	13/12/93	1	15	15		Ref. Res. rep. 3 93, Fin. rep. 2 94
Minefield - Dae	Tete	1	33°02'30"	15°12'21.8791"	48600	41	31/01/94	31/01/94	18				Ref. Res. rep. 2 94, Fin. rep. 3 94
Road - Duen - Chidobomomah	Tete	1	33°02'30"	15°12'21.8791"	78000		31/01/94	31/01/94					Ref. Res. rep. 2 94, Fin. rep. 3 94
Beige - Chuisse	Tete	1	33°02'30"	15°12'21.8791"	42365		31/01/94	31/01/94					Ref. Res. rep. 2 94, Fin. rep. 3 94
Road - Mpana - Baileya	Zambézia	3	33°02'30"	15°12'21.8791"	172801		31/01/94	31/01/94	68	72	50/10		Ref. Res. rep. 4 94, Fin. rep. 3 94
Minefield - Chupungu	Mozambique	3	33°02'30"	15°12'21.8791"	172801		31/01/94	31/01/94	68	72	50/10		Ref. Res. rep. 4 94, Fin. rep. 3 94
Minefield - Maredalungane	Mozambique	3	33°02'30"	15°12'21.8791"	172801		31/01/94	31/01/94	68	72	50/10		Ref. Res. rep. 4 94, Fin. rep. 3 94
8 Rows holes - Vitoralho Dam	Manhiça	2	32°46'49"	25°42'02"	612866		27/10/94	30/04/96	21	1			Ref. Fin. rep. 10 95
Minefield - Manhiça, Manhiça Dist.	Manhiça	2	32°46'49"	25°42'02"	80		27/10/94	30/04/96	21	1			Ref. Fin. rep. 4 96
Spot - road - Cahena Bassa-Zimbalwe	Tete	3			1000		27/10/94	25/11/94	1269	44			Ref. Fin. rep. 2 96
Spot - road - Cahena Bassa-Zimbalwe	Tete	3			800		27/10/94	25/11/94	1269	44			Ref. Fin. rep. 2 96
Minefield - Inanda, Maracoe District	Manhiça	1	32°46'49"	25°42'02"	3926		12/8/94	14/12/94	3	1			New road crossing suspended spot
Minefield - Chis, Cato District	Manhiça	1	32°46'49"	25°42'02"	128428		12/8/94	14/12/94	3	1			Ref. Fin. rep. 12 94
Minefield - Chis, Cato District	Manhiça	1	32°46'49"	25°42'02"	33237		12/8/94	14/12/94	3	1			Ref. Fin. rep. 1 96
Minefield - Chis, Cato District	Manhiça	1	32°46'49"	25°42'02"	350429		12/8/94	14/12/94	3	1			Ref. Fin. rep. 1 96
Minefield - Chis, Cato District	Manhiça	1	32°46'49"	25°42'02"	172655	3	12/8/94	14/12/94	3	1			Ref. Fin. rep. 1 96
Minefield - Chis, Cato District	Manhiça	1	32°46'49"	25°42'02"	3370429		12/8/94	14/12/94	3	1			Ref. Fin. rep. 1 96
Spot - Marenca, Tete District	Tete	HC	33°33'43.88"	17°08'23.9"	142558		25/11/96	23/1/97	15	23			Ref. Fin. rep. 01 97
Minefield - Manhiça, Manhiça District	Tete	HC	33°33'43.88"	17°08'23.9"	142558		25/11/96	23/1/97	15	23			Ref. Fin. rep. 01 97
Minefield - Chuanica, Chuanica Dist. set	Manhiça	4	33°29'26.76"	17°11'56"	126888		30/11/96	20/3/97	3	1			NPA 0 97
Minefield - Chuanica, Chuanica District	Manhiça	4	33°29'26.76"	17°11'56"	48852		30/11/96	20/3/97	3	1			NPA 0 97
Minefield - Chuanica, Chuanica District	Manhiça	4	33°29'26.76"	17°11'56"	28896		30/11/96	20/3/97	3	1			NPA 0 97
Spot - Bamba - Tete District	Tete	HC	17°25'25.8"	33°21'13.3"			11/8/97	14/8/97	1	1			NPA 0 97
Spot - Benga, Moatize District	Manhiça	HC	16°58'56.55"	33°13'59.63"	204725		21/7/97	23/9/97	13	3			Ref. Res. rep. 99/98, Fin. rep. NPA 0 97
Minefield - Fainha, Fainha District	Manhiça	SDR-1	33°31'63"	16°27'04"	50262		11/11/97	22/11/97	5	3			Ref. Res. rep. 97/05, Fin. rep. NPA 06/97
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	60496		8/3/97	5/5/97	2	16			Ref. Res. rep. 97/05, Fin. rep. NPA 06/97
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	31380	6718	29/11/96	16/11/97	12	5			Ref. Res. rep. 96/11, Fin. rep.
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	148669		1/10/98	07/04/98	24	49			Ref. Res. rep. 96/05, Fin. rep. NPA 02/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	135400		1/10/98	07/04/98	24	49			Ref. Res. rep. 97/12, Fin. rep. NPA 03/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	268113		1/10/98	07/04/98	24	49			Ref. Res. rep. 96/10, Fin. rep. NPA 03/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	23325		3/8/98	22/03/98	4	28			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	60874		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	207407/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
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Minefield - Mize, Chuan District	Tete	SDR-2	33°31'63"	16°27'04"	33307/90		15/04/98	11/05/98	2	650			Ref. Res. rep. 98/03, Fin. rep. 02/98/98
Minefield - Mize													

CONFIDENTIAL

CPD/GTZ/IHD/MARRP DEMINING PROJECT

FINAL REPORT: IHD OPERATION PHASE 2: DEMINING:
SAMBAZOKA VILLAGE: MACHAZE DISTRICT:
MANICA PROVINCE: MOCAMBIQUE.

September 1997

CONFIDENTIAL

(D207)

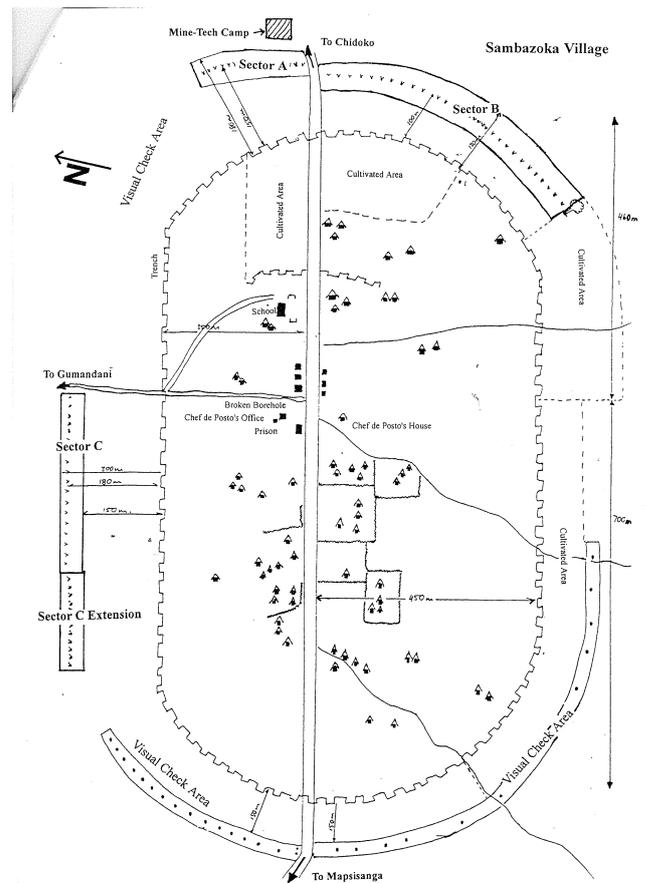
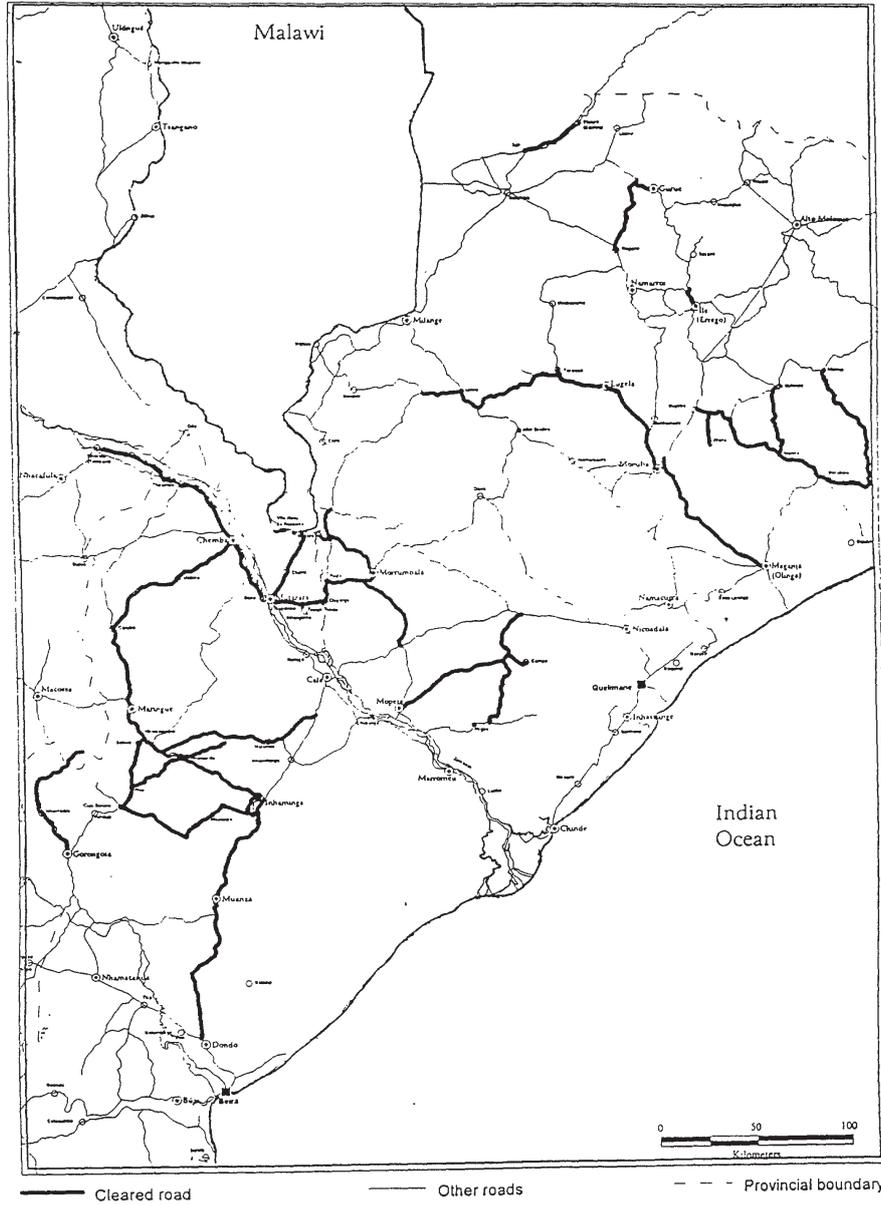


Figure 5: GTZ-Mine-Tech report of Sambazoka operation

- **“Baseline Assessment” Survey 2007 – 2008.** We identified 251 Confirmed Hazardous Areas listed in the “Baseline Assessment” Survey of HALO Trust in 2007 – 2008 that were not stored in the pre-2008 dataset. To identify these CHAs, we impose a buffer of 1000m radius and erased those GPS locations that overlap with a pre-2008 IMSMA intervention from the “Baseline Assessment” Survey.
- **RONCO** We accessed a report commissioned by USAID mapping 24 interventions covering 1994 and 1995 (see Figure 6). These interventions, mostly on roads in the central provinces of Sofala and Zambezia, were not stored by the Mozambican authorities and were therefore missing from the IMSMA database. All such interventions are on roads in the province of Sofala and Zambezia.
- **UNOMOZ/UNOHAC** We accessed the United Nations Archives in New York City and digitized information of the UN mission in the country (UNOMOZ and UNOHAC) in the period surrounding the Peace Accord of 1992 and the National Elections of 1994. Adding interventions for the early period was important, as the IMSMA database does not contain any information related to the ONUMOZ mission. Figure 7 reports the original map we retrieved from the archives. From these archives, we retrieve the following:
 - **Lornho GSG.** We add 16 interventions contained in the ONUMOZ archives in 1992 – 1994.
 - **GSG/Lornho & MECHEM.** We add 12 interventions in 1994.
 - **RONCO.** We add 2 interventions from RONCO under the ONUMOZ archives. These interventions are subsequent to those recorded by the USAID report.
 - **Norwegian People’s Aid.** We retrieve information on 2 interventions by NPA from the ONUMOZ archives. We then validated these two interventions from the NPA archives in Tete.
- **Khron Mechanical Mine Clearance.** We also checked the presence of Khron interventions using the original information provided by former Khron’s employees on their 3 interventions in Mozambique (Sabie ring; Moamba ring; Boane ring). All the three interventions are recorded in the IMSMA dataset, under the ADP interventions which has been subcontracting clearance to Khron.

OPERATIONS AREA



B

38

Figure 6: RONCO Map

1.4 Validation from Secondary Sources

We performed further validation checks using secondary sources. We devoted particular attention to small operators at the beginning of the Mine Action process in the 1990s. When available, we consulted the websites of commercial firms (e.g. Mechem and MgM). We also retrieved information from the 1999 and the 2002 Landmines Monitor report of Human Rights Watch. We checked and validated the following interventions for the following operators:

- **Mine-Tech** operations on roads clearance in support of UN between 1994 and 1995 (operations inside the UN Project Caminho).
- **Armor Special Clearance Services (SCS)** operations on villages in Sofala and Manica provinces.
- **Mechem and LORNHO** activities for Project Caminho. Moreover, we validated (i) an intervention on Massangir dam in 1999; and (ii) Mechem road clearance operations in 2001
- **Empresa Mocambiacana de Desminagem, Lda (EMD)** interventions in 2001 in Inhambane province.
- **Menschen gegen Minen (MgM)** operations in 2000 and 2001 in Chokwe and Guija district, Gaza province
- **Mozambique Mine Action (MMA)** road clearance operations in 2001 in Inhambane province.
- **RONCO** roads demining operation in 1994 under the USAID contract. Moreover, we validated its operation in 2001 in Sofala and Maputo provinces.

2 Summary Statistics

This section presents summary statistics of our final dataset. We report statistics on operators, data sources, area cleared, items removed, and timing of interventions. We then present details on the GIS and report-based classification of each intervention.

2.1 Operators

Our dataset contains information on 42 demining operators. In Table 1 we report the year of the first and last operation for each actor and the total number of interventions. Among these operators, two main groups can be identified: i) humanitarian NGOs and ii) commercial firms. The

first group comprises HALO Trust (United Kingdom), Handicap International (France), Norwegian People's Aid (Norway), APOPO (Belgium), and several Mozambican organizations (Afrovita, Associação de Sapadores Mozambicanos, FADM, CODEG, Necoquinas). In the group of commercial firms belong the rest of small operators like RONCO (US), Mozambican Mine Action (MMA), Bactec International, Empresa Mocambicana de Desminagem, JV Desminagem, Mine Kills, MgM, and Mine Tech.

Figure 8 reports the distribution of interventions by operator. In terms of demining tasks performed, the key player is HALO Trust accounting for 50% of the total demining activities in the country. Handicap International (Humanity and Inclusion) and APOPO were responsible for 19.14% and 14.83% of interventions, respectively. The percentage of operations conducted by the UN Accelerated Demining Program (ADP) is 7.1% and NPA completed around 3.4% of clearance interventions. We further provide a disaggregation of the distribution of interventions by operator for each of the three demining periods of Mine Action: 1992 – 1999, 2000 – 2007, and 2008 – 2015. The three pie charts in Figure 9 offer the tabulations. In line with the history of demining, sketched in Appendix II, the first period is characterized by a tripartite division between HALO Trust, NPA, and ADP in the Northern, Central, and Southern provinces, respectively. RONCO and Mine-Tech are important players in the mid 1990s. In the two subsequent periods, HALO Trust emerges as the leading actor in the demining process coupled with the increase of HI role (from the second period) and APOPO after 2008.

The activities of the various operators exhibit sizable spatial variation. We offer a visualization of the spatial evolution of demining operation for each of the main operators in Figure 10 (HALO Trust), Figure 11 (HI), Figure 12 (NPA), Figure 13 (APOPO), and Figure 14 (ADP).

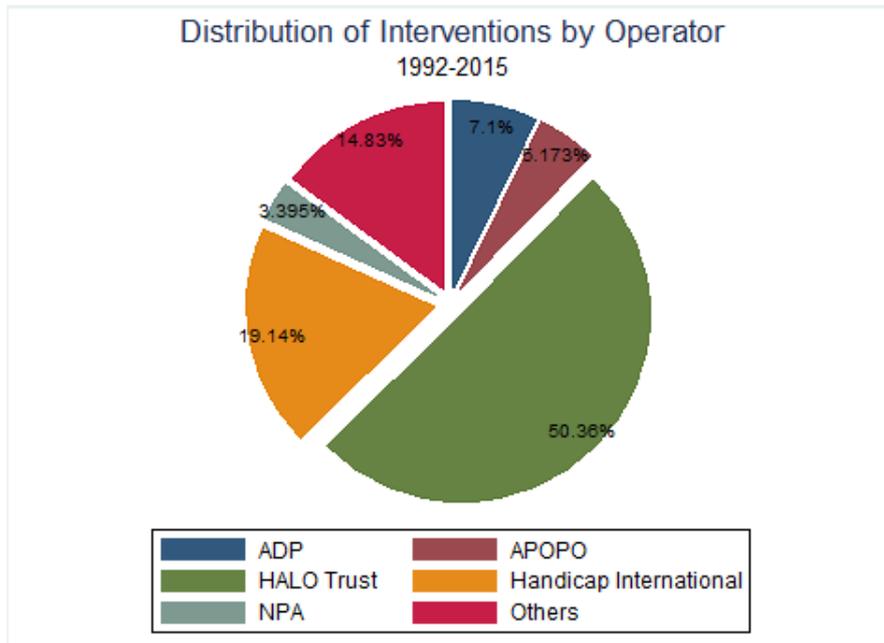


Figure 8: Distribution of Interventions by Main Operators

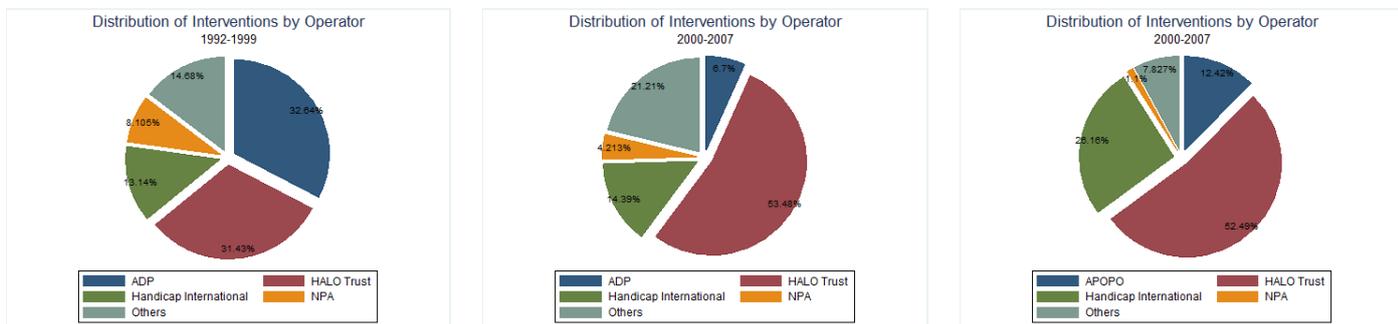
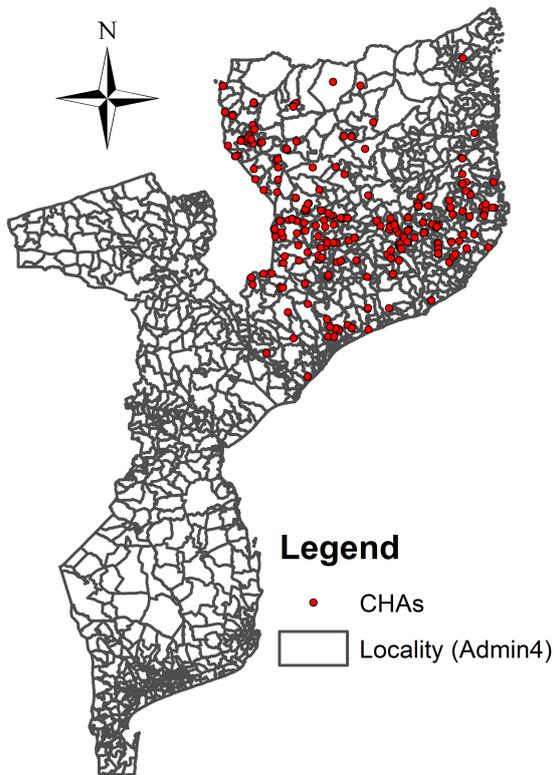


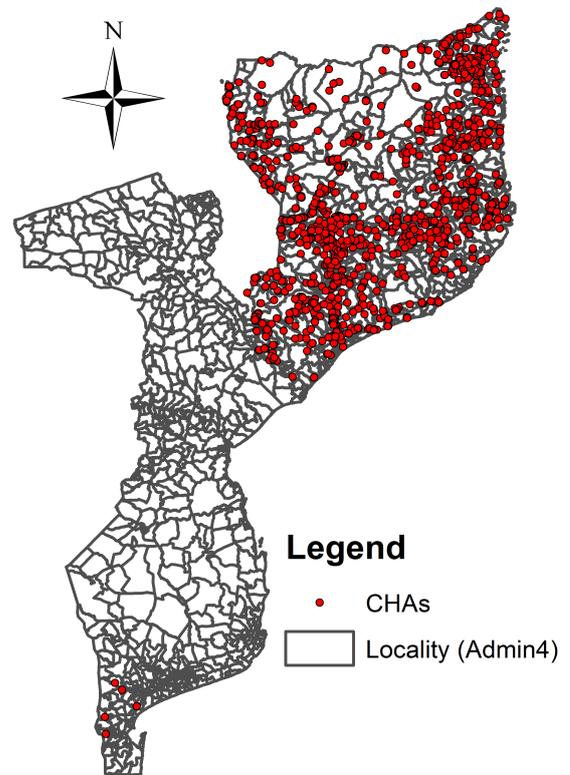
Figure 9: Distribution of Interventions by Main Operators and Periods

Table 1: Number and Timing of Intervention by Operator

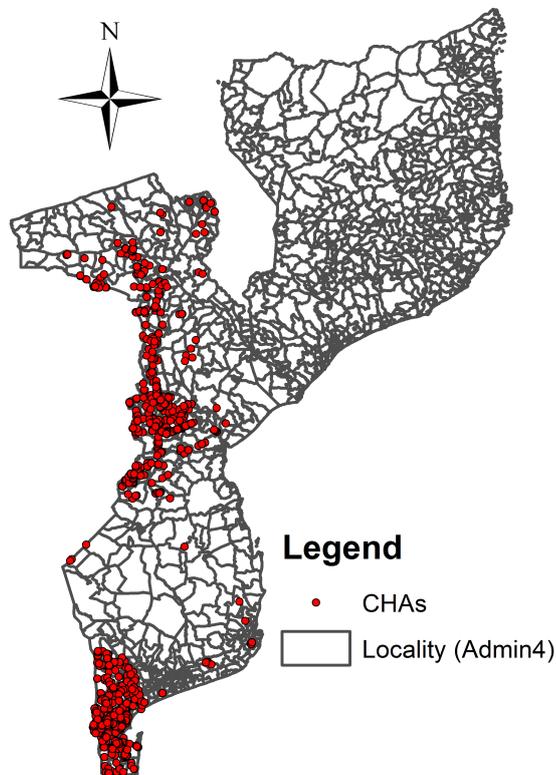
Operator	Number of Interventions	Percentage Number of Interventions	First Year	Last Year
ADP	527	7.100	1994	2006
AFROVITA	8	0.108	2001	2006
APOPO	384	5.173	2008	2015
ARMOR SCS	10	0.134	1997	2001
Associaao de Sapadores Moambicanos	16	0.216	2004	2006
BACTEC MOAMBIQUE	23	0.310	2004	2010
BICKMUTI LDA	9	0.121	2013	2014
CGTVA	2	0.027	1999	1999
CIDC	1	0.013	2006	2006
CODEG-Desminagem	1	0.013	2006	2006
DAG, Lda	3	0.040	2013	2013
Desminagem e Agricultura	36	0.485	2007	2013
ECOMS	1	0.013	2004	2004
EMD	81	1.091	1999	2014
FADM	63	0.849	2003	2014
GPC	6	0.081	1996	2001
GSG (Lorhno)	4	0.054	1993	1994
HALO Trust	3738	50.357	1994	2015
Handicap International	1421	19.143	1998	2015
IND	50	0.674	2001	2015
JV Desminagem	33	0.445	2004	2009
LIS 07	251	3.381	2001	2007
Lornho/RO/Mechem	6	0.081	1994	1994
MECHEM	67	0.903	1997	2006
MF Investimentos Lda	10	0.135	2009	2012
MGM	47	0.633	2000	2006
MINE-TECH	116	1.563	1997	2006
MMA	84	1.132	2001	2012
MMS, LDA	5	0.067	2011	2012
MONECHECHA-Lda	18	0.242	2010	2014
MOPROTECTOR Ltda	28	0.377	2010	2014
Mamacoma	17	0.229	2011	2012
Mechem	2	0.027	1994	1994
Mine Kills Lda	21	0.283	2007	2014
NECOCHAMINAS	6	0.081	2002	2006
NPA	252	3.395	1993	2015
Not Specified	13	0.175	2001	2006
REASeuro	9	0.121	2005	2006
RONCO	50	0.674	1994	2006
Scorpion-Desminagem	3	0.040	2011	2011
VAB DESMINAGEM	1	0.013	2013	2013
Total	7423	100		



HALO Trust 1992 – 1999

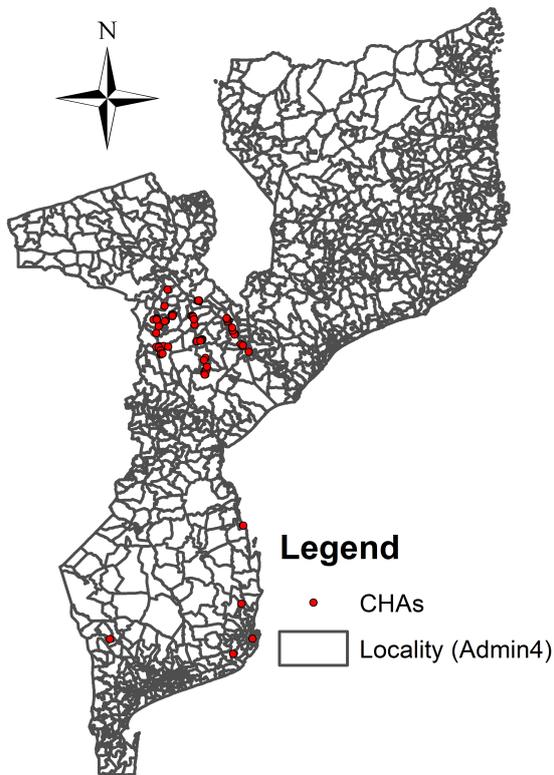


HALO Trust 2000 – 2007

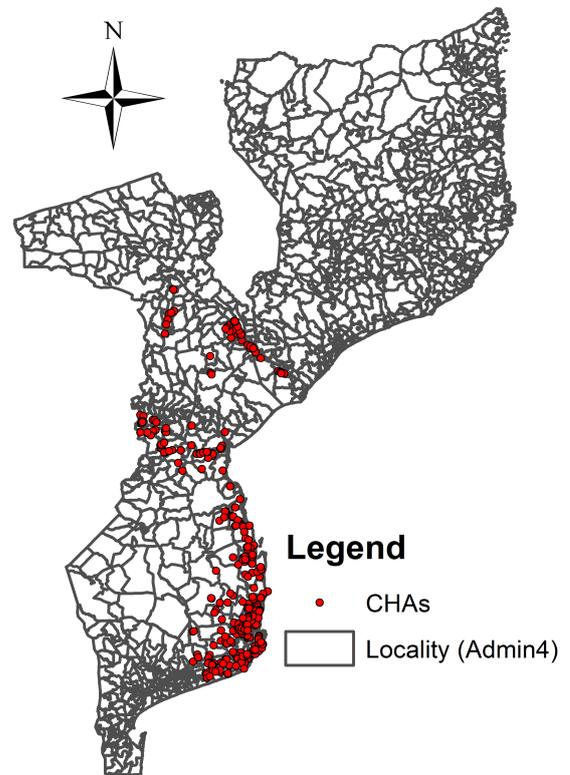


HALO Trust 2008 – 2015

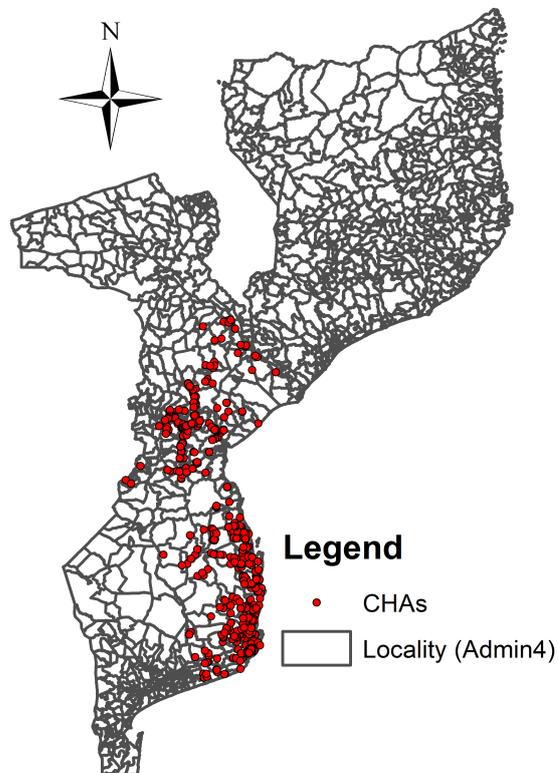
Figure 10: HALO Trust Interventions by Period



Handicap International 1992 – 1999

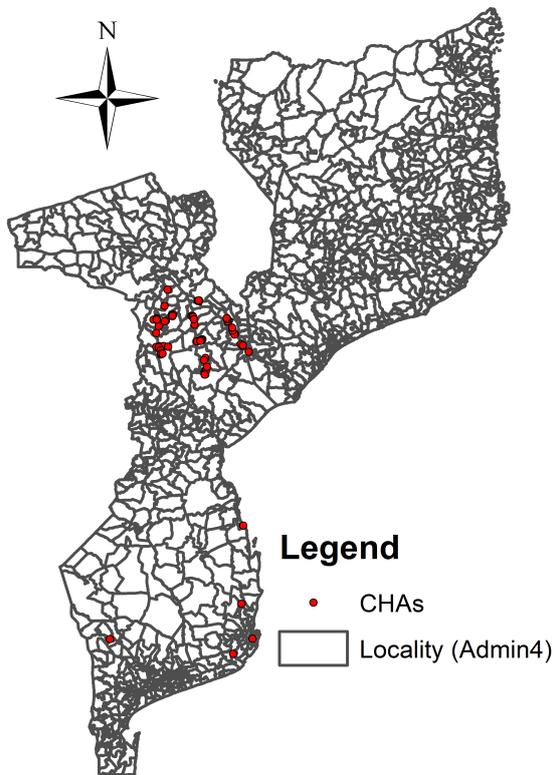


Handicap International 2000 – 2007

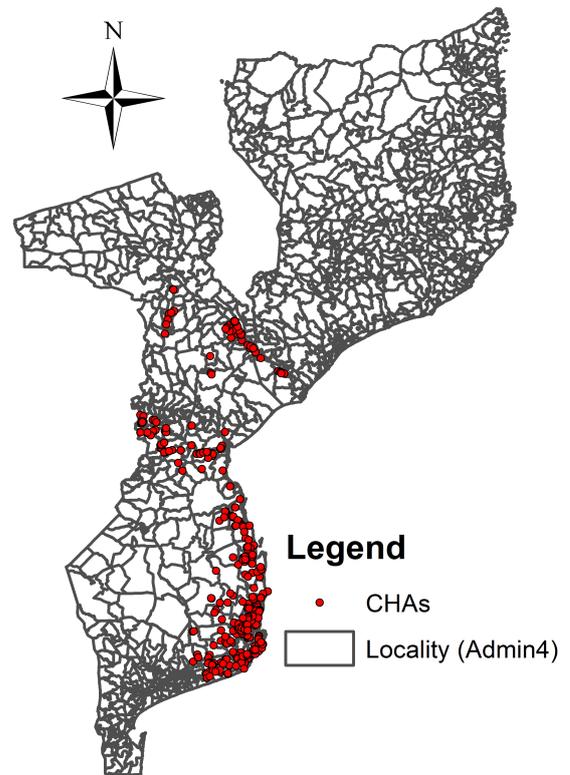


Handicap International 2008 – 2015

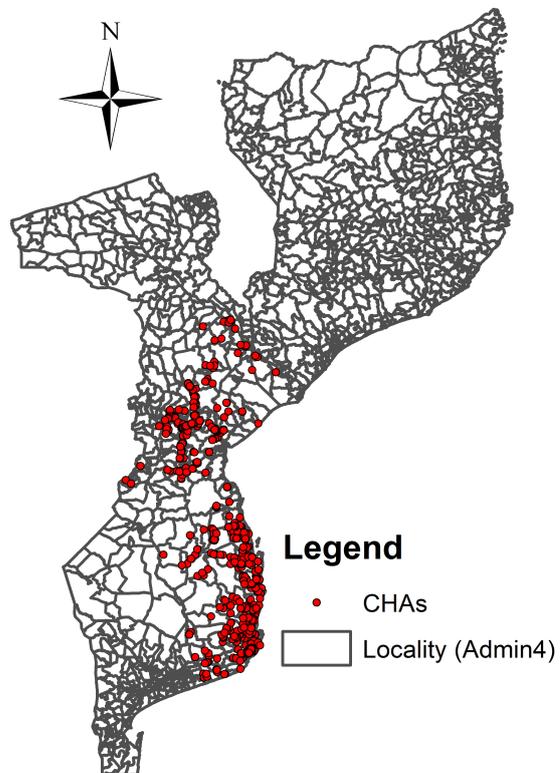
Figure 11: Handicap International Interventions by Period



NPA 1992 – 1999

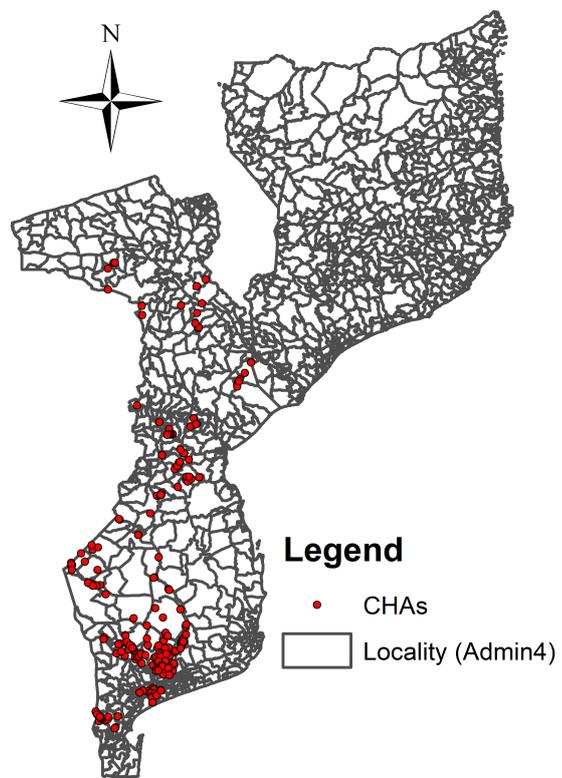


NPA 2000 – 2007



NPA 2008 – 2015

Figure 12: Norwegian People's Aid Interventions by Period



APOPO 2008 – 2015

Figure 13: APOPO Interventions by Period

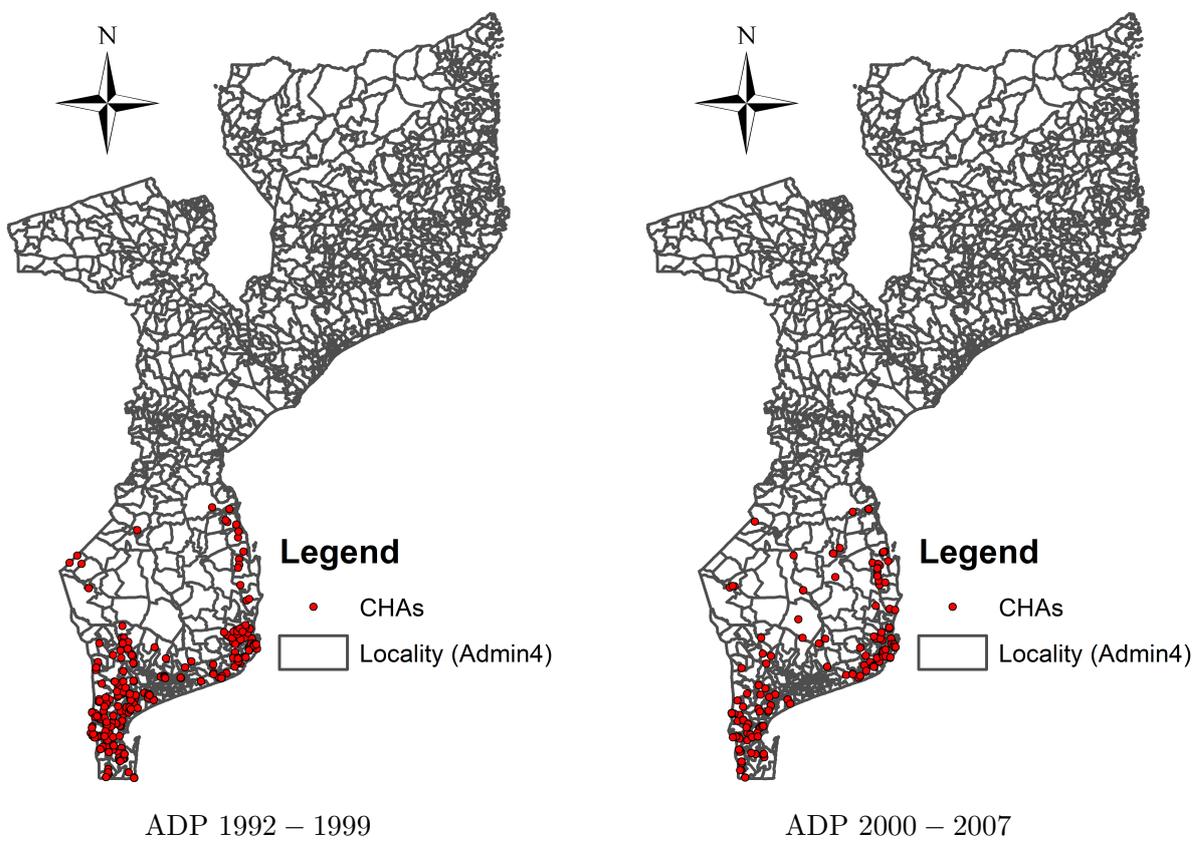


Figure 14: UN Accelerated Demining Program Interventions by Period

2.2 Duration of Interventions

Another important dimension regards the timing of interventions and its duration. For each intervention, we have information on the starting and ending date. Officials at the National Institute of Demining and the various NGOs alerted us that this information is of decent- but far from perfect quality. In Table 2 we break down the duration for each intervention. Around 92% of interventions were concluded in less than one year. The average intervention in this subsample lasts for 51 days. Around 3.62% of operations were concluded one year after the starting date. An additional 3.46% of intervention finished between 2 and 4 years after the start of the demining activities. Less than 1% of operation lasted more than 5 years, with a delay of 8 years in concluding the operations for 6 interventions. The longest intervention lasted 12 years in Macomia (Cabo Delgado), starting in August 1993 and concluding in November 2005. We further disaggregate the duration at the daily frequency. IND officials and deminers alerted us on non-negligible noise on the exact date and timing of intervention, though they argued that the reported year should be fine. These statistics should be, however, interpreted cautiously. The average time from start to finish of a demining intervention is 123.2 days; the median is just 8 days, as 41.6% of all interventions started and finished on the same day.

Table 2: **Duration at Intervention Level**

Years of Duration at Intervention Level	Freq.	Percent	Cum.
0	6,564	92	92
1	258	3.62	95.61
2	159	2.23	97.84
3	61	0.85	98.7
4	27	0.38	99.07
5	47	0.66	99.73
6	5	0.07	99.8
7	9	0.13	99.93
8	4	0.06	99.99
12	1	0.01	100
Total	7242	100.00	

2.3 Area of Interventions

We have information on the area of interventions as well as how many items (landmines and UXOs) that got cleared. Regarding the area of interventions, we have information on the cleared square meters for 4,202 interventions (56% of the universe of interventions). The average is 64949 square meter (a square with a side of 250m); while the median is 2500 square meter. The largest minefield we have measures 45,870,000 square meters (a square with a side of 6,7km) and it is located in Gurue district in Zambezia. Another large minefield (7,422,200 square meter) was cleared by EDM in 2006 on a road in Namacurra village (Zambezia province). APOPO in 2009 cleared the largest minefield (1,704,225

square meter) in the post-2008 period on the Maputo-Komatipoort corridor (Tsokate locality in Gaza province).

2.4 Items Removed

Regarding the items removed, we have information for the number of landmines and UXOs removed/destroyed for around 80% of the sample. In this sample, we have 1,787 interventions in which the clearance process led to no items found; while 4,252 led to the discovery of at least one landmine or UXOs. The average number of landmines is 41.22 with a standard deviation of 769.86; while the average number of Unexploded Ordnances is 577.61 with a standard deviation of 5,569.7. The largest number of landmines was found in Nametil (Cabo Delgado) in 2000 by HALO Trust. The minefield contained 29,729 landmines (28,773 Anti-Personnel mines and 955 Anti-Group mines). The most contaminated minefields in the post-2008 period were demined by HALO Trust in 2014 in Magoe district (Tete) at the border with Zimbabwe. Figure 15 depicts the two polygons for Khahira Luia and N'Soluwamuthu minefields; HALO Trust cleared 14,608 and 11,656 landmines, respectively.

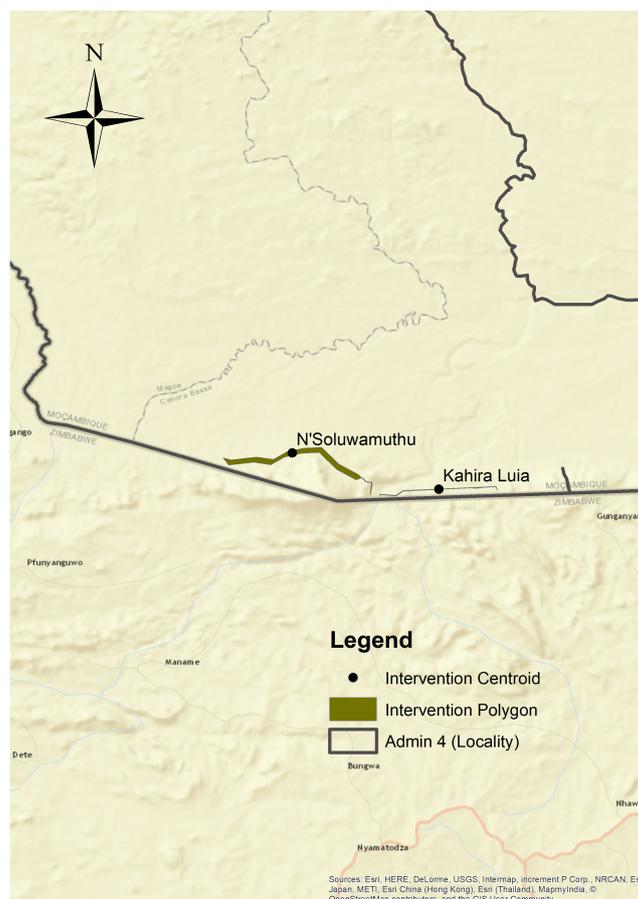


Figure 15: Khahira Luia and N'Soluwamuthu minefields (Tete province at the border with Zimbabwe)

High quality data stores information on both the country of production and the model of landmines. Panel A of Figure 16 illustrates the distribution of landmines by country of production for the period 2008 – 2015. In line with the history of the Civil War (see Appendix I), the majority of landmines were produced in Soviet Union 44.23% which was supporting the FRELIMO side. A sizable percentage of landmines (36.49%) were South African made, one of the main supporter of the RENAMO cause. Non negligible is the contamination due to the War of Independence: 1 every 10 landmines found between 2008 and 2015 was produced in Portugal. The same pattern is reflected by the most frequent landmine models deminers cleared. The Soviet MAPS landmines accounts for 35.91% of the landmines found in the post-2008; while the South African R2M2 model accounts for 25.2% of the cases.

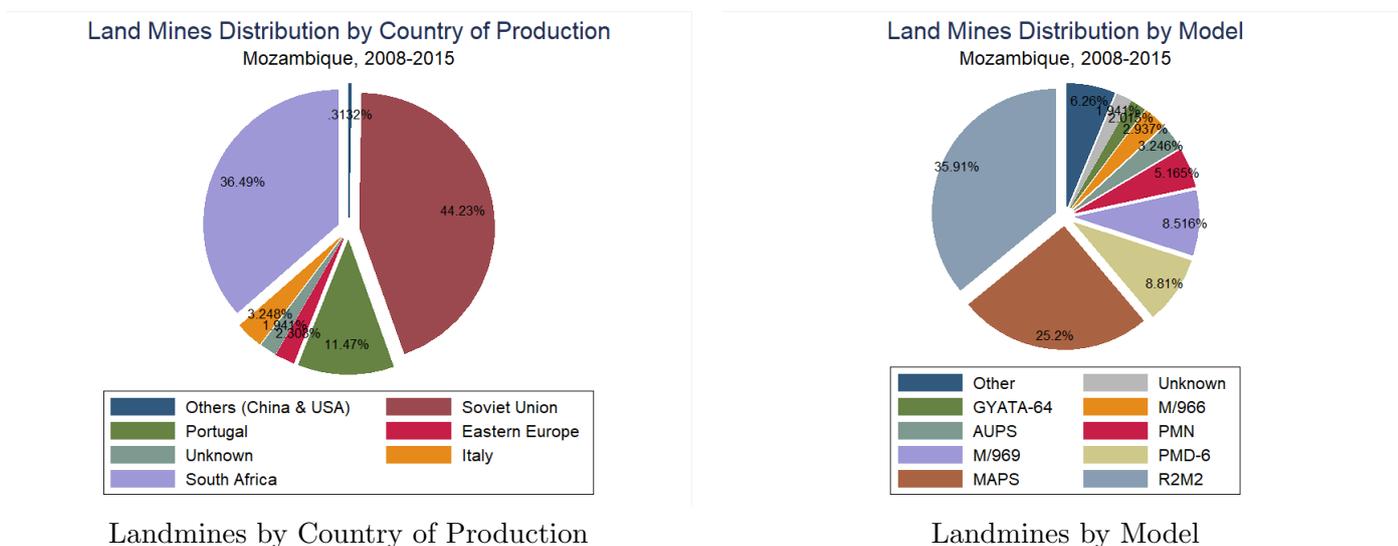


Figure 16: **Distribution of Landmines by Model and Country of Production.**

2.5 Heterogeneity Categories.

2.6 Report Based Categories

A characteristic of high quality reports is to contain a short description or a classification regarding the affected area of minefield. We are able to construct non-mutually exclusive categories for 4,497 interventions (60% of the total sample). To construct a report based classification we extracted information from the following fields of the original data:

- Type of Cleared Area: Contains further information on the actual area type that got demined.
- Area Enumeration: Containing a classification by the deminers on the type of area affected by the hazard.
- Hazard Name: The name of the site.

- **Hazard Description:** This contains a description compiled by the deminers of the activity performed as well as information on the site conditions.

First, we employed ready-to-use categorization following the one conducted by deminers and practitioners. Type of Demined Area and Area Enumeration store the following categories: footpath, farmland, village, school, house, road, forest, water supply, military infrastructure, coast, river, pasture, public infrastructure, residential area. From these two categories, we retrieve information from 916 out of 4497 interventions. In case of disagreement in the classification (when both are present), we assign the Type of Area Demined as this represent the place in which the demining intervention was performed.

Second, we apply a semantic search algorithm based on the name of the hazard. Following the practitioners categorization, we selected keywords to be assigned to the corresponding categories. For example, a hazard named like “Frelimo Barrack” is assigned to Military; while a hazard titled “Lichinga Road” is assigned to Road categories.

Third, we manually imputed multiple categories for those interventions that have a description of the activities performed. In some instances the information has to do with the performance of the clearance e.g. “Demining is Proceeding well” or “The minefield was fully demined”. In other cases, irrelevant information for the classification are stored e.g., “Mined Area”. Notice that the these two procedures combined increased the number of report based categories to 3581 (79.6%) out of 4,497. Not all the Hazard Description contents are useful for classification; as such we cannot retrieve meaningful information for 700 cases. For 2,131 interventions (47.4%) we derive the categorization from the name only; and for 1450 interventions (32.2%) we use the detailed description.

Forth, we further aggregated the different categories for the 4497 interventions into 13 non-mutually exclusive report-based categories: i) Road, Railway, Bridge; ii) Border; iii) Protection Ring & Residential; iv) Public Infrastructure; v) Military; vi) River; vii) water supply; viii) Electricity Pylons; ix) Footpath; x) Forest/Bush; xi) Farm; and xii) Not Classified. To better clarify the contents of the report based categories we report few examples for the some of these categories.

2.6.1 Example of Road Category

- ”The risk is not so high because even though it is suspected, the people are using the road as footpath. They acknowledge that only AT mines are suspected. Vehicles are not using the section of suspected road. There is alternative from the tour. The road from Mararanhe to Chissenguane was used as a main one from Buzi to Mushungue EN1 by big bus before civil war. Chissenguane village was occupied by Renamos troops. They mined the road from Mararanhe to interdict Frelimo troops movement on the road attacking them. According to the informants that information was supplied by old Renamos soldiers to local leaders. The certainty existing threat is because of the AT mine detonated on the road Estaquinha-Chissenguane in 2006 after vehicles moved on it several times. Locals would like the road to be renovated after clearance.”
Chissingana Locality in Sofala Province

- The road between Namarroi and Molumbo in NEIGHBOURING Milange District had long been closed due to the threat of mines. Halo employed LIRV to verify the road as clear and thus reopened this important inter-district highway bringing improved mobility, trade and all the attendant socio-economic benefits. Regone Locality in Zambezia Province.
- “The minefield is a turn in the Nacaroa-Mossuril track, 2km before Namipiza bridge, near Intete primary school and follow the road to Intete village.”

2.6.2 Example of Border Category

- “The minefield is all the same of ejacamba the system of mining and types of mines. It is also the same direction to Pundanhar and was mined by the Portuguese to hinder the Frelimo who were staying in Tanzania during the war time.” Nangade sede, Nagade District, Cabo Delgado province
- “The minefield starts from Mtitimila village where barbed wire started at 40m wide and 21km long. This goes to Pundanhar direction and was mined by the portuguese to hinder the Frelimo soldiers who were hiding themselves in Tanzania and were crossing Rovuma river to fight with the colonies.” Nangade sede, Nagade District, Cabo Delgado province
- “Along the border with Zimbabwe there are mines to prevent rape..” (Translated from Portuguese) Ressano Garcia town, Moamba district, Maputo province

2.6.3 Example of Protection Ring & Residential Category

- “All the entrances of the village are surrounded by AP mines, which are now identified as PMN and PMD-6 by a resident, on both sides of the small bridge. of the population. Information provided by the local Military Command” Maguiguana locality, Manhica district, Maputo province
- “the mined area starts from west part of Buzi river all the way to east region in a circle of 7 Kms around the village.” Buzi town, Buzi district, Sofala province
- “Ring that protects the village.” (Translated from Portuguese) Nalazi village, Guija district, Gaza Province
- “North to West area around the Hospital Town.” Murrupula town, Murrupula district, Nampula province
- “the area is situated close to the church, within meters of the local population and there fields.” Intaria locality, Macanhelas district, Niassa province.

2.6.4 Example of Military Category

- “This is an old frelimo base that served as a defense line for the village. They laid mines around the base in defense against the enemy attack from behind. The minefield runs from south to north with a distance of 50-100m from the base. It is limited to Northeast by cultivated field. ” Ex Frelimo base. Marromeu municipality in Sofala Province” (Translated from Portuguese).
- “Additional information: In this place is the former command of the FPLM near the local Dumbanengue (market) of Sitila.” (Translated from Portuguese) Sitila in Inhambane Province
- “The community sates that this minefield prevents them from moving freely in the area. The community is concerned that the local children born after war wont fear the area and might enter and have accident. Older resident avoid this area but if cleared would like to use it for farmland. Vuca centro dos antigos combatentes was a center or place inhabited by ex Frelimo liberation war troops. This ex-military center was once severely attacked by Renamo and for this reason a good re-enforcement of troops was sent by the government and all the population from the surrounding villages including Vuca was gathered together in the military center for protection. In order to deter Renamo troops, Frelimo soldiers laid mines in the south side of the center. The vast area between the center buildings and the suspect area was used for agriculture in order to produce food for the people living in the center during the war. Three accidents occurred during the war involving two children and a man who all died. This area is needed by the local for housing, chopping of sticks and wood for cooking and expansion of their cultivations.” Centro de Antingos combatentes. Maimelane municipality in Inhambane Province
- “The mined area is a semi-circle where once there was a position of the 26th battle of the 2nd Mapai brigade, part of the village of Chipilimo that connects to the Dindijiva lagoon field.” Mavue Sede in Gaza Province (Translated from Portuguese)
- “The mined area surrounds the barracks directly behind the Marrupa-Majune road.” Marrupa Barracks. Marrupa Sede in Niassa

2.6.5 Cross-Tabulation of Report-Based and GIS-based Categories

Finally, we illustrate the relationship between the report-based classification and the GIS-based one. We highlighted in bold the element of the matrix that belong to “common” categories in the two classification. For example “Road, Railways, and Bridge” report-based category is associated with Road and Railway GIS category. Our validation works quite well for categories like Electricity Pylon. It is worth noticing that we performed badly for both Road and Railways and Village GIS categories.

GIS Categories vs Report Based Categories

Matching Report-Based and GIS-Based Categories													
	Road, Railway, Bridge	Border	Protection Ring & Residential	Public Infrastructure	Military	River	Water Supply	Electricity Pylons	Footpath	Forest/Bush	Farm	Not Classified	Total GIS
GIS Road & Rail (100m)	196	106	104	38	130	108	24	17	97	36	7	478	1193
GIS Border (10000m)	36	42	40	34	53	38	12	84	29	21	31	260	618
GIS Caminas (1000m)	44	65	82	18	53	75	9	2	57	19	3	269	617
GIS Civil War (1000m)	17	38	47	14	23	27	5	9	32	9	3	156	342
GIS River (100m)	5	1	7	2	3	2	0	0	3	1	0	16	37
GIS Village (1000m)	94	85	129	21	122	91	8	44	81	28	4	458	1052
GIS Electricity Grid (100m)	7	10	9	8	1	5	1	256	12	8	0	58	360
GIS Residual	302	313	378	234	578	430	69	658	235	121	1	1731	4656
Total Report-Based	669	542	667	331	845	661	117	957	448	218	32	2851	7423

Notes. The table reports cross-validation between the report-based and GIS-based categories. The Data Appendix gives detailed variable definitions and data sources.

3 Disaggregation by Provinces and Periods

In this section we provide a detailed description of the three periods of the Mine Action program for each of the ten Mozambican provinces.

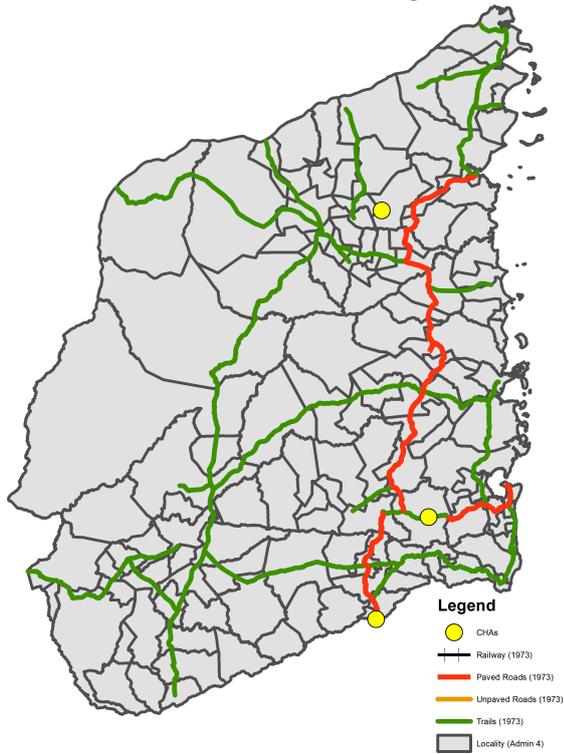
3.1 Cabo Delgado Province

The province of Cabo Delgado experienced 508 demining interventions from 1993 to 2012. As in the other three Northern provinces, the key player was HALO Trust. In fact, HALO performed 87.2% (443 interventions) of the demining activities in the region. Other demining operators include: AFROVITA (1), Empresa Moçambicana de Desminagem (EDM) Lda (5), IND (10), MONECHECHA Ltda (1), MOPROTECTOR Lda (3), and Mine Kills Lda (2). Moreover, we added 42 cleared minefields from the LIS 2007. According to GIS-classification, the two main categories of interventions were villages (93) and the transportation network (68) (see Figure 18).

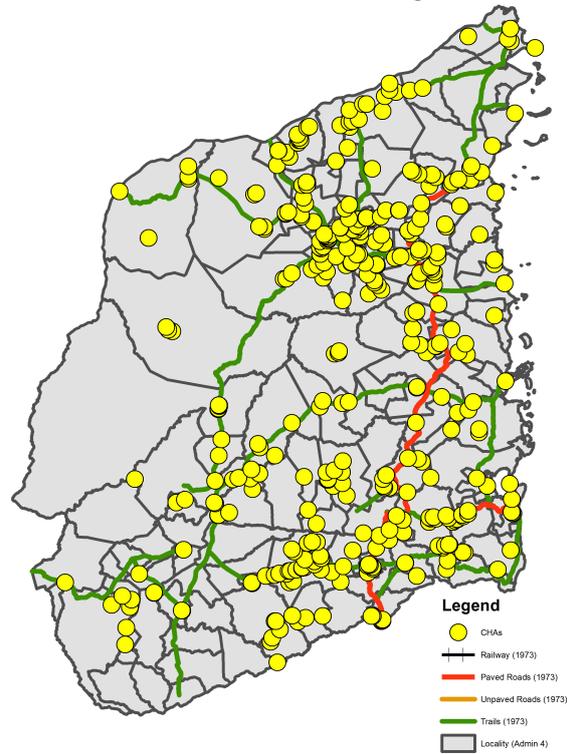
Appendix Figure 17 portrays the spatial distribution of demining activities in Cabo Delgado for each of the three phases of the Mozambican Mine Action program. Out of the 130 localities in Cabo Delgado, 98 (75.4%) were affected by land mines contamination in 1992. In the first period of the Mine Action program (1992-1999), almost no demining activities took place. Starting in 1997, HALO Trust slowly started to deal with the contamination problem in the region. In the late 90s, HALO performed a total of 3 demining operations including a road and a village. The second period (2000-2007) represented a turning point in the demining activities of the province. HALO Trust completed 440 demining interventions, eliminating 86.6% of the total threats in Cabo Delgado. AFROVITA is the only other NGOs to be active in this period (1 intervention in 2004).

By the end of 2007, 86 out of the 98 contaminated municipalities were now free from landmines. After the departure of HALO Trust to the South of the country, some residual threats (21) were cleared by few Mozambican commercial operators: EMD (5), IND (10), MONECHECHA (1), MOPROTECTOR (3), and Mine Kills (2).

Clearance of CHAs in Cabo Delgado 1993-1997



Clearance of CHAs in Cabo Delgado 2000-2007



Clearance of CHAs in Cabo Delgado 2008-2015

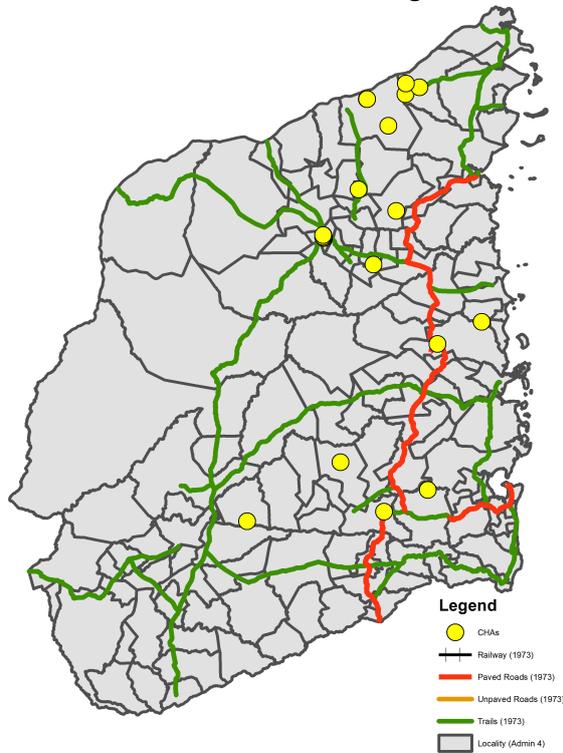


Figure 17: Interventions in Cabo Delgado

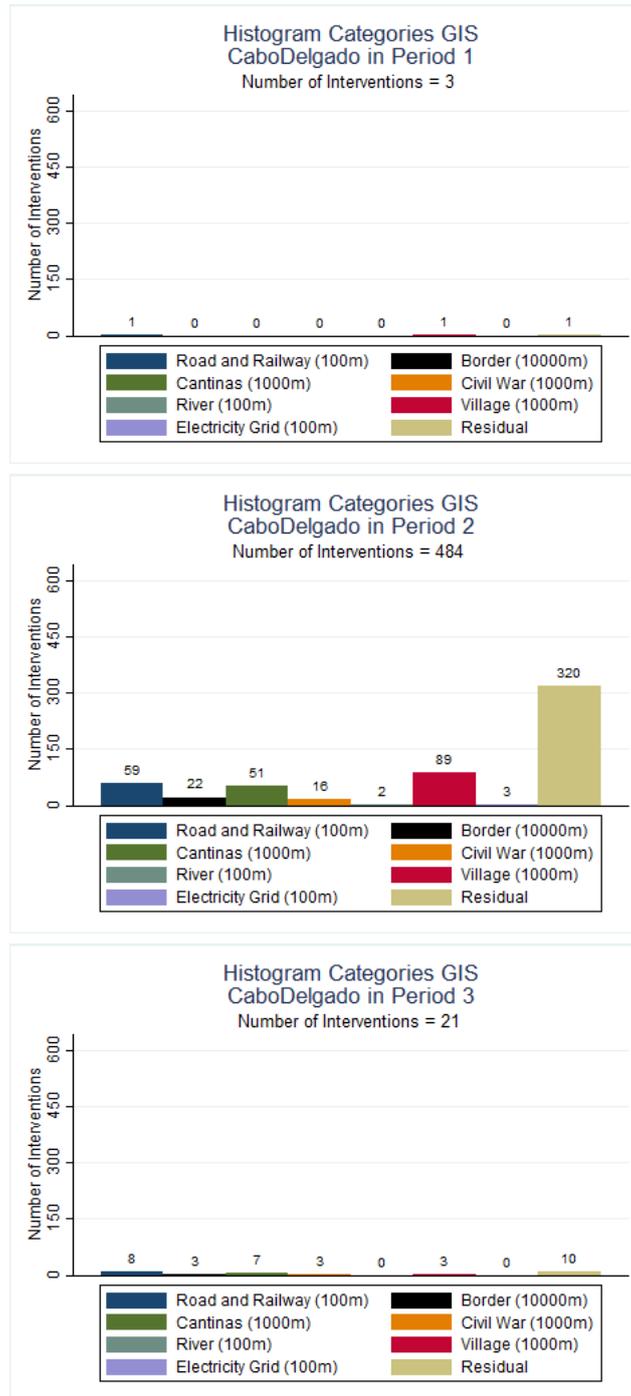


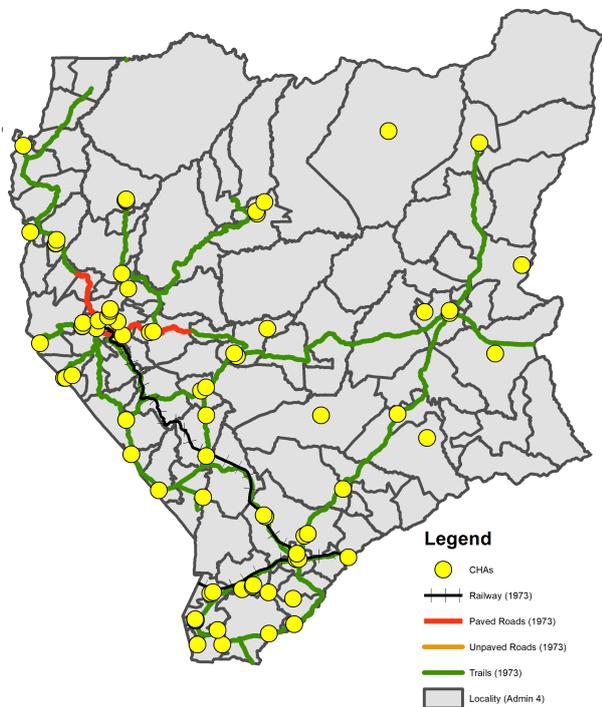
Figure 18: GIS Category Interventions in Cabo Delgado

3.2 Niassa Province

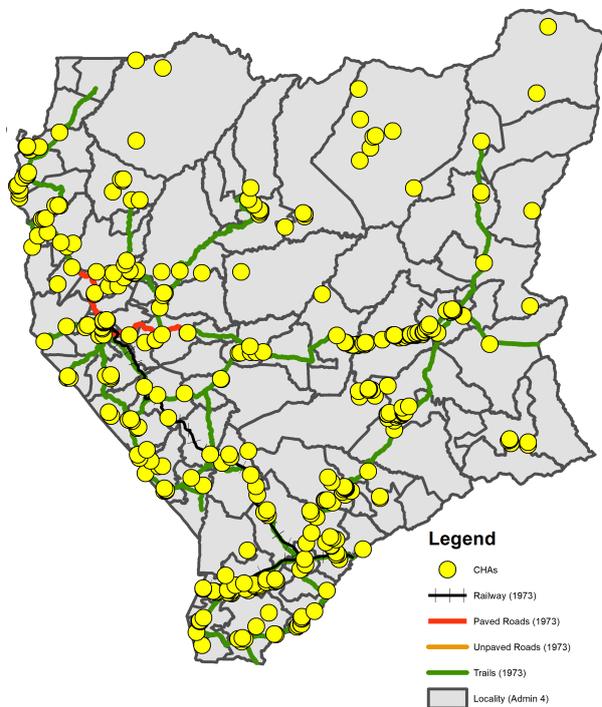
Niassa province saw a total of 572 demining interventions from 1995 to 2012. HALO Trust, which completed 78% (446 interventions) in the region. The Mozambican Army (Forças Armadas de Defesa de Moçambique - FADM) has been second most important player in Niassa, with 47 interventions. The other operators active in Niassa were: EDM (2), IND (19), MF Investimentos (1), MONECHECHA (1), MOPROTECTOR (3), Mine Kills (11), and Scorpion Desminagem Lta (3). The LIS 2007 recorded additional 28 interventions. Figure 20 gives the non-mutually exclusive GIS-based categories for the province. Across the three periods, the majority of interventions were on the vicinity of the villages (89), border (55), and transportation network (54).

Appendix Figure 19 shows the spatial distribution of demining activities in Niassa for each of the three periods. Contamination across localities was severe: 83% (73 out of 87) localities were affected by minefields. Regarding the first period (1992-1999), HALO Trust commenced landmine clearance in 1996, after two demining interventions in 1995 (one performed by the UNHCR). By the end of 1999, 86 interventions were completed by HALO, with the majority of clearance targeting trails and roads (59%) and villages and colonial commercial places (32%). Some demining activities (8%) took place along the Lichinga-Cuamba railway line. In the beginning of 2000, no affected locality was listed as mine-free. With the new millennium, demining operations increased throughout the province. HALO Trust continued to be the principal player in Niassa. By the end of 2007, HALO had completed 81% (307) of the clearance activities. In 2003-2004, the FADM also completed several tasks (47). During this period, the Mozambican commercial operator EDM cleared a trail and part of the electric lines nearby Lichinga. These efforts allowed to declare 41 localities landmine free. In the last period (2008-2015), few more CHAs out of the HALO's "Baseline Assessment" were discovered. Additional 46 interventions were performed between 2010 and 2012. The IND, with its Northern office, directly performed 19 operations. Mozambican commercial operators completed the remaining 35 tasks in the following way: DAG (16), MF Investimentos (1), MONECHECHA (1), MOPROTECTOR (3), Mine Kills (11), and Scorpion Desminagem Lta (3).

Clearance of CHAs in Niassa 1993-1999



Clearance of CHAs in Niassa 2000-2007



Clearance of CHAs in Niassa 2008-2015

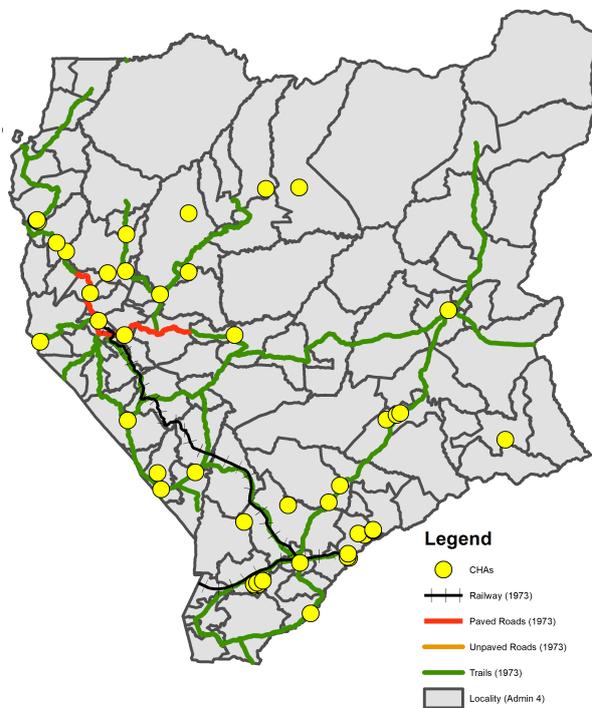


Figure 19: Interventions in Niassa

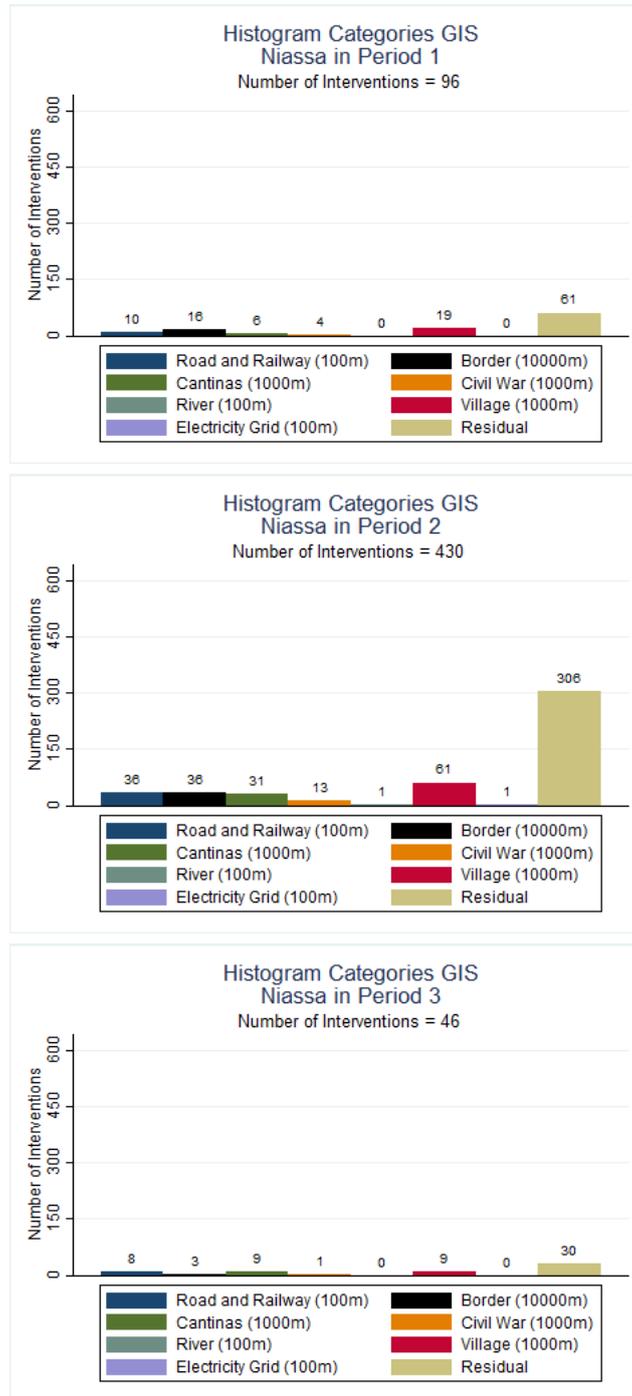


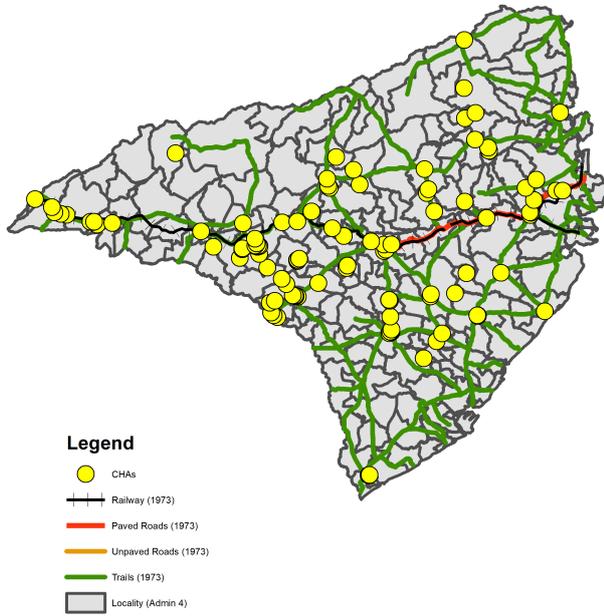
Figure 20: GIS Category Interventions in Cabo Delgado

3.3 Nampula Province Summary

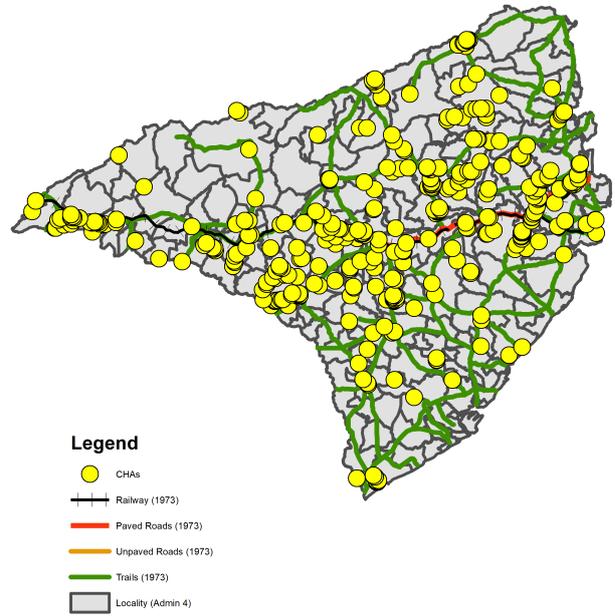
612 landmine clearance operations took place in Nampula province. HALO Trust was the main operator completing 92% (566) of the tasks. Residual tasks were performed by mostly commercial operators and one humanitarian demining company (Norwegian People's Aid). Among the commercial operators, most of them were Mozambican including Desminagem e Agricultura (DAG) (1), Empresa Moçambicana de Desminagem (EDM) Lda (2), MONECHECHA (4); while, the UK MINE-TECH and the Dutch REASeuro were among the foreign commercial demining companies active in Nampula. Finally, IND, which created a local office in Nampula in 2009, performed 6 demining interventions. Regarding the GIS-based categories, 137 interventions involved demining around villages; demining activities on roads and railways were also particularly intense: 79 intervention targeted the transportation network, with the railway line connecting Lichinga to Nampula severely affected. Figure 22 reports the GIS-categories interventions by period.

Appendix Figure 21 depicts the spatial distribution of demining activities in Nampula across the three periods. Contamination in Nampula province across localities was smaller, in relative terms, compared to the other Northern provinces: out of the 172 localities, 106 (62%) were affected by landmines. In spite of the dominance of HALO Trust in Nampula, NPA performed the first demining in 1994 in the village of Imala, nearby Mecuburi. In 1996 HALO Trust started to operate in the province. By the end of 1999, HALO had cleared 120 threats. In 1997 MINE-TECH made two interventions on the primary road connecting Lichinga to Nampula. EDM performed a demining intervention on the railway line linking Lichinga to Nampula in 1999. At the beginning of 2000, demining operations freed 6 localities from mine contamination. The second period of the Mine Action program saw significant progress in terms of demining activities in Nampula. HALO Trust had completed 446 interventions by the end of 2007. Between 2005 and 2006, the Dutch REASeuro completed 9 interventions on roads and on the electric grid between Nampula and the town of Mussuril. The Mozambican commercial firm EDM cleared a road nearby the town of Nametil in 2006. These efforts reduced significantly the number of localities affected by landmines to only 9 at the end of 2007. After 2007 and the departure of HALO Trust, subsequent surveys detected few new minefields. 13 additional operations were performed by the IND (6) and Mozambican commercial companies (DAG (1), JV Desminagem (2), and MONECHECHA (4)) between 2010 and 2012.

Clearance of CHAs in Nampula 1993-1999



Clearance of CHAs in Nampula 2000-2007



Clearance of CHAs in Nampula 2008-2015

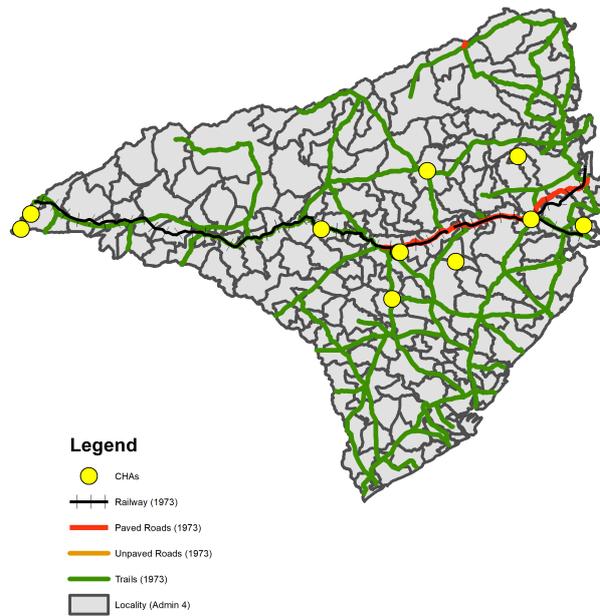


Figure 21: Interventions in Nampula

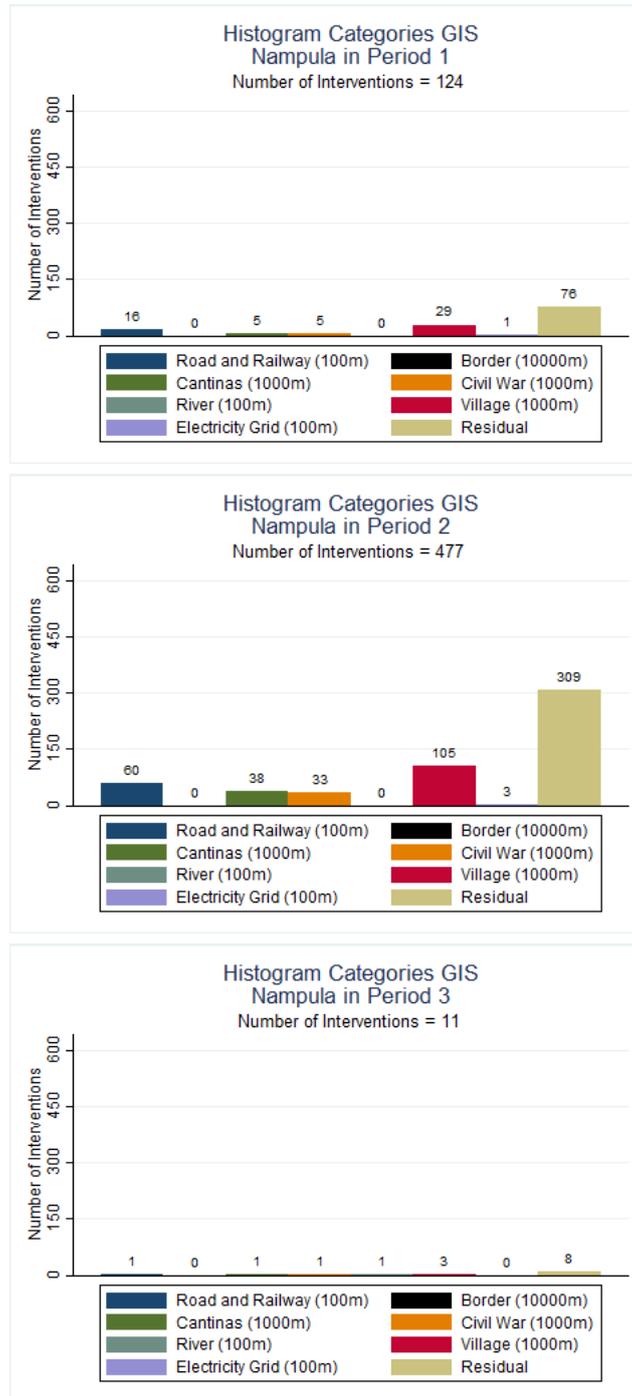


Figure 22: GIS Category Interventions in Cabo Delgado

3.4 Zambezia Province Summary

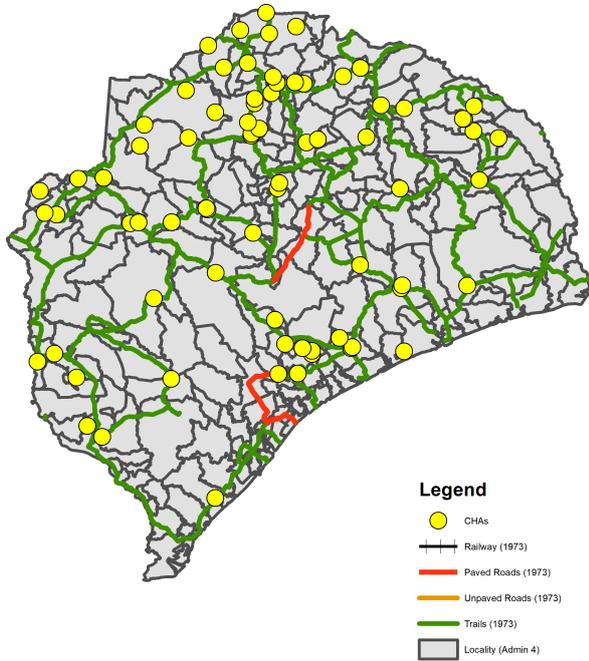
The province of Zambezia experienced 759 demining interventions during the Mine Action program in Mozambique. HALO Trust performed 86% (654) of the interventions. The residual players were JV Desminagem (14), MINE-TECH (11), IND (12), RONCO (9), Desminagem e Agricultura (DAG) (8), Empresa Moçambicana de Desminagem (EDM) Lda (8), Mine Kills Lda (3), Norwegian People's Aid (3), MONECHECHA Lda (2). Figure 24 plots the distribution of GIS-based categories by period. The mostly affected category in Zambezia is the transportation network (192), followed by villages (109).

Appendix Figure 23 illustrates the spatial distribution of demining activities in Zambezia across time. At the time of the Peace Agreement in Rome, Zambezia presented the highest number of mine-affected municipalities in Northern Mozambique: a total of 136 (66% of the total number of localities). Between 1992–1994 HALO Trust did 7 interventions and established its headquarters in this province. At the same time, RONCO (4) and NPA (1) were active on the ground. In response to the need for refugees repatriation from Malawi, the majority of demining operations in this period focused on the clearance of threats affecting roads and trails.

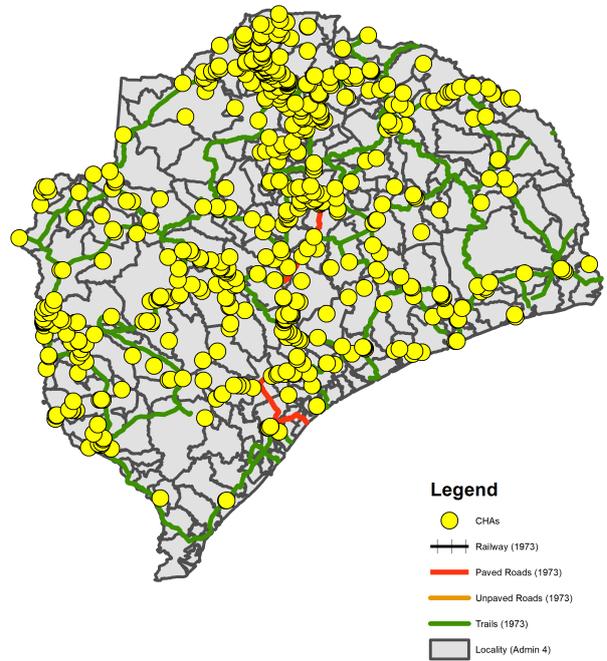
These initial operations allowed to fully clear only one locality. By the end of 1999, Halo Trust reached 61 interventions in the province. RONCO performed few interventions (5) in 1995 before terminating its contract with USAID; while in 1998 MINE-TECH did a couple of demining activities.

During the first phase, a total of 6 municipalities were completely demined. In the second phase (2000-2007) demining operations accelerated. A total of 660 clearance tasks were concluded. HALO Trust completed 586 demining activities and closed its operation in the province in 2007. Two Mozambican commercial operators EMD, JV Consultores and the UK MINE-TECH completed a total of 30 interventions (7, 14, and 9, respectively). As in the previous period, the majority of demining activities took place along roads (57%) and villages (28%). As a results of this process, 115 municipalities were declared fully cleared from the threats of landmines. After being declared mine-free in 2007, few more minefields were found in 2010 (19 interventions coordinated by the IND with the involvement of local commercial operators DAG, MONECHECHA, and Mine Kills) and in 2012 (2 demining activities from DAG).

Clearance of CHAs in Zambezia 1993-1999



Clearance of CHAs in Zambezia 2000-2007



Clearance of CHAs in Zambezia 2008-2015

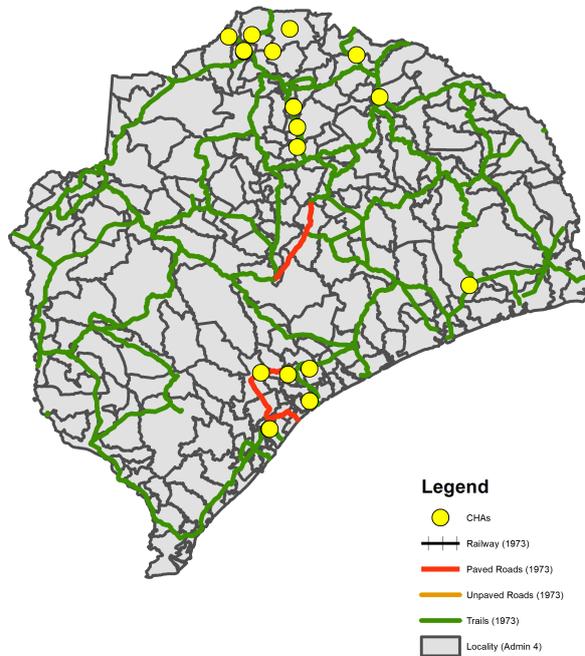


Figure 23: GIS Category Interventions in Zambezia

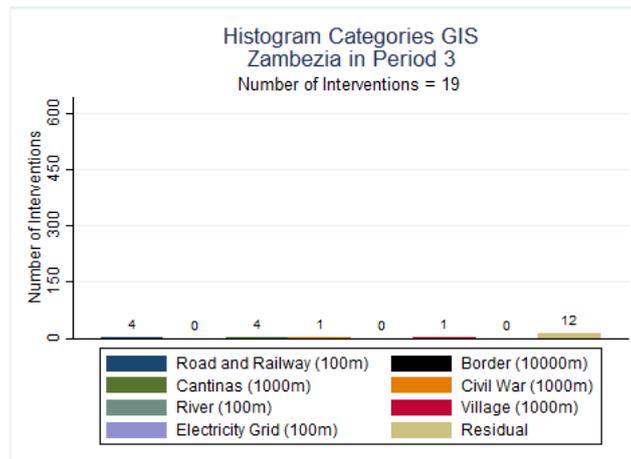
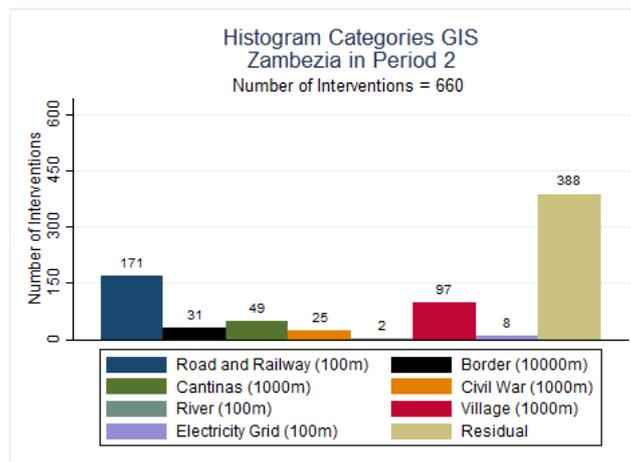
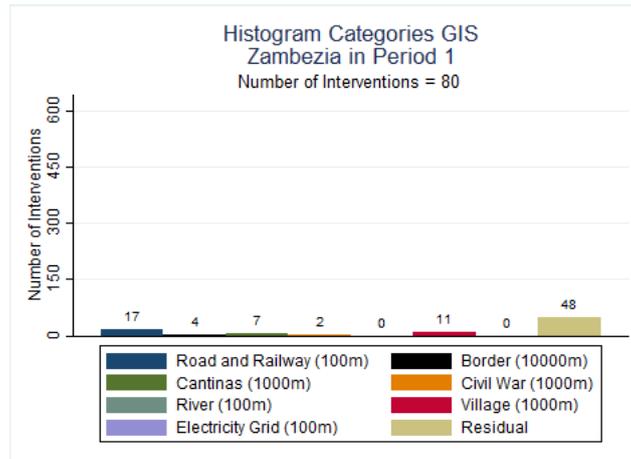


Figure 24: Interventions in Zambezia

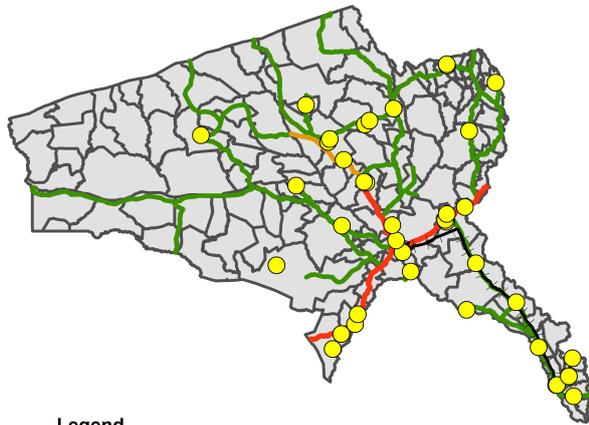
3.5 Tete Province Summary

From 1993 until 2015, 327 demining interventions were performed in the Central-Eastern province of Tete. During this period 13 humanitarian and commercial, demining operators were active. HALO Trust completed 165 interventions and the Norwegian People's Aid 90. Other clearance actors were APOPO (10 interventions), BACTEC (2), Desminagem e Agricultura (6), Empresa Moçambicana de Desminagem (EDM) Lda (6), JV Desminagem (1), MF Investimentos Lda (4), Mechem (2), Mine Kills Lda (3), and RONCO (5). As Figure 26 shows, the majority of interventions were performed to clear the border with Zimbabwe (71 operations), followed by clearance of roads (58) and villages (46).

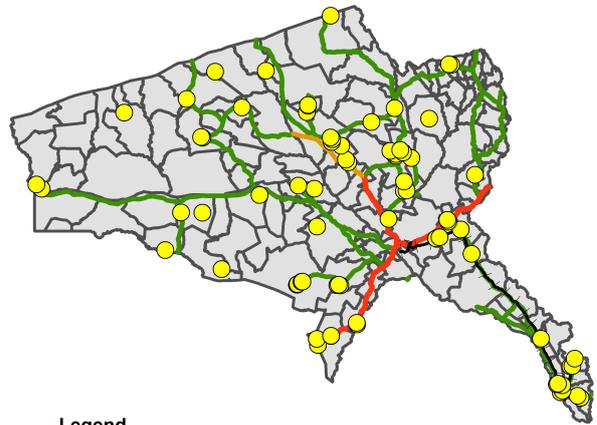
Appendix Figure 25 portrays the spatial distribution of demining activities in Tete. In 1992, 71 (56%) localities out of 127 were affected by landmines, one of the smaller contamination rates in the country. Tete was one of the provinces where the early years (1992-1994) of demining activities were highly productive. Under the direction of the ONUMOZ mission, both NPA and the commercial firms Mechem and RONCO undertook several road clearance interventions to facilitate refugees' repatriation from Malawi. NPA completed 11 demining interventions at the end of 1994; while, Mechem and Ronco performed 2 operations each. From 1995 to 1999, NPA kept on going with demining operations in the province, concluding 27 additional interventions by the end of 1999. In 1997, Mechem cleared a threat on the Zambezi river, nearby Cheuza locality in Mutarara district.

By the end of the first phase, 6 municipalities were freed from the threat of land mines. From 2000 to 2007, the clearance progress started to slow down. Only 76 interventions were completed by NPA (40), DAG (2), and RONCO(3). Ronco came back in the region in 2005 – 2006 to clear villages and roads nearby the town of Nhamayabue (Mutarara district). While the Northern provinces experienced an increase in the pace of demining across localities, only 21 were fully cleared during these 8 years in Tete. Following the departure of NPA from the Mozambique in 2006, several players entered Tete province to finish the demining process in the region. From 2008 till 2015, HALO Trust completed 165 interventions. APOPO contributed with 10 operations in 2013 and 2014. While, NPA, returning in Mozambique in 2012, completed 12 additional tasks from 2012 until 2015. The remaining operations were divided as follows: Bactect (2), DAG (4), EMD (6), IND (2), JV Desminagem (1), MF Investimentos (4), MOPROTECTOR (1), and Mine Kills (3).

Clearance of CHAs in Tete 1993-1999



Clearance of CHAs in Tete 2000-2007



Clearance of CHAs in Tete 2008-2015

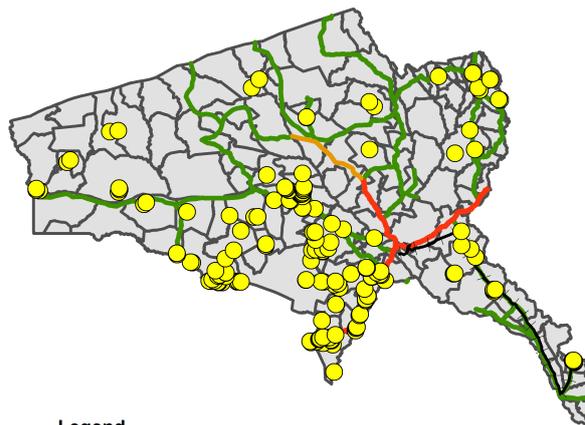


Figure 25: GIS Category Interventions in Tete

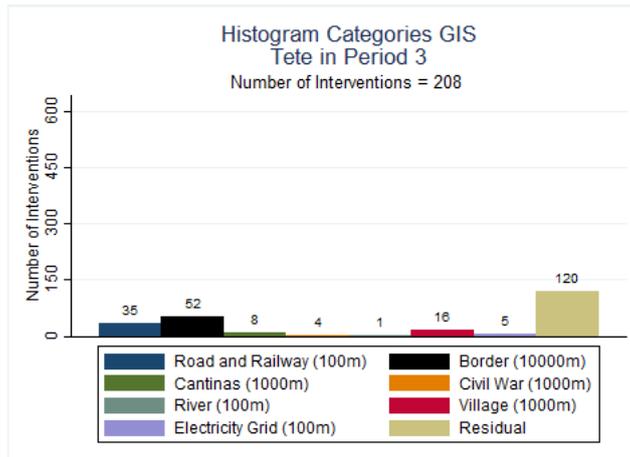
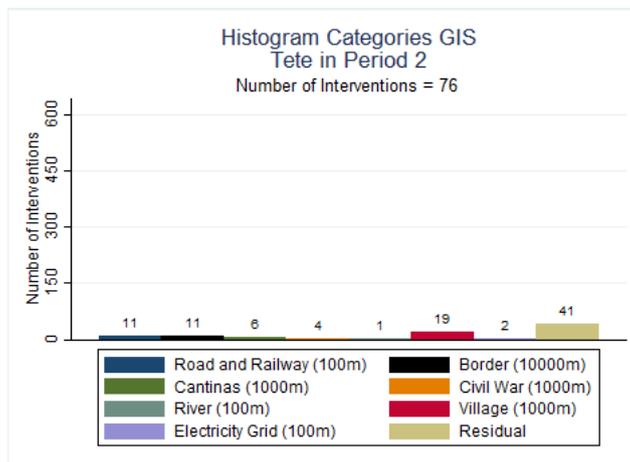
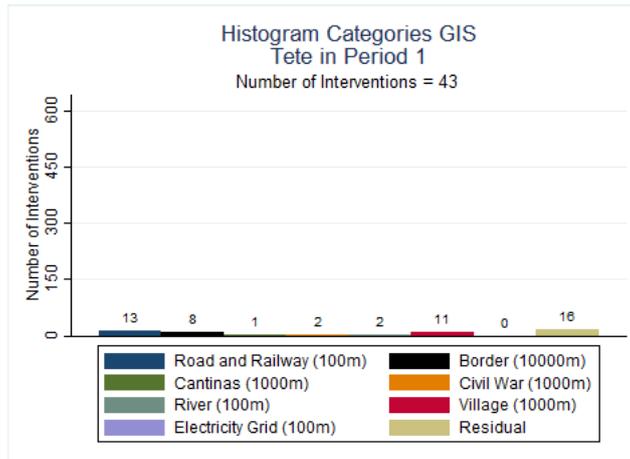


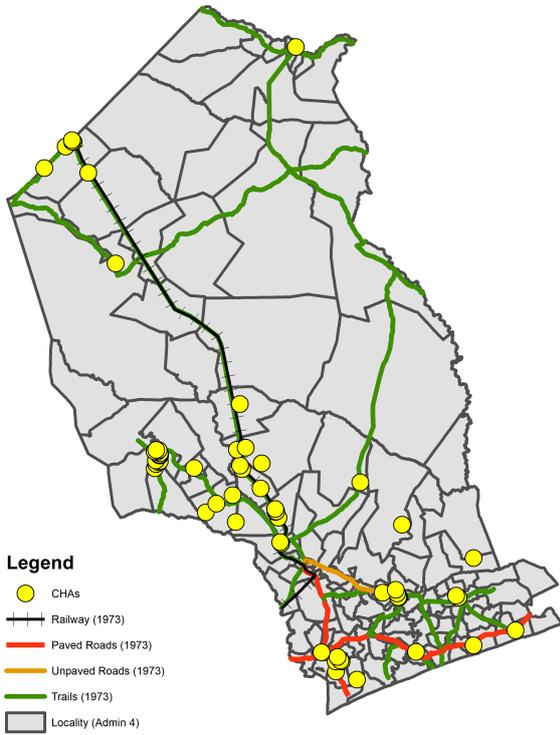
Figure 26: Interventions in Tete

3.6 Gaza Province Summary

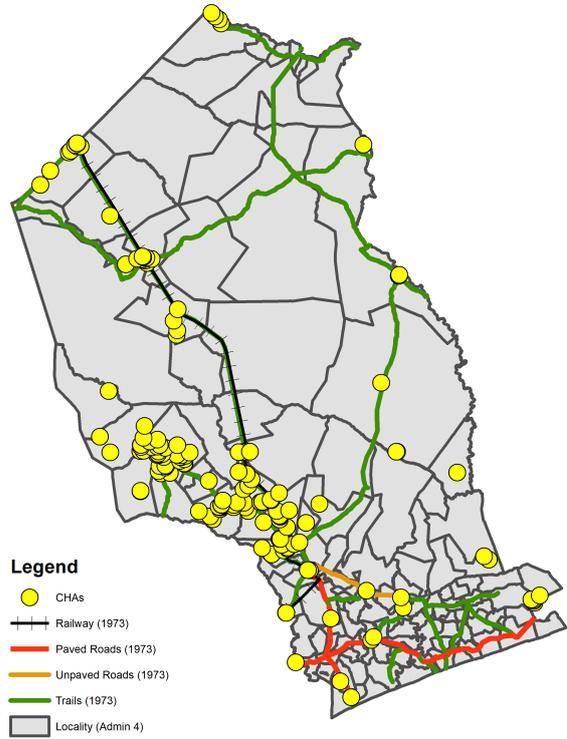
In the Southern province of Gaza, our dataset reports a total of 453 demining interventions between 1995 and 2015. During the Mine Action program, 17 demining operators were active. The actor that completed most activities in the province was APOPO, conducting almost 39% (175) of the interventions. Other important players for the province were United Nation's Accelerated Demining Program (UNADP) (64), Mozambique Mine Action (MMA) Lda (61), MECHEM (60), and Menschen gegen Minen (MGM) (40). The remaining players, operating at different stages of the program, were: AFROVITA (2), Associacao de Sapadores Macambicanos (2), ECOMS Desminagem (1), Empresa Moçambicana de Desminagem (EDM) Lda (1), Mozambican Army (Forças Armadas de Defesa de Moçambique - FADM) (3), GPC International (1), Halo Trust (9), JV Desminagem (6), MF Investimentos (1), MINE-TECH (4), and NECOCHAMINAS (6). Focusing on the GIS-based categories of interventions, 85 operations interested the transportation network (like the railway line connecting Maputo to Chicualacuala); 44 interventions were performed to clear mined-affected villages; while, 42 interventions involved the clearance for the Zimbabwean border. Figure 28 delivers the tabulation for the three periods.

Appendix Figure 27 portrays the spatial distribution of demining activities in Gaza across periods. In the beginning of 1992, the landmine contamination was present in 70 out of 129 localities (56%). Reflecting the logistic difficulties of the UNADP, which was the most important player in the South in the initial phase (1992-1994), no demining activities were recorded in Gaza until the end of 1994. From 1995, landmine clearance started in the province. The UNADP completed 42 demining operations, mostly focusing on village protection-ring clearance (like Macia, Eduardo Mondlane and Mandlakaze villages) and demining of trails. Commercial operators were active during this period: MECHEM completed 16 tasks; while, MINE-TECH finished 4. Yet, locality-level clearance remained low, with only 9 becoming landmine free. By the end of 2007, more operators entered the region. The UNADP performed only 22 operations in these 7 years. At the same time, MMA (61), Mechem (44) and MGM (40) started to operate extensively in Gaza. In spite of the increased participation in the province, only 17 additional localities were listed as fully cleared during these 8 years. In the beginning of the fourth period, the shutdown of the UNADP in 2006 changed the composition of demining operators in the Gaza. APOPO became the main demining operator. From 2008 to 2015, APOPO completed 175 tasks, targeting the remaining affected roads, river access, railways and villages. Among the remaining operators, HALO Trust played an important role in the clearance of the Zimbabwean border between 2009 and 2011.

Clearance of CHAs in Gaza 1993-1999



Clearance of CHAs in Gaza 2000-2007



Clearance of CHAs in Gaza 2008-2015

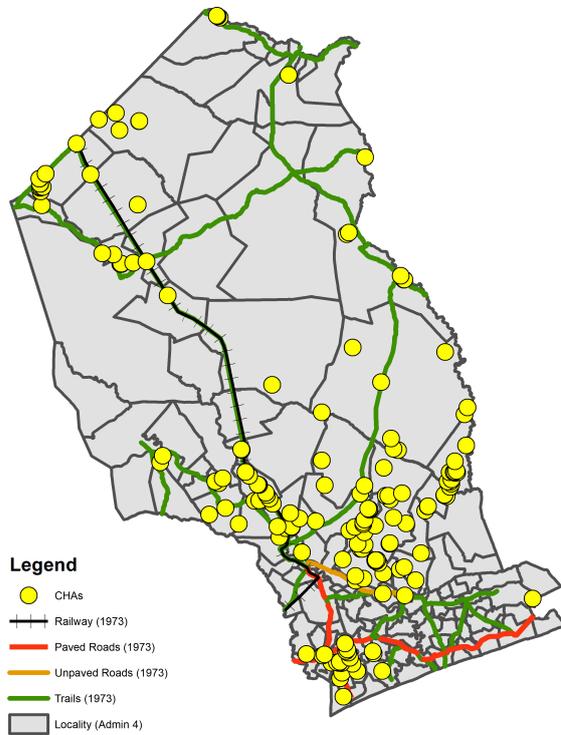


Figure 27: Interventions in Gaza

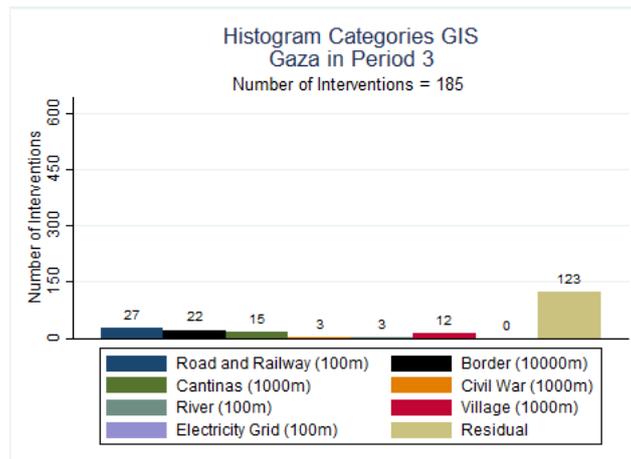
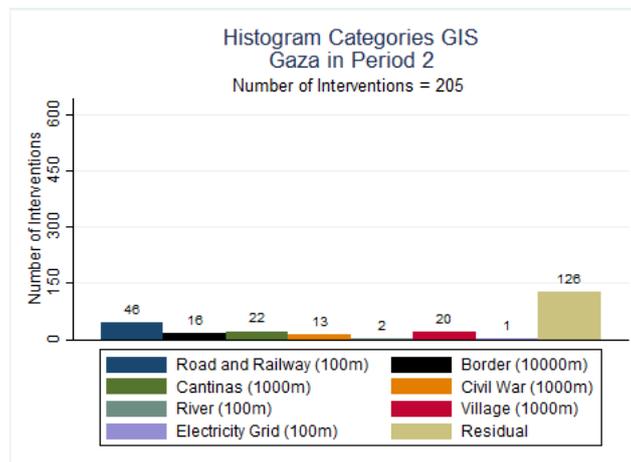
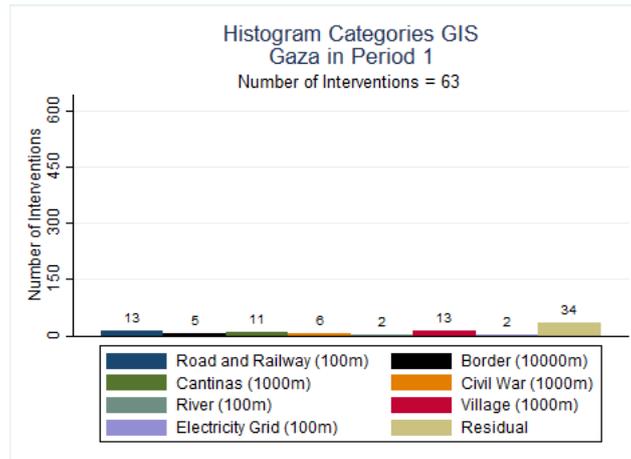


Figure 28: GIS Category Interventions in Gaza

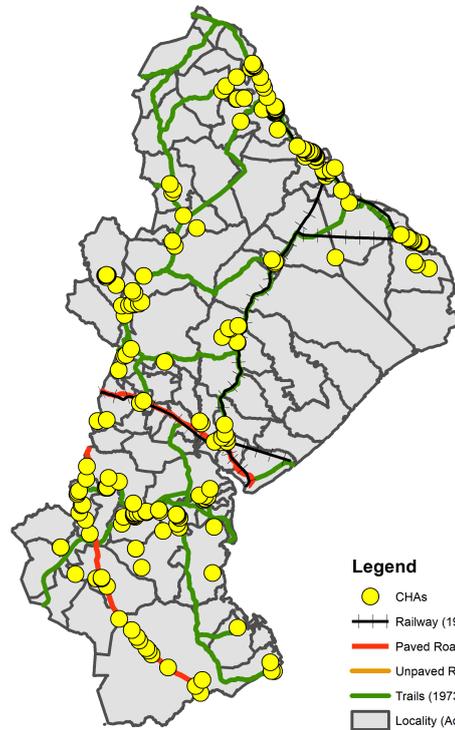
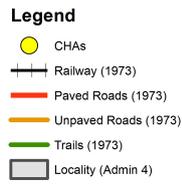
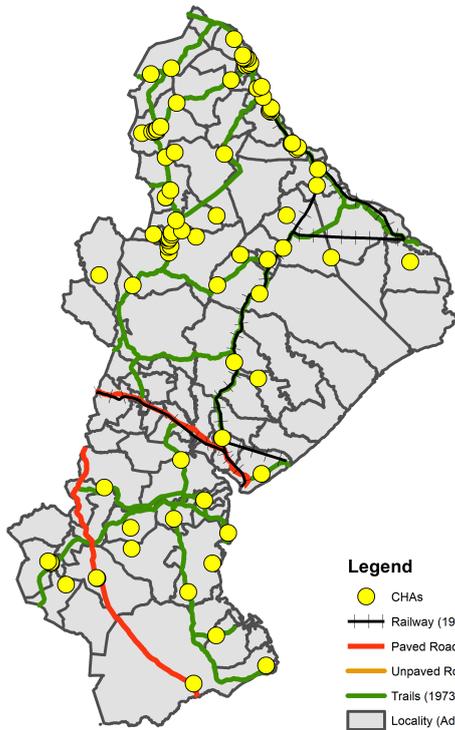
3.7 Sofala Province Summary

Between 1992 and 2015, 27 demining operators got involved in demining activities in the province of Sofala, completing a total of 936 interventions. According to our database, Handicap International (HI) was the main player in this region. Starting its operations in the province in 1999, HI completed a total of 562 (60%) landmine clearance interventions. APOPO (57), NPA (67), HALO Trust (48), EMD (36), MINE-TECH (42), and RONCO (23) have been other important players throughout the years. Figure 30 gives the tabulation of GIS-based categories by period. Clearance of the transportation network was important with 144 activities performed. Demining activities on villages and colonial commercial harbors were frequent as well (93 and 78); while 32 clearance activities were related to area of confrontation between FRELIMO and RENAMO (Gorongosa, the main headquarters of RENAMO, is located in Sofala).

Appendix Figure 29 presents the spatial distribution of demining activities in Sofala across the different demining phases of the Mozambican Mine Action program. Almost all localities were affected by minefields: 72 out of 81. Sofala was one of the province in which the ONUMOZ mission was active in the post-Peace agreement period (1992-1994). Hence, it is no surprise that all the interventions (24 in total) in this initial phase came from UN's and USAID's contracts like GSG/Lorhno (4), MECHEM (6) and RONCO (13). All activities involved road clearance as the main task of these commercial actors was to free communications and transportation for the refugees' repatriation. Despite the relatively large number of interventions in these early years, only one locality became landmine free. From 1995 to 1999, due to the limited capacity of NPA, HI start assisting the Norwegian NGO in the region. Among the two, they performed 77 out of the 97 interventions in this period. The remaining operations were completed by MINE-TECH (18). These tasks added merely 2 more landmine free localities. During the second phase of Mine Action (2000-2007), HI and NPA maintained their cooperation, until NPA left the country in 2006. This joint effort allowed to complete 153 out of the 255 interventions in this period, with HI covering 119 interventions and NPA 34. 12 more municipalities were declared mine-free. Finally, in the last period (2008-2015), HI increased its capacity in the province and was able to cover 377 operations (67% of the total for the period). Additional help came from APOPO (57) and HALO Trust (48). Thanks to the efforts in this final period, the remaining 55 affected municipalities were finally declared free from contamination.

Clearance of CHAs in Sofala 1993-1999

Clearance of CHAs in Sofala 2000-2007



Clearance of CHAs in Sofala 2008-2015

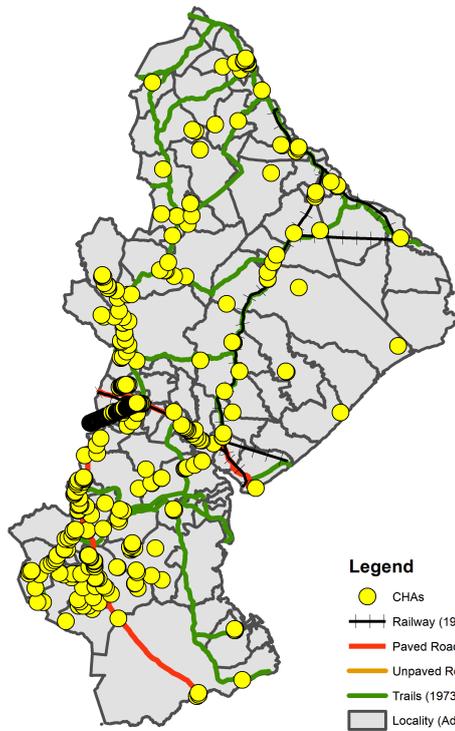


Figure 29: Interventions in Sofala

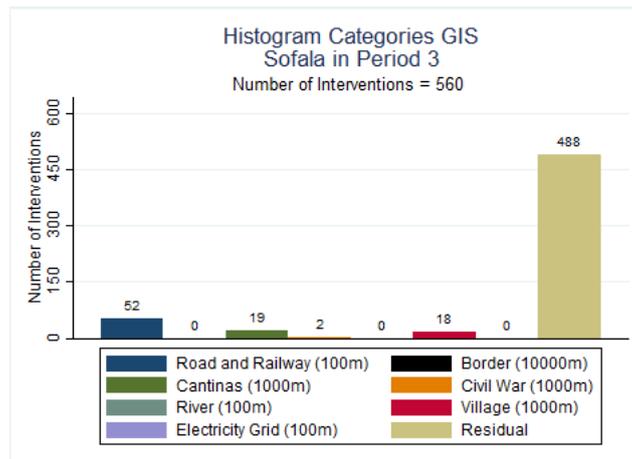
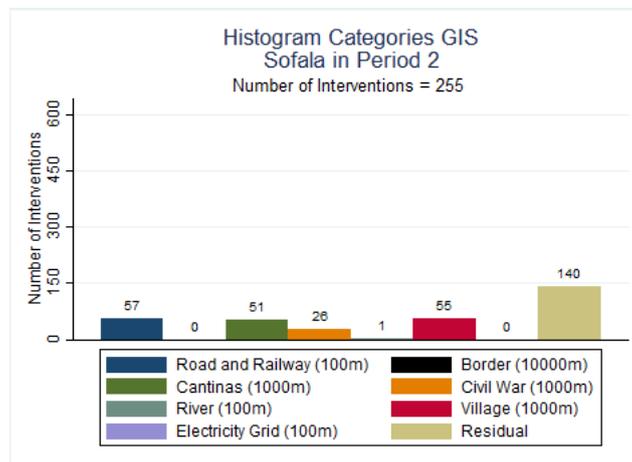
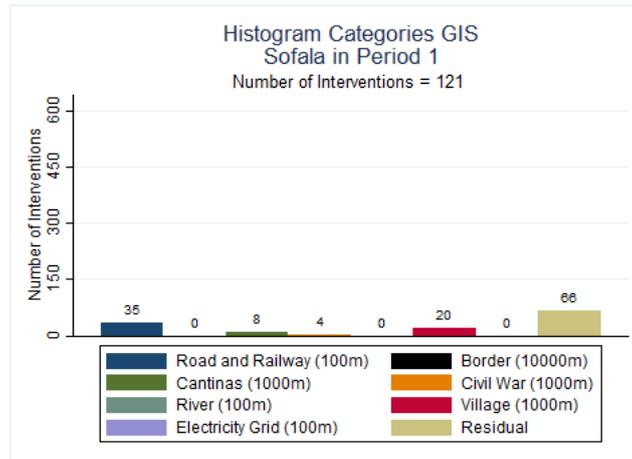


Figure 30: GIS Category Interventions in Sofala

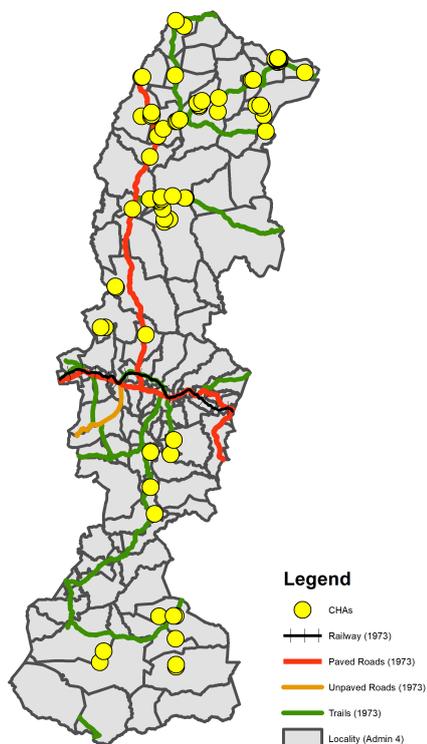
3.8 Manica Province Summary

According to our dataset, the number of demining activities in Manica province, throughout the 23 years of Mine Action totaled 1,053. An important actor in the province was HALO Trust, which conducted a total of 595 (56% of all operations). Handicap International and APOPO were prominent players with 198 (19%) and 90 (8.5%) interventions, respectively. Norwegian People's Aid played a non-negligible role with 88 (almost 8%) interventions. The other demining actors were AFROVITA (1), Associacao de Sapadores Moçambicanos (ASM) (9), IND (1), MINE-TECH (15), Mozambique Mine Action (MMA) Lda (10), Mine-Tech (15), RONCO (3), and Special Clearance Services (SCS) (5). Figure 32 reports the GIS-based categories by period for Manica. The most represented categories are clearance of villages (142) and demining on the transportation network (128). Very importance is the clearance activity on borders with Zimbabwe (103).

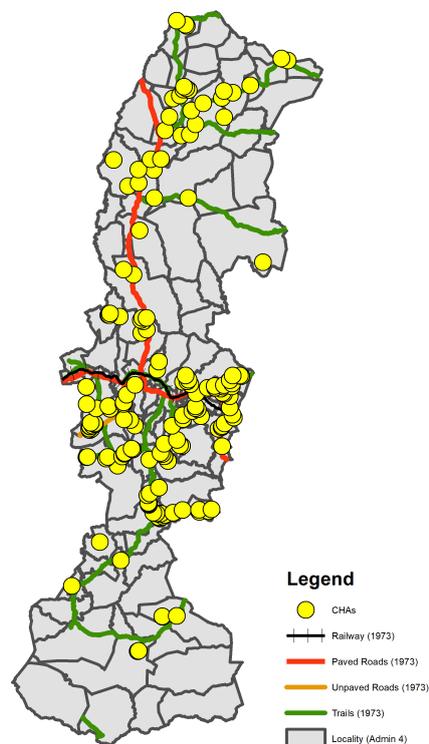
Appendix Figure 31 portrays the spatial distribution of demining activities in Manica across time. In Manica, the contamination was extensive with 85 out of 104 municipalities affected by landmines. Similar to the other Southern regions, the start of demining activities was sluggish. In the initial years (1992-1994), RONCO delivered the only demining operation in the region, clearing part of a trail connecting Chiramba to Nhacolo (Tambara district). From 1995 to 1999, NPA and HI started to operate in the region, entering from the North and the South, respectively. HI completed 63% (49) of the interventions in the second period; while, NPA conducted 24% (19) of them. Additional operations were delivered by MINE-TECH, MT, and SCS (mostly involved in clearance of villages).

42 localities were declared mine free by 2000. The activities of NPA (68) and HI (59) kept on expanding in the second period (2000-2007). MINE-TECH (9) remained present in the province (along with RONCO and SCS). MMA entered the province, by establishing its headquarters in Chimoio. MMA performed 10 interventions in Barue, Gondola, Guro and Sussundenga districts. In spite of the efforts in this phase, only 7 additional localities were freed from landmines by the end of 2007. The final phase (2008-2015) saw an increased impetus for mine clearance in Manica. The operations in this phase account for 74% (777) of total clearing activities in the province. This push towards completion was due to the efforts of HALO Trust (595) and the help of all the other main players in this final period (APOPO (90), HI (90), NPA (1)). The remaining 76 affected localities were cleared during these final 8 years.

Clearance of CHAs in Manica 1993-1999



Clearance of CHAs in Manica 2000-2007



Clearance of CHAs in Manica 2008-2015

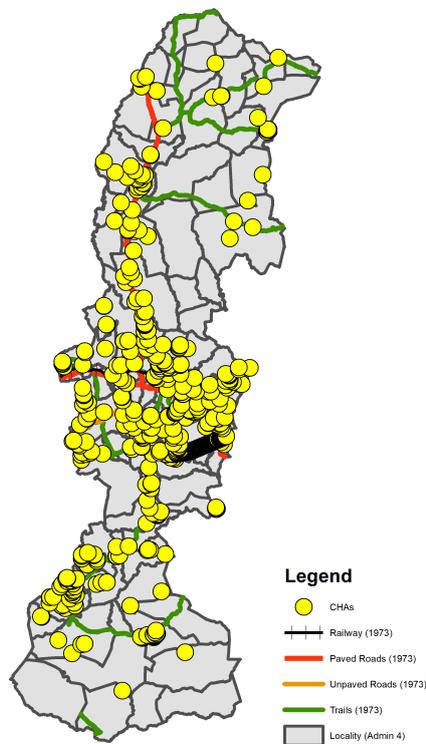


Figure 31: Interventions in Manica

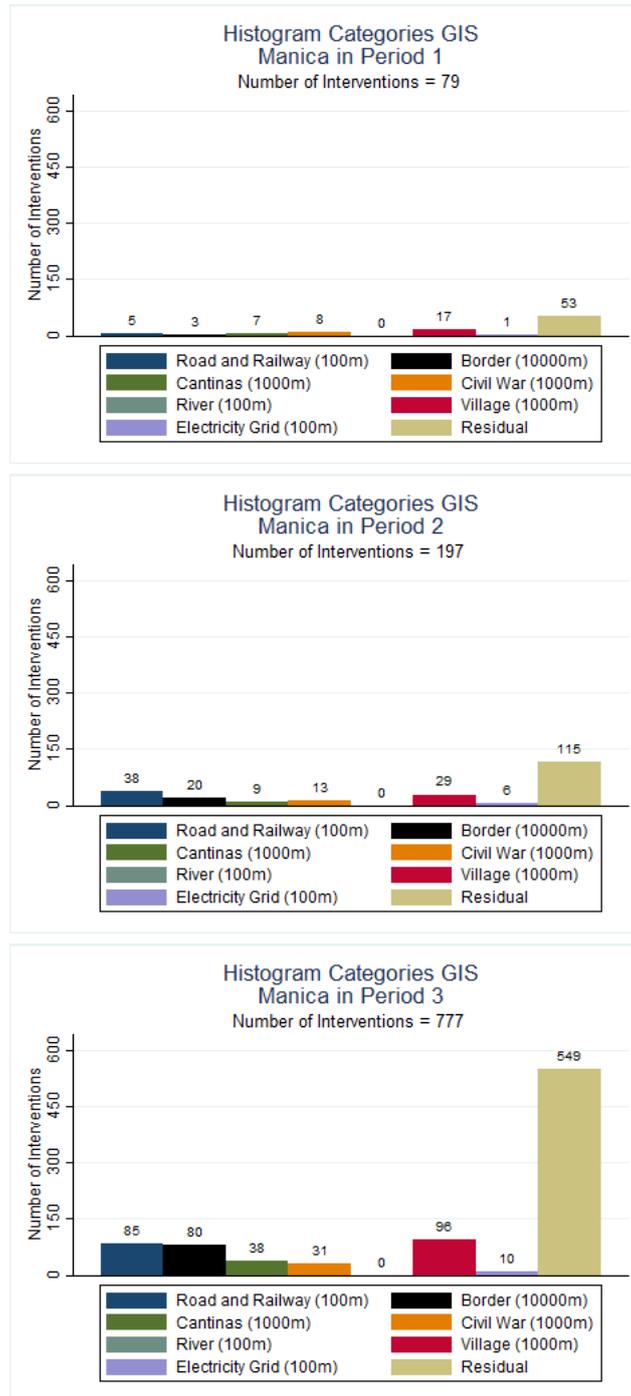


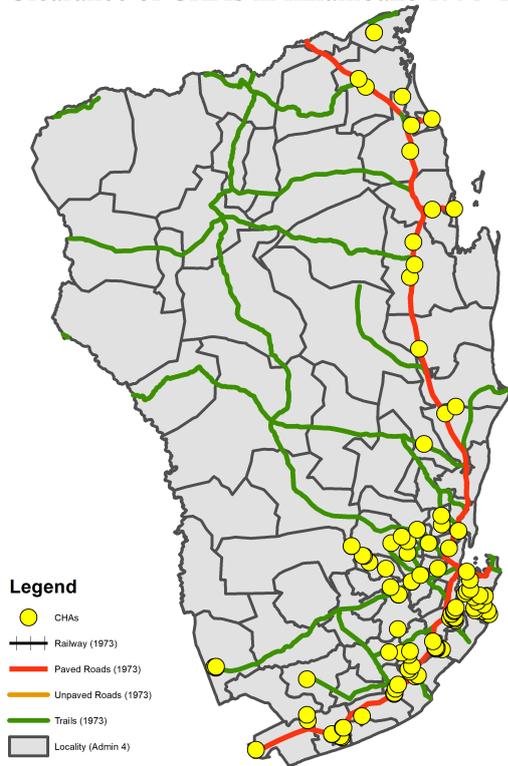
Figure 32: GIS Category Interventions in Manica

3.9 Inhambane Province Summary

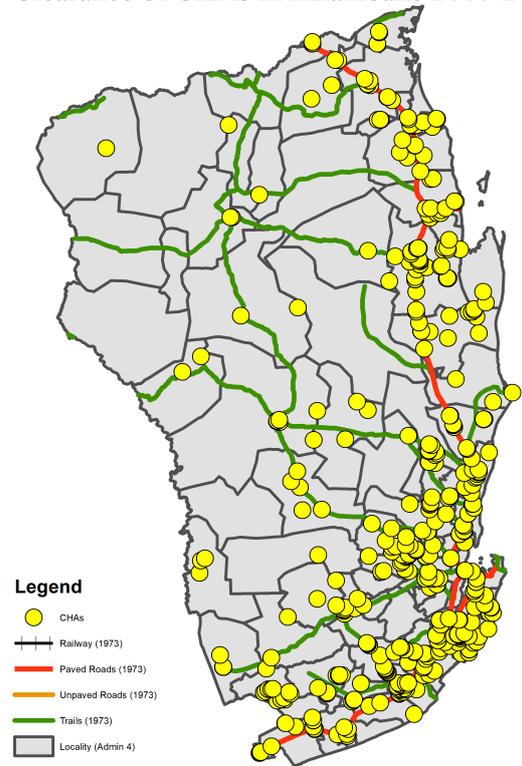
Inhambane was one of the most affected provinces in Mozambique with 992 demining activities. A key player for the province was Handicap International, that started its demining activities in 1998. By the end of 2015, HI conducted a total of 653 operations (66% of the total interventions). In the initial phase, United Nation's Accelerated Demining Program played an important role, completing 184 clearance activities. Another 16 players were present in Inhambane at different points of the demining process: BACTEC Mozambique (13), BICKMUTI LDA (7), EMD (10), FADM (1), GPC (1), HALO Trust (182), IND (1), JV Desminagem (9), MF Investimentos Lda (5), MINE-TECH (36), MMA (6), MONECHECHA-Lda (1), MOPROTECTOR Ltda (8), Mamacoma (16), Mine Kills Lda (1), NPA (1), and RONCO (1). Regarding the GIS-based classification of threats, the majority of interventions (211) involved sites in proximity of the transportation network; 169 and 99 interventions happened in the vicinity of villages and colonial commercial towns, respectively.

Appendix Figure 33 presents the spatial distribution of demining activities in Inhambane over time. This province had the highest rate of landmine contamination in the country, with almost 94% of its localities (75) being mined. As for the Manica province, the initial years of Mine Action (1992 – 1994) in Inhambane were characterized by very few interventions (NPA (1) and UNADP (4)). From 1995 – 1999, UNADP started to increase its presence in the province, performing 78 interventions (of mostly trails and roads as well as villages). An important contribution to mine clearance in this phase was that of MINE-TECH with 30 interventions (e.g., Quissico village), HI started its operations (4) in the later phase of the first period (specifically, in Inhassoro and Inharrime). By the end of 1999, only 1 municipality was declared free from mines. During the second phase (2000 – 2007), HI escalated its presence completing 341 demining operations, spanning from village clearance (like Vilankulo, Massinga and Morrumbene) to trails and roads. Before shutting down its program in 2006, the UNADP delivered 102 demining operations. In this phase, 11 additional localities were completed freed from minefields. Finally, the third period (2008-2015) allowed to declare Inhambane as mine free by 2015. By increasing even further its capacity, HI completed 341 demining activities. These efforts allowed to clear the remaining 63 mine-affected municipalities.

Clearance of CHAs in Inhambane 1993-1999



Clearance of CHAs in Inhambane 2000-2007



Clearance of CHAs in Inhambane 2008-2015

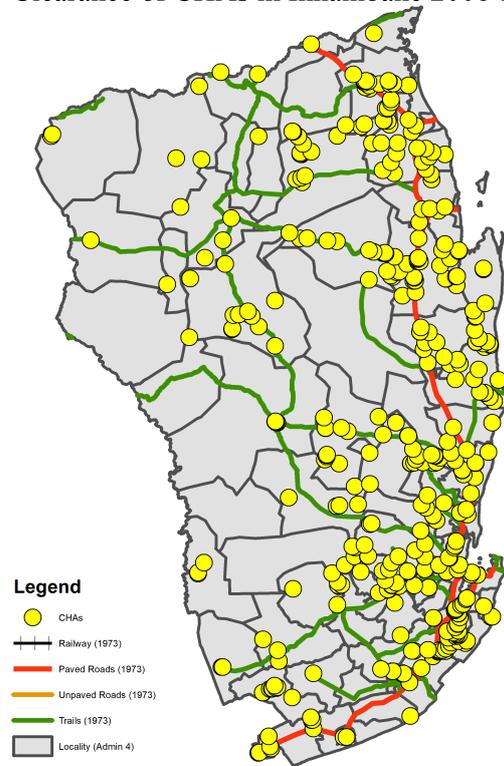


Figure 33: Interventions in Inhambane

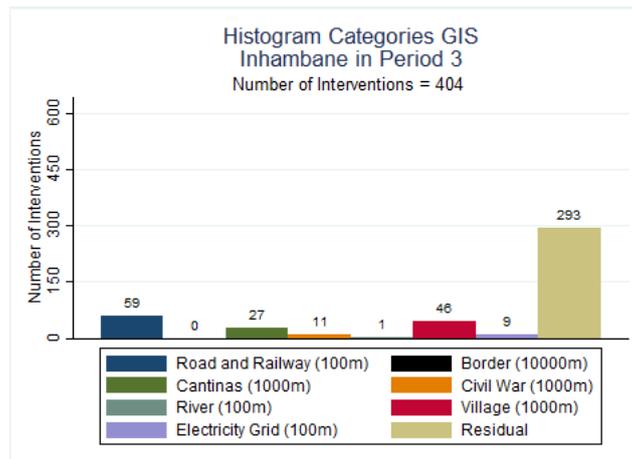
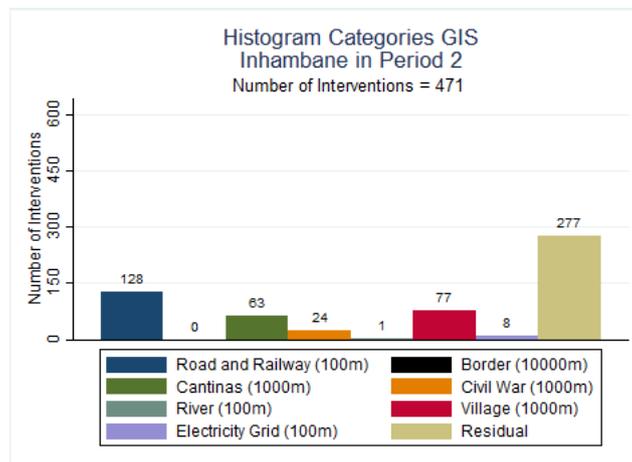
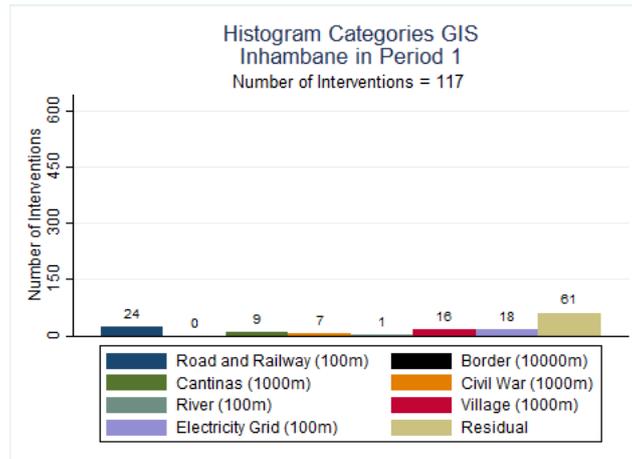


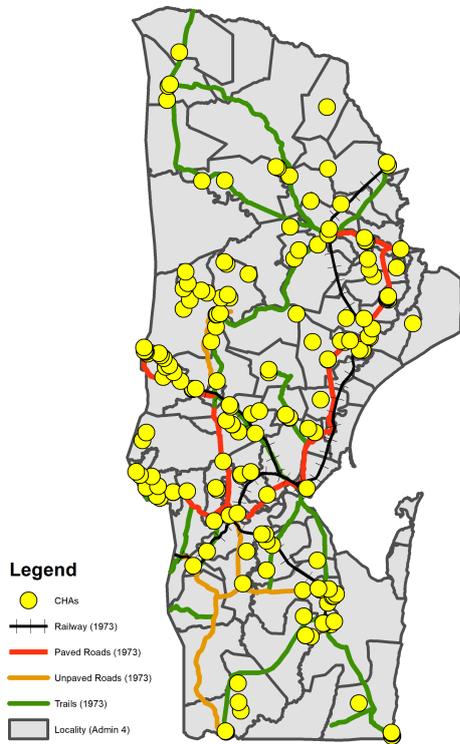
Figure 34: GIS Category Interventions in Inhambane

3.10 Maputo Province Summary

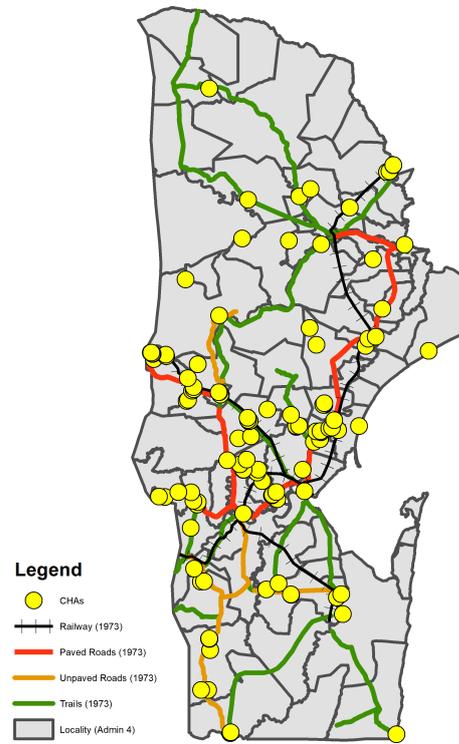
The province of Maputo (including the capital of Maputo) was the province with the highest number of interventions: 1,206. The capital was barely contaminated (only 5 interventions are recorded in our database over 23 years). The dominant actor in the province was HALO Trust, that moved to Maputo after 2007, with 798 interventions (66%). UNADP (275) and APOPO (452) were also important actors during the program in Maputo. The other deminers that contributed to the clearance of Maputo province are AFROVITA (4), BACTEC Mozambique (1), BICKMUTI LDA (1), CGTVA (2), CODEG-Desminagem (1), EMD (12), FADM (10), GPC International (4), JV Desminagem (2), MECHEM (7), MGM (7), MINE-TECH (5), MMA (7), MSF (25), Mine Kills Lda (1), Ronco (9). Figure 36 depicts the distribution of GIS-based categories across the three periods of demining activities. The most represented categories are the clearance of the borders with South Africa, Swaziland, and Zimbabwe (288 interventions) and the restoration of the electric line connecting Maputo to South Africa (282). Demining of transportation network (174) and villages (158) was also substantial.

Appendix Figure 35 shows the spatial distribution of demining activities in Maputo province for phase of the Mozambican Mine Action program. 71 out of the 78 localities were contaminated by landmines. In the first phase (1993-1999), UNADP performed 172 interventions. Several involved clearing trails/roads and villages (like the Moamba and Boane rings cleared in collaboration with MINE-TECH/GTZ). Only 3 localities were freed from landmines by the end of 1999. The second period of interventions (2000 – 2007) saw a slowdown in the demining activities in the province. A total of 161 interventions were recorded at the end of 2007. UNADP was still the main player at the time, with 103 interventions. Some activities from RONCO (9), MGM (7), AFROVITA (4) took place, along with those of HALO Trust (6) in 2007. Similarly, the speed of clearance across localities was also very low: with 32 more municipalities becoming land-mine free during the second phase. Starting in 2008, the pace of demining picked up. HALO Trust, after establishing its base in Maputo, completed 792 interventions by the end of 2014. APOPO performed several interventions (52) between 2012 and 2014.

Clearance of CHAs in Maputo 1993-1999



Clearance of CHAs in Maputo 2000-2007



Clearance of CHAs in Maputo 2008-2015

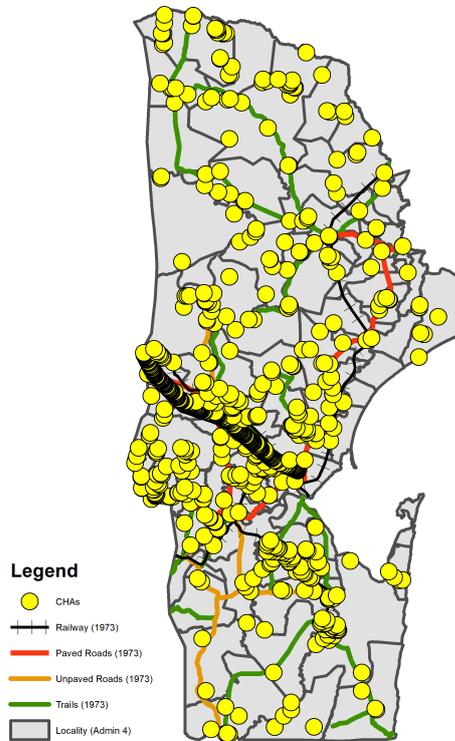


Figure 35: Interventions in Maputo Province

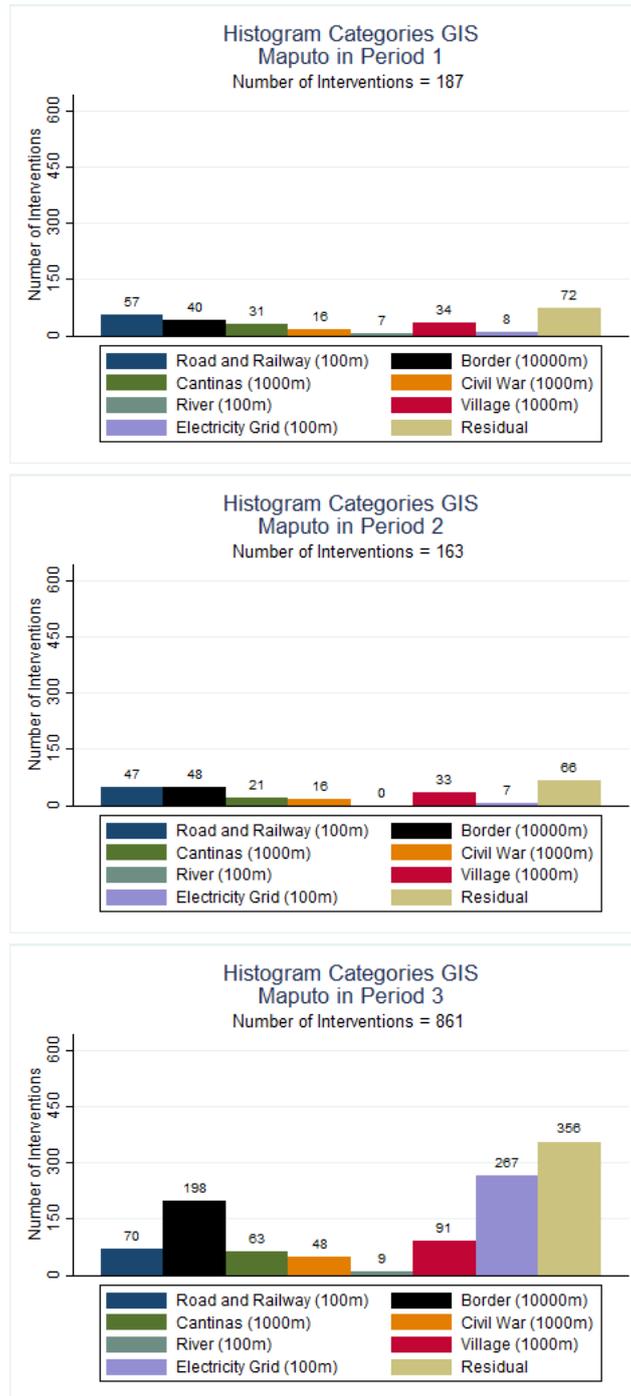


Figure 36: GIS Category Interventions in Maputo Province

Landmines and Spatial Development

Appendix V

Correlates of Landmines *

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June 18, 2018

Abstract

This appendix first presents the analysis of the correlates to landmines across Mozambican localities. Second, the appendix reports the cross-sectional analysis of the correlates of the timing of demining operations, distinguishing between the initial demining intervention and the last operation, leading to locality's full clearance.

*Additional material can be found at www.land-mines.com

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Contents

1	Correlates of Confirmed Hazardous Areas	3
1.1	Extensive Margin. Linear Probability Model Estimates	3
1.2	Extensive and Intensive Margin. Poisson ML Estimates	5
1.3	Summary	6
2	Correlates of the Timing of Clearance	6
2.1	Timing of Clearance	6
2.2	Correlates of the First Intervention across Localities	7
2.3	Correlates of the Final Intervention across Localities (Full Clearance)	8
2.4	Summary	9

1 Correlates of Confirmed Hazardous Areas

This section reports the results of the analysis that explores the correlates of Confirmed Hazardous Areas (CHAs) at the locality level. First, we report the analysis of the correlates of contamination (“extensive” margin). Second, we report the analysis of the correlates of the intensity of contamination (“intensive” margin). Table 1 reports summary statistics of all variables used in the Appendix across Mozambican localities.¹

1.1 Extensive Margin. Linear Probability Model Estimates

Table 2 reports linear probability model (LPM) estimates on the correlates of the presence of CHAs across Mozambican localities. The dependent variable is an indicator that takes the value of one if there is at least one confirmed hazardous area (CHA) in a Mozambican locality (administrative division 4). The dependent variable equals zero for localities without any contamination. Out of 1077 localities with population information in the pre-war population census, 786 had at least on CHA, while the remaining localities were not contaminated.²

Given the vast size of the country, its huge regional diversity, and the differential impact of the war of independence and the subsequent civil war across regions, we always include province-level (administrative unit 1) fixed effects. The constants (not reported) are highly significant, as contamination was significantly higher in Inhambane and to a lesser extent in Sofala and Maputo as compared to Gaza and Tete. This accords with the historical narrative (detailed in Appendix *I* and Appendix *II*).

All specifications include the log land area, a highly significant variable. Naturally, larger in terms of landmass localities are significantly more likely to be contaminated. In columns (2)-(9) we examine the predictive power of a set of potential correlates of minefields (CHA), conditioning on locality’s size and provincial location.

In column (2), we examine the role of the locality sharing borders with South Africa (16), Zimbabwe (39), Malawi (51), Tanzania (15), Zambia (14), and Swaziland (7), respectively. In line with the narratives on the history of the war of independence and the civil war, the probability of contamination is lower for adjacent to Zambia localities in the North-West, as Zambia was not much involved to conflict.

In column (3), we investigate the link between landmine contamination and geographic characteristics, namely elevation, soil suitability of agriculture, malaria ecology, and proximity to the coast. We also include the log number of towns and villages to explore whether localities with more populated areas are also more likely to be mined. Conditional on locality size and province, localities with a higher number of villages-towns are more likely to be mined. Moreover, contamination is related to

¹We report estimates across 1077 localities with population data in the 1980 Census. The results are similar in the full sample of 1187 localities.

²Probit ML estimates are similar and omitted for brevity.

malaria prevalence, a result that may be driven by the link between malaria ecology and conflict (e.g., Cervellati, Sunde, and Valmori (2017) and Cervellati, Esposito, Sunde, and Valmori (2017)).

In column (4), we look at the relationship between landmine placement and the colonial transportation network (in 1973). We augment the specification with indicator variables that reflect the presence of paved roads, unpaved roads, trails, railways, and navigable rivers, in each locality. Contamination is higher in connected, as opposed to non-connected to the colonial transportation system localities. Paved roads and trails increase the likelihood of contamination in a locality; having also a railway crossing a locality increases the probability of contamination by 12.7% whereas the presence of navigable rivers does not seem to play a role. It is useful to keep in mind that the three main railways run along paved as well as unpaved roads forming the so-called “development corridors”.

In column (5), we explore the association between contamination and civil war incidents (using data from Domingues et al. (2011), Robinson (2006), Sundberg, Lindgren, and Pads kocimaite (2010), and Sundberg and Melander (2013)). While the civil war data are far from being complete, the coefficient on the civil war incident indicator that equals one for localities experiencing major conflict (16% of the sample) is positive and highly significant. Localities experiencing a major civil war event faced a 22% increased likelihood of landmine contamination.

In columns (6), (7), and (8) we augment the specification with proxies of early development. In column (6) we use a dummy variable that identifies localities hosting a commercial harbor (*cantinas*) in 1965. The estimate is significantly positive suggesting that localities of commercial importance during the colonial era were systematically more likely to be mined. In column (7) we use a dummy variable that equals one for lit in 1992 localities. It is important to keep in mind that mine contamination is likely to have influenced the level of development, as recorded in luminosity at the end of civil war in 1992. Lit localities appear to have been systematically mined.

In column (8), we proxy early development with log population density in 1980, using the first post-independence population census (that is also largely pre-civil-war as during 1977 – 1980 the warfare was small-scale, almost exclusively targeting infrastructure). Similarly to the specifications in (6) and (7), there is a significantly positive correlation between population density and landmine contamination.

In column (9), we control simultaneously for all variables. A locality’s landmass, its population density, the experience of a civil war event and proximity to the colonial transportation network remain robust predictors of landmine contamination. These results are in line with the historical narrative of landmine contamination during 1964 – 1992, regarding the targeting of the transportation infrastructure, its proximity to the borders as well as the rather indiscriminatory nature of landmine contamination. Nevertheless, even if one takes into account all these historical, geographic, and population features the predictive power of this rich model (that also included province constants) is still modest, accounting for 22.7% of the overall variation in the extensive margin of landmine presence.

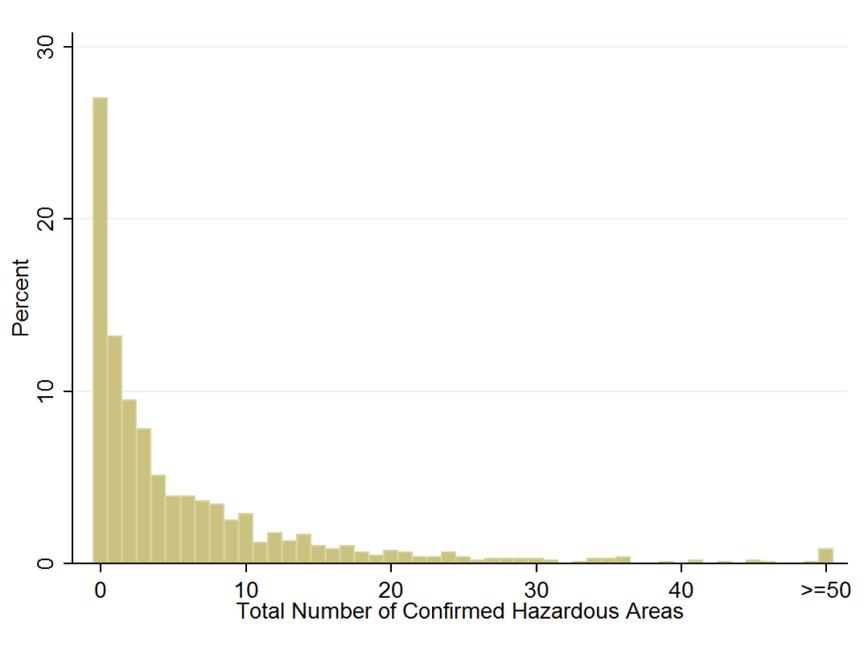


Figure 1: Distribution of Confirmed Hazardous Areas by Locality

1.2 Extensive and Intensive Margin. Poisson ML Estimates

We repeated the analysis on the correlates of landmine contamination looking at both the intensive and the extensive margin. Figure 1 plots the distribution of confirmed hazardous areas (CHA) across all Mozambican localities.

We then estimated regressions associating the number of CHA to the various geographic, locational, population, and economic variables we used before. As the outcome variable is a count we estimated maximum-likelihood Poisson models (see Wooldridge (2002) and Cameron and Trivedi (2013)).³ Table 3 presents the Poisson ML estimates. The structure of the table follows Table 2. All specifications include province fixed effects and log land area. The count-model estimates are quite similar to the linear probability model results. Larger in size and more populous as of 1980 localities, with more villages/towns, a history of civil war events, and with access to colonial paved roads and railways, are significantly more mined (more CHAs). Furthermore, the Poisson ML estimates uncover a positive association between contamination and proximity to the South African border, where several large minefields were placed during the Civil War, as the Mozambican government was trying to cut down RENAMO's supply lines from the South African Special Forces.

³As there is some evidence of overdispersion in the dependent variable, we have also experimented with Negative Binomial ML estimation. The results are similar and not reported for brevity.

1.3 Summary

The simple cross-locality analysis on the correlates of landmine placement accord well with the history of the war of independence and the civil war and the widespread use of landmines (see Appendix I). The cross-sectional correlations in 2 and 3 show with formal econometric techniques that landmine use was concentrated in some border regions (mostly with Malawi), in major villages/towns, and in roads-railroads.

2 Correlates of the Timing of Clearance

The demining process went through roughly three phases from 1992 to 2015 (see Section 2 of the paper and Appendix II). A distinctive feature of the 24 year-long process was the lack of coordination, prioritization, and centralization in the initial phases. Landmine clearance was highly heterogeneous both spatially and temporally. In this Section we examine the correlates of the timing of clearance, checking whether the timing of intervention is associated to observable characteristics.

2.1 Timing of Clearance

Before reporting the correlates of the time of demining, it is important to distinguish between two key dates of clearance. The first corresponds to the year that the first demining operation took place in a given locality. The second reflects the date that the demining operations were completed in a given locality, leading to full clearance of the locality from CHAs. Most of the (855) contaminated localities had more than one CHA (see Figure ??); as such there were multiple interventions in a given locality, often by different operators.

Table 4 tabulates the number of years between the first and the last clearance operation and the corresponding percentage of localities. 22% of contaminated localities was cleared within the same calendar year. But for around 40% of contaminated localities, more than 10 years elapsed between the first and the last intervention. The median (average) number of years to clear a locality is 6 (6.98) years with a standard deviation of 5.93. When we exclude localities where clearance was completed in the same year, the average number of years to clear a district is 9 years (median is 8) with a standard deviation of 5.22.

At first glance, it looks puzzling that once clearing operations start it would take 7 years before the locality is fully cleared, especially because demining operations last on average 2 months.

Delays reflect the following factures. First, from new “discoveries” of (confirmed) hazardous areas. The government, international agencies, and demining operators had an incomplete picture of the problem in the initial decade. For example, both the 1994 and the 2001 country-wide surveys were incomplete, contained errors and misclassified hazardous areas (see for a discussion and illustrations Appendix II). Moreover, many parts of the country were inaccessible even in 2001, almost a decade

after the end of the civil war. The same considerations apply to the 2007 HALO Trust “Baseline Assessment”. For example, focusing only on the post-2008 data, 45% of the interventions were performed on “new” confirmed hazardous areas that were not present in the “Baseline Assessment”.

Second, some confirmed hazardous areas were cleared at some point, but subsequently mined were found and thus these areas were reclassified as containing explosive war remnants (CHAs). This reflected the poor information of surveying teams in 1994 and in 2001 and the weak capacity of government demining agencies. For example, HALO Trust performed interventions in Lione Village in 2002 and then went back to the village in 2004 to clear additional land mines. ADP completed operation on Matola bridge in 1998 and returned in 2006 to the bridge because new mines were found. Finally, HALO Trust cleared land mines in Chinzunga Minefield in 2010 and then performed additional clearing operations in 2013 on the same spot.

A third factor that exacerbated delays in clearing a given locality was the fact that interventions during 1992 – 2006 focused on a single site. For example, a demining operator was involved in clearing electricity pylons or clearing mines blocking access to dams only. This demining operator did not look at other hazardous areas as their contract was solely about clearance of infrastructure. As such, the locality was not freed from contamination, as other sites remained uncleared. It was only after 2007 – 8, that a district-by-district approach in clearance was finally implemented.

Panel A of Figure 2 plots the share of localities that got a first demining intervention over time. By the end of 1994, clearance operations had started in just 6.54% (56) of contaminated localities (855). By early 2000, the cumulative percentage (number) of localities where some clearing had taken place was 48.53% (415). It jumps to 89.12% in 2007.

Panel B of Figure 2 depicts the yearly evolution of the share of localities that have been fully cleared. Compared to the starting year of operations, a very different picture emerges. By the end of 1994, when the first democratic elections took place, only 6 (0.7%) contaminated localities had been fully cleared. The percentage (number) slightly increases to 5.61% (48) in 2000, when the National Institute of Demining (IND) starts becoming operational. Indicating how slowly mine clearance proceeded in Mozambique, roughly half (442) localities were fully cleared by the end of 2007.

2.2 Correlates of the First Intervention across Localities

We commence the examination of the correlates of the timing of clearance, investigating the geographical and socioeconomic correlates of the first year of intervention at the locality level. The sample consists of 786 localities that had at least one confirmed hazardous area (CHA) and we have information on the population density as of 1980 (overall 855 localities were contaminated).⁴

Table 5 reports Poisson ML model estimates. The dependent variable is the number of years elapsed between 1992 and the year of the first intervention in a given locality. Thus, the outcome

⁴The results are similar if we use all 855 contaminated localities rather than restricting estimation to those with population info in the 1980 Census.

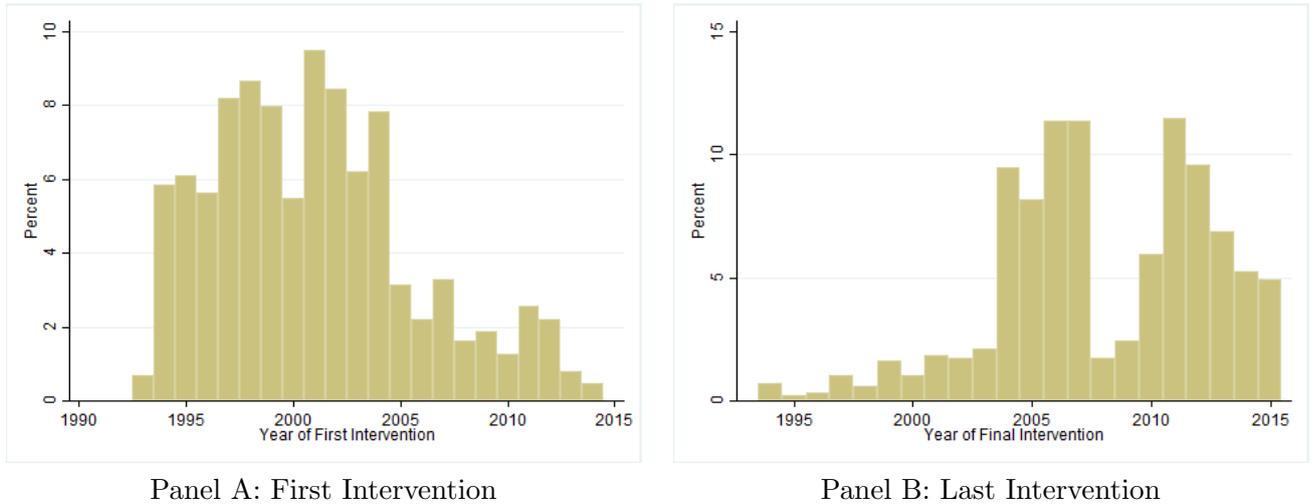


Figure 2: **Distribution of First and Last Intervention by Locality**

variable takes values from one (first clearance took place in 1993) up until twenty one (first clearance in 2013). Figure 2 gives an illustration of the distribution. As before, all specifications include province fixed-effects to account for the non-negligible heterogeneity of clearance across the country. We always control for the land surface of the locality, as larger in terms of land area localities seem to have been targeted earlier than smaller ones.

Across the different specifications, we find that demining began earlier in localities adjacent to the Malawian border; this seems to reflect the response to the early humanitarian emergency and the need to repatriate the large number of refugees (more than 1 million) from camps in Malawi in 1993 – 1994. Conversely, localities along the Zimbabwean border saw a late first intervention. The history of demining operations backs-up this findings as many minefields close to the Zimbabwe cleared in the ending phases. Interventions started earlier in localities with higher population density in 1980 and localities that experienced major civil war events. Elements of the colonial transportation network enter with a negative sign suggesting prioritization of the transportation corridors, however, they are not statistically significant. While in some instances demining prioritized the clearance of roads (with Malawi for example), many roads were left unclear in the early phases.

2.3 Correlates of the Final Intervention across Localities (Full Clearance)

We then examine the geographical, location, and socioeconomic correlates of the final year of interventions (full clearance) looking again on localities with at least one confirmed hazardous area (CHA). The dependent variable is the number of years between 1992 and the year of the last clearing operation in a given locality. Thus, the dependent variable takes values from zero up to twenty three. Figure 2 gives an illustration of the distribution.

Table 6 reports Poisson ML estimates. The table mirrors 5. The province constants -included in

all specifications- are highly significant, as clearance was completed in the Northern provinces before the Centre and the South. Log land area and enters in all permutations with a significantly positive coefficient. So, although demining operations start earlier in large (in terms of area) localities (often close to the borders), these localities are fully cleared from landmines later.

Adjacent to Zimbabwe, Swaziland, and Tanzania localities were cleared at a later stage. This accords well with the historical narrative of landmine clearance (see Appendix II). For example the large minefields on the Tanzanian border, laid by the Portuguese during the war of independence, were cleared by HALO Trust just before the completion of their activities in the Northern Provinces. Likewise, some large minefields in the Zimbabwe border, laid by the Rhodesian armed forces and by FRELIMO in the early stages of the civil war, were cleared in the end (and minefields on the Zimbabwe side are currently cleared). Features of early development, presence of commercial hubs, the 1973 transportation network, population density in 1980, and light density in 1992 are not much correlated with the timing of localities' full clearance from landmines and UXOs. Moreover, the increase in the R^2 when adding the rich vector of potential covariates in column (9) is tiny, 33.9% as compared to 0.32 when we solely add province constants and log land area.

The timing of localities' full clearance is likely affected by the extent of contamination, which, however, was far from known when demining operations started in 1992 (and even in 2001 when the Landmine Impact Survey was conducted). In localities with more CHAs, clearing may take longer, *ceteris paribus*. So, we re-estimated the Poisson ML specifications associating the timing of full clearance with the various locational, geographic, and socioeconomic variables, conditioning on the degree of contamination. To that effect, we assign contaminated localities into five quintiles based on the number of CHA and rerun the Poisson ML model augmenting the specifications with these dummy variables.

Table 7 reports the results. Before discussing the estimates it is important to stress that these specifications are far from ideal, as the government, demining operators, donors, and the United Nations had a scattered and incomplete knowledge of the spatial distribution of contamination. Not surprisingly localities with fewer CHAs were cleared earlier. Conditioning on the degree of contamination renders most variables insignificant. It is instructive to look at the difference in the predictive power between the specification in column (1) to that of column (9). Adding these 20 covariates reflecting important geographic and socioeconomic traits the fitted R^2 barely increases.

2.4 Summary

The analysis of the correlates of the timing of landmine clearance shows that the process of rendering localities landmine-free did not follow a systematic pattern. While some areas experienced earlier interventions (for example larger in terms of size localities and somewhat more developed localities), the timing of full clearance is not systematically related to locational and socioeconomic features. These simple cross-sectional results fit with the narrative (detailed in Appendix II) of landmine clearance

and its key features: the lack-of-coordination among demining operators and the government; the weak capacity of the governmental agencies dealing with demining (CND and IND), the ad-hoc and short-term nature of landmine clearance operations, with NGOs being financially constrained, the flaws of the 1994 and 2001 nation-wide surveys, and the swings in donor support.

Table 1: **Descriptive Statistics**

	Population Sample					
	Observations	Mean	Standard Deviation	Median	Min	Max
Share of Contaminated localities in 1992	1077	0.730	0.444	1.000	0	1
Number of Threats in 1992	1077	6.534	14.715	3.000	0	238
Lit 1992	1077	0.104	0.305	0.000	0	1
Adjacent Zimbabwe (dummy)	1077	0.032	0.175	0.000	0	1
Adjacent Zambia (dummy)	1077	0.013	0.113	0.000	0	1
Adjacent South Africa (dummy)	1077	0.014	0.117	0.000	0	1
Adjacent Malawi (dummy)	1077	0.044	0.204	0.000	0	1
Adjacent Swaziland (dummy)	1077	0.006	0.080	0.000	0	1
Adjacent Tanzania (dummy)	1077	0.014	0.117	0.000	0	1
Elevation	1077	0.327	0.332	0.209	0	1.73
Malaria Ecology	1077	11.191	3.446	11.239	.267	18.6
Suitability of Agriculture	1077	0.485	0.190	0.452	.0895	.968
Log - Number of Villages	1077	2.080	0.808	2.079	0	4.49
Log - Distance Coast	1077	-2.243	1.085	-2.113	-4.6	-.372
Paved Road 1973 (dummy)	1077	0.182	0.386	0.000	0	1
Unpaved Road 1973 (dummy)	1077	0.021	0.145	0.000	0	1
Trail 1973 (dummy)	1077	0.669	0.471	1.000	0	1
Railway Colonial (dummy)	1077	0.131	0.337	0.000	0	1
Navigable River (dummy)	1077	0.228	0.420	0.000	0	1
Cantina 1965 (dummy)	1077	0.608	0.488	1.000	0	1
Civil War (dummy)	1077	0.165	0.372	0.000	0	1

Notes: The table gives summary statistics for the main variables across Mozambican localities for which information on population across the different censi (1980, 1997, 2007); this is the unit of analysis. The Data Appendix gives detailed variable definitions and data sources.

Table 2: Correlates of Minefields - Linear Probability. Province FE

	Threat (dummy)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Adjacent Zimbabwe (dummy)		0.057 (0.088)							0.110 (0.072)
Adjacent Zambia (dummy)		-0.227** (0.114)							-0.076 (0.092)
Adjacent South Africa (dummy)		0.043 (0.101)							0.024 (0.110)
Adjacent Malawi (dummy)		-0.041 (0.067)							-0.092 (0.066)
Adjacent Swaziland (dummy)		-0.081 (0.049)							-0.162** (0.073)
Adjacent Tanzania (dummy)		-0.026 (0.132)							0.055 (0.128)
Elevation			0.086 (0.132)						0.110 (0.122)
Malaria Ecology			0.021** (0.009)						0.022*** (0.008)
Suitability of Agriculture			-0.126 (0.095)						-0.142 (0.094)
Log - Number of Villages			0.074*** (0.026)						0.044* (0.024)
Log - Distance Coast			0.061 (0.042)						0.062 (0.040)
Paved Road 1973 (dummy)				0.116*** (0.038)					0.104*** (0.039)
Unpaved Road 1973 (dummy)				0.084 (0.116)					0.116 (0.113)
Trail 1973 (dummy)				0.167*** (0.036)					0.122*** (0.032)
Railway Colonial (dummy)				0.127*** (0.044)					0.100** (0.042)
Navigable River (dummy)				0.025 (0.034)					0.004 (0.034)
Civil War (dummy)					0.225*** (0.025)				0.153*** (0.027)
Cantina 1965 (dummy)						0.115*** (0.027)			0.050* (0.029)
Lit							0.089** (0.043)		-0.021 (0.044)
Log - Population Density 1980								0.068*** (0.013)	0.035** (0.014)
Log - Land	0.079*** (0.014)	0.079*** (0.014)	0.028* (0.015)	0.077*** (0.013)	0.082*** (0.013)	0.074*** (0.014)	0.082*** (0.014)	0.148*** (0.018)	0.067*** (0.020)
Province FE	Yes								
R-squared	.115	.114	.155	.165	.148	.13	.118	.134	.226
Observations	1077	1077	1077	1077	1077	1077	1077	1077	1077

Notes: The table reports the linear probability model (LPM) estimates associating the presence of confirmed hazardous areas (CHAs) at the locality level with location, geography, and other locality characteristics. In all specifications the dependent variable is an indicator variable that takes on the value of one if a at least one confirmed threat was present in the locality. All specifications include the log of land area and province fixed effect. In Column (1), we control for the log landmass. In column (2), we control for the (log) distance of the municipality centroid from the border of South Africa, Zimbabwe, Malawi, Tanzania, Zambia, and Swaziland. In Column (3), we control for geographic and location characteristics at municipality level such as mean elevation, malaria stability index, suitability of agriculture, (log) distance from the closest big city (Maputo, Beira or Nacala), and (log) distance from the coast. Column (4) introduces transportation network elements at colonial time (1973) like presence of paved road (dummy), unpaved road (dummy), trail (dummy), railways (dummy). In columns (5), (6), (7), and (8) we include a dummy for Civil War events, an indicator for the presence of colonial commercial harbors (*Cantinas*), a dummy equal one if the municipality is lit in 1992, and the (log) of population density in 1980. In Column (9) we controls for all the controls together. The Data Appendix gives detailed variable definitions and data sources. Below the estimates, the table gives standard errors clustered at the Admin-2 level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 3: Correlates of Minefields - Poisson ML. Province FE

	Number of Threats (count)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Adjacent Zimbabwe (dummy)		-0.010 (0.452)							0.263 (0.346)
Adjacent Zambia (dummy)		-1.443*** (0.416)							-0.946** (0.367)
Adjacent South Africa (dummy)		0.535** (0.232)							0.713*** (0.218)
Adjacent Malawi (dummy)		0.136 (0.208)							-0.092 (0.243)
Adjacent Swaziland (dummy)		-0.121 (0.337)							-0.037 (0.230)
Adjacent Tanzania (dummy)		-0.226 (0.303)							0.332 (0.307)
Elevation			0.179 (0.754)						-0.314 (0.962)
Malaria Ecology			0.014 (0.033)						0.020 (0.040)
Suitability of Agriculture			0.264 (0.364)						0.128 (0.295)
Log - Number of Villages			0.361*** (0.119)						0.266** (0.118)
Log - Distance Coast			-0.003 (0.134)						0.176 (0.142)
Paved Road 1973 (dummy)				0.709*** (0.119)					0.655*** (0.113)
Unpaved Road 1973 (dummy)				0.063 (0.239)					0.116 (0.235)
Trail 1973 (dummy)				0.268 (0.184)					0.210 (0.152)
Railway Colonial (dummy)				0.400* (0.229)					0.465** (0.191)
Navigable River (dummy)				-0.216 (0.167)					-0.221 (0.176)
Civil War (dummy)					0.696*** (0.170)				0.477*** (0.163)
Cantina 1965 (dummy)						0.213 (0.152)			-0.102 (0.139)
Lit							0.188 (0.163)		-0.341** (0.133)
Log - Population Density 1980								0.273*** (0.057)	0.151** (0.059)
Log - Land	0.348*** (0.050)	0.338*** (0.051)	0.267*** (0.061)	0.437*** (0.064)	0.330*** (0.045)	0.337*** (0.049)	0.355*** (0.050)	0.617*** (0.071)	0.412*** (0.075)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1077	1077	1077	1077	1077	1077	1077	1077	1077
Log Likelihood	-6657	-6598	-6440	-6127	-6344	-6624	-6645	-6413	-5635
R2 Fitted	.111	.114	.151	.199	.148	.113	.124	.134	.266

Notes: The table reports the Poisson Maximum Likelihood (ML) estimates associating the presence of confirmed hazardous areas (CHAs) at the locality level with location, geography, and other locality characteristics. In all specifications the dependent variable is the number of confirmed hazardous areas present in the locality. All specifications include the log of land area and province fixed effect. In Column (1), we control for the log landmass. In column (2), we control for the (log) distance of the municipality centroid from the border of South Africa, Zimbabwe, Malawi, Tanzania, Zambia, and Swaziland. In Column (3), we control for geographic and location characteristics at municipality level such as mean elevation, malaria stability index, suitability of agriculture, (log) distance from the closest big city (Maputo, Beira or Nacala), and (log) distance from the coast. Column (4) introduces transportation network elements at colonial time (1973) like presence of paved road (dummy), unpaved road (dummy), trail (dummy), railways (dummy). In columns (5), (6), (7), and (8) we include a dummy for Civil War events, an indicator for the presence of colonial commercial harbors (*Cantinas*), a dummy equal one if the municipality is lit in 1992, and the (log) of population density in 1980. In Column (9) we controls for all the controls together. The Data Appendix gives detailed variable definitions and data sources. Below the estimates, the table gives standard errors clustered at the Admin-2 level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 4: Total Number of Years to Clear a Locality

Total Number of years to fully clear a locality	Number of Localities	Percentage of Municipalities
	(1)	(2)
0	191	22.34
1	35	4.09
2	37	4.33
3	37	4.33
4	52	6.08
5	52	6.08
6	45	5.26
7	37	4.33
8	38	4.44
9	38	4.44
10	37	4.33
11	27	3.16
12	42	4.91
13	40	4.68
14	30	3.51
15	28	3.27
16	27	3.16
17	17	1.99
18	18	2.11
19	8	0.94
20	16	1.87
21	3	0.35
Total	855	100

Notes: The table tabulates the time elapsed between the first and last intervention in the Mozambican localities, for which information on population across the different censi (1980, 1997, 2007). For further details on the duration of intervention see Appendix III.

Table 5: Number of Years until First Intervention. Poisson ML. Province FE

	Number of Years until First Intervention								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Adjacent South Africa (dummy)		-0.002 (0.096)							-0.002 (0.126)
Adjacent Zimbabwe (dummy)		0.258*** (0.081)							0.214*** (0.082)
Adjacent Malawi (dummy)		-0.336** (0.149)							-0.256* (0.148)
Adjacent Tanzania (dummy)		0.078 (0.069)							0.039 (0.100)
Adjacent Zambia (dummy)		0.195 (0.144)							0.051 (0.126)
Adjacent Swaziland (dummy)		0.012 (0.126)							0.110 (0.094)
Elevation			-0.054 (0.173)						-0.027 (0.171)
Malaria Ecology			-0.015 (0.011)						-0.016 (0.012)
Suitability of Agriculture			-0.236* (0.138)						-0.145 (0.123)
Log - Number of Villages			-0.053 (0.034)						-0.016 (0.033)
Log - Distance Coast			0.015 (0.051)						0.009 (0.053)
Paved Road 1973 (dummy)				-0.086 (0.058)					-0.036 (0.061)
Unpaved Road 1973 (dummy)				-0.180 (0.123)					-0.219* (0.117)
Trail 1973 (dummy)				-0.115*** (0.043)					-0.065 (0.044)
Railway Colonial (dummy)				-0.114 (0.093)					-0.083 (0.081)
Navigable River (dummy)				-0.020 (0.061)					-0.011 (0.059)
Civil War (dummy)					-0.267*** (0.053)				-0.230*** (0.054)
Cantina 1965 (dummy)						-0.098** (0.040)			-0.011 (0.041)
Lit							-0.065 (0.056)		0.046 (0.054)
Log - Population Density 1980								-0.077*** (0.022)	-0.046** (0.022)
Log - Land	-0.030* (0.017)	-0.041** (0.018)	-0.018 (0.021)	-0.034* (0.018)	-0.039** (0.017)	-0.027 (0.018)	-0.032* (0.018)	-0.107*** (0.023)	-0.088*** (0.031)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	786	786	786	786	786	786	786
Log Likelihood	-2399	-2377	-2385	-2378	-2365	-2392	-2398	-2383	-2319
R2 Fitted	.103	.128	.125	.134	.139	.112	.106	.126	.197

Notes: The table reports the Poisson Maximum Likelihood (ML) estimates associating the timing of the first intervention at the locality level with location, geography, and other locality characteristics. In all specifications the dependent variable is the number of years (from 1 to 22) until first intervention took place in the locality (from 1992). All specifications include the log of land area and province fixed effect. In Column (1), we control for the log landmass. In column (2), we control for the (log) distance of the municipality centroid from the border of South Africa, Zimbabwe, Malawi, Tanzania, Zambia, and Swaziland. In Column (3), we control for geographic and location characteristics at municipality level such as mean elevation, malaria stability index, suitability of agriculture, (log) distance from the closest big city (Maputo, Beira or Nacala), and (log) distance from the coast. Column (4) introduces transportation network elements at colonial time (1973) like presence of paved road (dummy), unpaved road (dummy), trail (dummy), railways (dummy). In columns (5), (6), (7), and (8) we include a dummy for Civil War events, an indicator for the presence of colonial commercial harbors (*Cantinas*), a dummy equal one if the municipality is lit in 1992, and the (log) of population density in 1980. In Column (9) we controls for all the controls together. The Data Appendix gives detailed variable definitions and data sources. Below the estimates, the table gives standard errors clustered at the Admin-2 level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 6: Number of Years until Last Intervention. Poisson ML. Province FE

	Number of Years until Last Intervention								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Adjacent South Africa (dummy)		0.035 (0.038)							0.025 (0.038)
Adjacent Zimbabwe (dummy)		0.122*** (0.043)							0.125*** (0.047)
Adjacent Malawi (dummy)		-0.016 (0.053)							-0.033 (0.052)
Adjacent Tanzania (dummy)		0.062 (0.057)							0.120** (0.059)
Adjacent Zambia (dummy)		-0.067 (0.109)							-0.083 (0.105)
Adjacent Swaziland (dummy)		0.061** (0.027)							0.064* (0.037)
Elevation			0.058 (0.088)						0.036 (0.091)
Malaria Ecology			-0.003 (0.007)						-0.001 (0.007)
Suitability of Agriculture			-0.042 (0.061)						-0.046 (0.062)
Log - Number of Villages			0.023 (0.017)						0.018 (0.017)
Log - Distance Coast			-0.001 (0.023)						0.011 (0.024)
Paved Road 1973 (dummy)				0.037 (0.027)					0.037 (0.031)
Unpaved Road 1973 (dummy)				0.015 (0.038)					0.010 (0.037)
Trail 1973 (dummy)				0.021 (0.020)					0.016 (0.019)
Railway Colonial (dummy)				-0.007 (0.037)					-0.001 (0.035)
Navigable River (dummy)				-0.029 (0.023)					-0.034 (0.023)
Civil War (dummy)					0.023 (0.021)				0.003 (0.023)
Cantina 1965 (dummy)						0.033 (0.020)			0.022 (0.020)
Lit							0.002 (0.030)		-0.017 (0.033)
Log - Population Density 1980								0.020* (0.011)	0.014 (0.012)
Log - Land	0.030*** (0.009)	0.026*** (0.009)	0.024** (0.011)	0.032*** (0.009)	0.030*** (0.009)	0.029*** (0.009)	0.030*** (0.009)	0.049*** (0.014)	0.034* (0.018)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	786	786	786	786	786	786	786
Log Likelihood	-2179	-2174	-2175	-2176	-2178	-2177	-2179	-2177	-2166
R2 Fitted	.32	.329	.331	.324	.321	.322	.32	.32	.339

Notes: The table reports the Poisson Maximum Likelihood (ML) estimates associating the timing of the last intervention at the locality level with location, geography, and other locality characteristics. In all specifications the dependent variable is the number of years (from 1 to 23) until last intervention took place in the locality (from 1992). All specifications include the log of land area and province fixed effect. In Column (1), we control for the log landmass. In column (2), we control for the (log) distance of the municipality centroid from the border of South Africa, Zimbabwe, Malawi, Tanzania, Zambia, and Swaziland. In Column (3), we control for geographic and location characteristics at municipality level such as mean elevation, malaria stability index, suitability of agriculture, (log) distance from the closest big city (Maputo, Beira or Nacala), and (log) distance from the coast. Column (4) introduces transportation network elements at colonial time (1973) like presence of paved road (dummy), unpaved road (dummy), trail (dummy), railways (dummy). In columns (5), (6), (7), and (8) we include a dummy for Civil War events, an indicator for the presence of colonial commercial harbors (*Cantinas*), a dummy equal one if the municipality is lit in 1992, and the (log) of population density in 1980. In Column (9) we controls for all the controls together. The Data Appendix gives detailed variable definitions and data sources. Below the estimates, the table gives standard errors clustered at the Admin-2 level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 7: Number of Years until First Intervention. Poisson ML. Province FE. Controlling for CHAs Contamination.

	Number of Years until Last Intervention								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CHAs - 1st Quintile	-0.305*** (0.026)	-0.303*** (0.027)	-0.304*** (0.025)	-0.306*** (0.026)	-0.308*** (0.027)	-0.304*** (0.027)	-0.305*** (0.026)	-0.304*** (0.027)	-0.304*** (0.027)
CHAs - 2nd Quintile	-0.116*** (0.026)	-0.109*** (0.027)	-0.116*** (0.026)	-0.119*** (0.026)	-0.119*** (0.027)	-0.115*** (0.026)	-0.115*** (0.026)	-0.115*** (0.026)	-0.115*** (0.027)
CHAs - 3rd Quintile	-0.108*** (0.018)	-0.106*** (0.018)	-0.106*** (0.018)	-0.108*** (0.018)	-0.110*** (0.018)	-0.107*** (0.018)	-0.108*** (0.018)	-0.107*** (0.018)	-0.106*** (0.018)
CHAs - 4th Quintile	-0.047*** (0.016)	-0.043*** (0.016)	-0.049*** (0.016)	-0.047*** (0.016)	-0.048*** (0.016)	-0.047*** (0.016)	-0.047*** (0.017)	-0.047*** (0.017)	-0.044*** (0.016)
CHAs - 5th Quintile	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)	0.000 (.)
Adjacent South Africa (dummy)		0.015 (0.034)							0.009 (0.038)
Adjacent Zimbabwe (dummy)		0.083*** (0.029)							0.076** (0.033)
Adjacent Malawi (dummy)		-0.066 (0.051)							-0.070 (0.053)
Adjacent Tanzania (dummy)		0.035 (0.057)							0.070 (0.065)
Adjacent Zambia (dummy)		0.037 (0.102)							0.007 (0.099)
Adjacent Swaziland (dummy)		0.028* (0.016)							0.030 (0.031)
Elevation			0.020 (0.076)						0.002 (0.079)
Malaria Ecology			-0.004 (0.006)						-0.004 (0.006)
Suitability of Agriculture			-0.053 (0.053)						-0.038 (0.054)
Log - Number of Villages			0.008 (0.014)						0.011 (0.014)
Log - Distance Coast			-0.003 (0.020)						0.006 (0.022)
Paved Road 1973 (dummy)				0.013 (0.023)					0.012 (0.027)
Unpaved Road 1973 (dummy)				0.001 (0.026)					-0.004 (0.027)
Trail 1973 (dummy)				-0.004 (0.018)					-0.004 (0.018)
Railway Colonial (dummy)				-0.006 (0.034)					-0.001 (0.032)
Navigable River (dummy)				-0.033 (0.020)					-0.035* (0.020)
Civil War (dummy)					-0.013 (0.021)				-0.023 (0.021)
Cantina 1965 (dummy)						0.018 (0.019)			0.024 (0.018)
Lit							0.011 (0.025)		0.015 (0.026)
Log - Population Density 1980								0.003 (0.010)	-0.000 (0.011)
Log - Land	0.007 (0.008)	0.004 (0.008)	0.005 (0.010)	0.008 (0.008)	0.006 (0.008)	0.006 (0.008)	0.007 (0.008)	0.009 (0.011)	0.001 (0.015)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	786	786	786	786	786	786	786
Log Likelihood	-2108	-2105	-2105	-2106	-2107	-2107	-2108	-2108	-2101
R2 Fitted	.467	.472	.47	.469	.467	.468	.468	.467	.48

Notes: The table reports the Poisson Maximum Likelihood (ML) estimates associating the timing of the last intervention at the locality level with location, geography, and other locality characteristics. In all specifications the dependent variable is the number of years (from 1 to 23) until last intervention took place in the locality (from 1992). All specifications include the log of land area, province fixed effect, and quintiles of contamination of confirmed hazardous areas. In Column (1), we control for the log landmass and quintiles of contamination of confirmed hazardous areas. In column (2), we control for the (log) distance of the municipality centroid from the border of South Africa, Zimbabwe, Malawi, Tanzania, Zambia, and Swaziland. In Column (3), we control for geographic and location characteristics at municipality level such as mean elevation, malaria stability index, suitability of agriculture, (log) distance from the closest big city (Maputo, Beira or Nacala), and (log) distance from the coast. Column (4) introduces transportation network elements at colonial time (1973) like presence of paved road (dummy), unpaved road (dummy), trail (dummy), railways (dummy). In columns (5), (6), (7), and (8) we include a dummy for Civil War events, an indicator for the presence of colonial commercial harbors (*Cantinas*), a dummy equal one if the municipality is lit in 1992, and the (log) of population density in 1980. In Column (9) we controls for all the controls together. The Data Appendix gives detailed variable definitions and data sources. Below the estimates, the table gives standard errors clustered at the Admin-2 level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

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Landmines and Spatial Development

Appendix VI

Sensitivity Analysis, Local Effects *

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Abstract

This Appendix presents various sensitivity checks and graphical illustrations of the within-locality association between regional development-urbanization and landmine clearance.

*Additional material can be found at www.land-mines.com

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Contents

1	Graphical Illustration. Landmine Clearance and Local Development	3
2	Alternative Outcomes	4
2.1	Population	4
2.2	Building New Roads and Improving Pre-Existing Ones	6
3	Sensitivity Checks. Local Effects of Demining	7
3.1	Controlling for New Roads and Improvements in the Pre-Civil-War Road Network	7
3.2	Dropping Maputo Province	8
3.3	Dropping Big Cities (Maputo, Beira, Nacala)	8
3.4	Northern Provinces	8
3.5	Lights Transformation	9
3.6	Dynamic Panel Estimates	9
3.7	First and Last Intervention	9
3.8	Restricting Estimation to Contaminated Localities	10
3.9	Collapsing Demining Intervention at Site Level	10
3.10	Admin-3 Unit Analysis	10
3.11	Confirmed Hazardous Areas vs “Cancelled” Suspected Hazardous Areas	11
4	Heterogeneity	12
4.1	Alternative GIS Classification Thresholds	12
4.2	Locality Features	13
4.3	Report-Based Categorization of CHAs	14

Sensitivity Analysis - Local Consequences of Demining

We have performed a plethora of sensitivity checks to assess the robustness of the within-locality association between development and demining. We have also looked at alternative-to-luminosity outcome variables to better understand the impact of demining. Before going over the sensitivity analysis, we present some visualizations of the within-locality association between luminosity and landmine clearance.

1 Graphical Illustration. Landmine Clearance and Local Development

It is useful to plot the evolution of luminosity around the year of full clearance, as this provides a visualization of the local estimates. Below we present four figures tracing log luminosity (Figures 1a and 2a) and the probability that the locality is lit (Figures 1b and 2b) around the timing of full clearance ($year = 0$). We partial out locality-specific constants (fixed-effects) and province-specific year fixed effects and then plot the residuals of luminosity in the 10 years before and 10 years after each locality's full clearance from contamination. The dashed horizontal lines give the mean values of demeaned luminosity before and after full clearance. Before discussing the graphs, a few caveats are in order. First, given the presence of positive spillovers, these “control”-“treatment” before-after graphs just illustrate local effects assuming no externalities. Second, there is noise in the exact date of recording of interventions, a concern that is non-negligible for demining activities before 2001 and before 2007.

The two Panels in Figure 1 illustrate the before and after full clearance evolution of luminosity across all contaminated localities. Figure 2 plot the demeaned luminosity before and after clearance looking across localities with more than one confirmed hazardous area (CHA), as this allows examining the evolution of luminosity for localities with a non-trivial degree of contamination.

The pattern is similar across all Figures: upon full clearance luminosity increases and remains higher throughout the post-demining period. The influence of demining is long lasting. One more pattern that is evident across Figures is that luminosity appears to start increasing one-to-three years before complete clearance, as demining operators are clearing more and more of the underlying contamination. This is to be expected as the duration of demining operations for the median locality was roughly 6 years whereas for those with more than one CHA the median duration was 8 years.

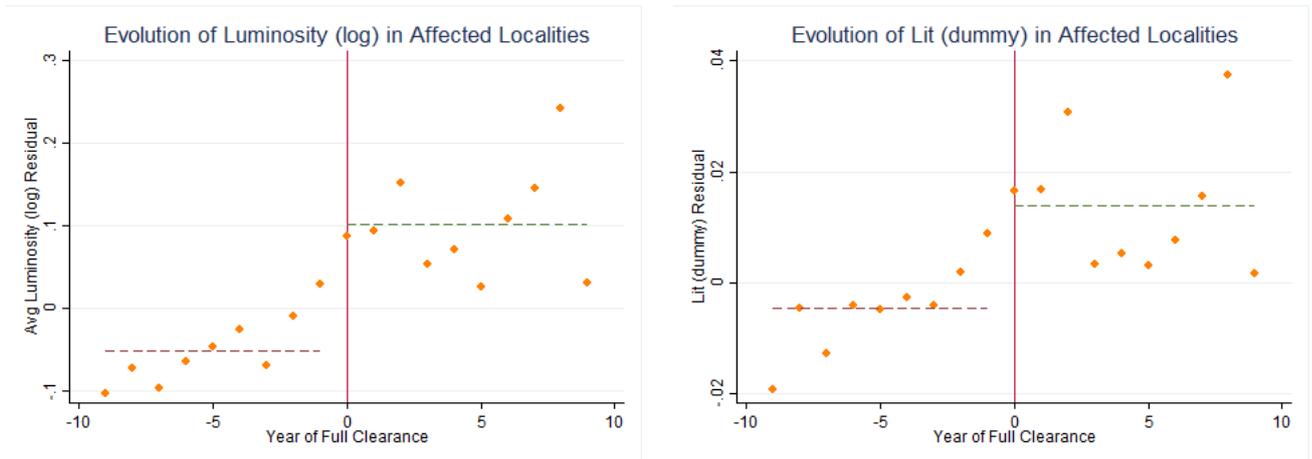


Figure 1: **Evolution of Luminosity before and after Last Year of Intervention.**

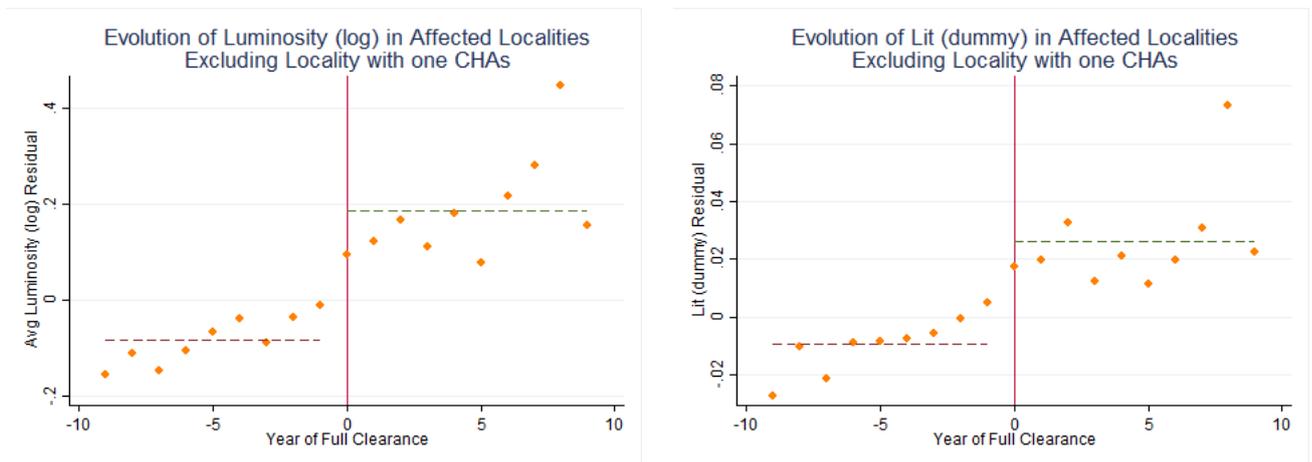


Figure 2: **Evolution of Luminosity before and after Last Year of Intervention. Excluding Localities (162) with only one Confirmed Hazardous Area.**

2 Alternative Outcomes

2.1 Population

During the civil war, there were widespread population movements both as a result of violence and because of landmine contamination. At the same time, both the FRELIMO government and RENAMO moved peasants to “development villages” and labor camps, respectively (see the historical overview in Appendix I). Unfortunately, locality-level data on population and casualties at the end of the civil war in 1992 are not available, so cleanly estimating the impact of demining on repatriation is not feasible. One way to gauge the degree of population reshuffling is to look at the evolution of population between

the pre and post-civil war censuses. The correlation of log population at the locality level between 1980, the first post-independence Census, and 1997, the first-post-civil war census, is 0.59 suggesting significant changes in the population distribution during this 17-year period. Perhaps, what is more telling is the fact that the correlation of log population between the pre and post-civil war period strengthens across localities as time elapses; the correlation becomes 0.66 between log population in 1980 and in 2007. This suggests that the spatial distribution of population gradually returns to the one observed during the pre-civil war era.

Among the goals of demining interventions particularly during the early years, was to facilitate the return of the internally and externally displaced people. There were more than 1.5 million refugees mostly in Malawi and Zimbabwe, but also in Swaziland and Tanzania. And there were more than 2 million internally-displaced people, residing at dire conditions either in the big cities or in camps or in border areas. We used information on local population for 1980 and 2007 and explore whether reducing the degree of mine contamination in a given locality (or eliminating it altogether) influences the number of people living in that locality. We recognize that changes over time in the number of people reflects both internally displaced people and refugees in border areas returning to their homes (this is in line with United Nations action and both HALO Trust and NPAs action on the Malawian border) as well as differences in net fertility rates.

We attempt to capture the relationship between population movements and demining activities by estimating long-run-difference specifications over the 1980 – 2007 period. Unfortunately, we are constrained to use 2007 as the terminal year, because the national statistical agency has not processed the 2017 census data, yet. Table 1 gives the results. The unconditional specification in column (1) reveals a significantly positive association between the log of cleared CHAs (Confirmed Hazardous Areas) and population growth. The coefficient retains its economic and statistical significance when we condition on various pre-civil-war features (paved, unpaved roads, the presence of cantinas) as well as population and luminosity (in columns (3) and (5)). The same pattern is detected with the cleared dummy that identifies fully cleared by landmines and UXOs localities, but the estimate on the indicator variable is noisy and does not pass standard significance levels. This applies both in the unconditional specification (in column (2)) and when we control for pre-clearance factors (in columns (4) and (6)). This might be because by 2007, only 48% of the contaminated localities were fully cleared, as well as the possibility that displaced individuals would start coming back home as soon as demining would start and not wait till the full clearance of their ancestral localities which has taken several years. Another

reason behind the weaker and insignificant associations between landmine clearance and population comes from the fact that landmine clearance may foster development, promoting agglomeration, but at the same time, it may allow people residing in remote areas to leave and move to bigger towns and communities. [This is an issue that the “market access” estimation is taking into account.]

2.2 Building New Roads and Improving Pre-Existing Ones

Going over the documents on the history of demining it becomes clear that the latter enabled access to previously unusable segments of the network and often times upon the completion of demining there were improvements on the transportation network. As an illustrative example among the many we encountered, a report from a HALO Trust operation in Lapala (in Nampula province in the North) in 2002 states that “*clearance will allow the rehabilitation of the [affected] road. Demining will benefit the local population and restore the free circulation of vehicles. Moreover, vehicles will be able to avoid the big detour they currently face in the vicinity of Lapala village.*” At the same time, since the end of the civil war many new roads have been constructed. A natural question is how the timing of demining maps into these changes in the transportation network.

To answer this question we collected information on the Mozambican transportation network including roads, railways and navigable rivers. Information on the road network was kindly provided by the National Road Administration (ANE), which produced a detailed georeferenced database of the Mozambican roads for three different points in time. Namely, 1998, 2003, and 2011. For each road segment we have information on the conditions (paved, unpaved or trail) and quality (good, fair, bad). Data for the railways network come from the Ministry of Transport and Communication. For each of the rail corridors, we were able to identify the name and the length of each segment. There are three main railways, all connecting the coastal areas in the Indian Ocean to inland: the Northern line links Nacala to Malawi; the central line connects Beira to Zimbabwe; and the Southern route goes from Maputo to South Africa. A peculiar feature of the Mozambican rail network, intimately connected to its colonial experience, is the absence of any connection among these three main corridors. We also collected data on navigable rivers from the Ministry of Transportation (and we are in the process of getting data on port cities). We count 12 navigable rivers in Mozambique.¹ With the exception of the Zambezi, Mozambican rivers do not allow large or medium-sized boats to sail and are far less exploited than road and rail.

¹Namely, Buzi, Chinde, Incomati, Limpopo, Lugenda, Lurio, Messalo, Pungwe, Ruvuma, Save, Tembe, Zambezi.

We then digitized information on the conditions and quality of the transportation network in the colonial era. We accessed a map from the colonial archives in Maputo from 1973 depicting both roads and railroads infrastructure. Analogous to the 2011 roads data, we retrieved detailed information and reconstructed the classification of the colonial road network into paved, unpaved or trail conditions. Regarding the railroads, we complemented the information from the colonial archives with self-collected sources on the railroad conditions and status (functioning or destroyed) at the end of the Civil War in 1992.²

Table 2 gives panel estimates that associate new road building and improvements of the pre-war transportation network with landmine clearance. In columns (1)-(2) the dependent variable is an indicator that takes the value one if a new road appears in the locality at the end of each of the four periods of demining (namely in 1992, 1999, 2007, and 2015). In columns (3)-(4) the dependent variable reflects whether there has been an improvement in the colonial transportation network (of 1973). The estimated coefficients in (1) and (3) suggests that localities that experienced a larger number of clearance interventions were both more likely to have new roads and see improvements in the pre-existing network. Upon full clearance of a locality from CHA, new roads were not more likely to be built (column (2)), but existing roads were more likely to be upgraded.

3 Sensitivity Checks. Local Effects of Demining

3.1 Controlling for New Roads and Improvements in the Pre-Civil-War Road Network

A natural question that comes from the earlier results (in Table 2), is whether the demining - luminosity association (uncovered in Table 2) is (partly) driven by improvements in the transportation network that is also linked to landmine clearance. We address this inquiry, in Table 3 we repeat estimation of the baseline (difference-in-difference empirical specification) associating luminosity with landmine clearance, controlling for changes (new roads and improvements) in the local transportation infrastructure. The coefficient on demining declines by 5% – 10% suggesting that a small part of the local influence of demining on economic performance operates via the improvement of the local transportation network.

²We interviewed several experts and consulted the archives of the Ministry of Transportation in Maputo.

3.2 Dropping Maputo Province

We examine the stability of the estimates when excluding the Maputo Province, as both luminosity and contamination are substantially high. In Maputo Province, 30% of localities were already lit in 1992 (with the country average being just 9%). Contamination was also considerable in the province (though not in the capital), affecting 91% of the localities. Table 4 reports the fixed effects estimates when we drop the 78 localities of Maputo province. The table structure “mirrors” Table 2 of the main paper that presented the baseline panel fixed-effect estimates. There is a strong link between demining activities and luminosity. The “beta” coefficient of the logarithm of $(1 + \text{number of cleared CHA})$ increases by 9%-13%, whereas the coefficient on complete clearance is almost identical to the one reported in the Table.

3.3 Dropping Big Cities (Maputo, Beira, Nacala)

We also estimated specifications dropping the three big cities, Maputo, Beira, and Nacala, as in the end of conflict in 1992, these cities were packed with refugees. Moreover, development is considerably higher in these three cities. Table 5 replicates our baseline specification estimates dropping the three localities hosting the largest cities, Nacala in the North, Beira in the Center, and Maputo in the South. The results are very similar to the baseline local estimates. There is a significantly positive within-locality association between luminosity and landmine clearance; localities with high luminosity are not driving the association.

3.4 Northern Provinces

We restricted estimation to the less developed Northern provinces. This is useful for a couple of reasons. First, it is a good “internal” validity check as the Northern provinces have been (and still are) disconnected from the South and Centre. Second, due to various historical reasons, the Mozambican North was way less developed than the South. Third, the Northern provinces were freed from landmine contamination in 2007 and thus we have a considerable post-clearance number of observations. Fourth, as Halo Trust was the dominant demining operator, we look in a sample of localities cleared by the same NGO. Fifth, HALO Trust data appear less noisy. Table 6 replicates the baseline panel fixed-effects specifications in the 590 localities (49.7% of the total) of the country’s Northern Provinces (Cabo Delgado, Niassa, Nampula, and Zambezia). The coefficient on the log number of cleared accumulated confirmed hazardous areas (CHA) and the cleared CHA indicator is positive and highly significant.

The estimates are similar to the baseline specifications (in the full sample of localities), reported in Table 2 of the main paper. If anything the implied economic magnitudes are larger, a result that most likely stems from reduced measurement error.

3.5 Lights Transformation

The 2015 measures of luminosity are recorded by a different satellite (VIIRS) than those used up until 2013 (DMSP-OLS) (Michalopoulos and Papaioannou (Forthcoming)). To make the measurements of the two satellite data comparable we have followed Li, Li, Xu, and Wu (2017). But one may wonder how this transformation affects the results. In Table 7 we run the baseline panel specifications stopping in 2013 (rather than going till 2015), as this allows using data from DMSP-OLS. As of 2013, 87 localities (10.1% of the universe of contaminated ones) are still not fully cleared; and 35.30% of the localities are lit in 2013. Stopping in 2013 does not change the overall picture. While the estimated coefficients drop slightly, the relationship between demining and luminosity retains significance.

3.6 Dynamic Panel Estimates

We estimated dynamic panel specifications, allowing for inertia in the dependent variable. As the time dimension exceeds 20, the “Nickell-bias” emerging from the joint inclusion of the lagged dependent variable and the locality-specific constants is unlikely to be large. Table 8 reports the dynamic panel estimates. There is inertia in luminosity, as the autoregressive term AR(1) coefficient (a_1) is around 0.4 – 0.5. The estimate on the log number of CHA and the cleared dummy retain their statistical significance. Given persistence in luminosity, the “long-run” effect of landmine clearance on luminosity is higher than the “short-term” effect ($\beta_{LT} = \frac{\beta_{ST}}{1-a_1}$). This is consistent with the “long/medium-run” association between landmine clearance and local economic activity (reported in in Table 2, columns (4)-(8) and in Table 3) being larger than the estimates reported in Table 2, columns (1)-(4).

3.7 First and Last Intervention

We also examined whether development-urbanization, as reflected in luminosity, increases with the first/initial demining operation or whether luminosity increases when the locality is completely cleared by contamination. Table 9 reports the results. Luminosity increases consistently when after a locality is fully cleared by contamination. Luminosity in the years between the first and the last CHA intervention is not statistically different from the average luminosity before the first intervention. This

lack of significance mitigates also concerns that the positive association between landmine clearance and luminosity is driven by the presence of deminers on the ground or because of contemporaneous development projects. If this was the case, the association between luminosity and clearing landmines would become manifest as soon as the first intervention commences. The fact that luminosity increases after the locality is fully cleared suggests that development-urbanization spikes once the area is free of CMA.

3.8 Restricting Estimation to Contaminated Localities

We also estimated quite restrictive specifications looking only on the sample of contaminated by landmines localities. Omitting localities without any CHA is inefficient, as, by dropping the “pure control” group, we do not properly account for general trends and dynamics in luminosity. Yet, exploiting (within-locality) variability looking only on contaminated areas, we perhaps account well for hard-to-observe differential growth trends in the two groups of localities. Table 10 presents the results. Across all perturbations, the coefficient on the cleared CHA indicator and the log number of cleared CHA is positive and statistically different than zero. The estimate is quite similar to the full-sample (baseline) estimates, reported in Table 2, though somewhat less precisely estimated. In spite of relying solely on variation in the timing of clearance within contaminated localities, the link between luminosity and CHA clearance retains economic and statistical significance.

3.9 Collapsing Demining Intervention at Site Level

We rerun our main specification after collapsing the data at the site level. Multiple demining interventions might be linked to the same hazardous areas (see Appendix III for further details). After aggregating the 7,423 interventions, we obtain 6712 hazardous areas. This aggregation is innocuous both for the number of affected localities (855) and for the timing of full clearance (average duration is 6.89 years). Table 11 that “mirrors” Table 3 of the main body gives the results. The estimate is almost identical to the intervention baseline estimates.

3.10 Admin-3 Unit Analysis

We conduct our analysis at the locality level, the finest administrative (level 4) units of Mozambique. This allows accounting at the finest possible-level for local features and unobservable features (by the inclusion of admin-4 unit fixed-effects). We explored the sensitivity of the luminosity - CHA clearance

association conducting the analysis at coarser, admin-3 units”. We aggregated the luminosity and demining data across admin-3 units (“Postos Administrativos”) and rerun the baseline panel fixed-effects specifications across 417 admin-3 units over the period 1992 – 2015. This serves two purposes: First, it reduces measurement error on the spatial dimension of the data. Second, using a larger unit of analysis partially accounts for spatial (though still localized) spillovers. The aggregation at admin-3 level stresses the severity of landmine contamination: out of the 417 admin-3 units, 379 “Postos” (90%) were contaminated by landmines. Table 12 gives the results. The within-postos correlation between luminosity and landmine clearance is quite strong. The coefficients are statistically significant in all permutations. The estimates (and standardized coefficients) are somewhat larger than the baseline one (estimated at the finer level), hinting to the positive externalities of demining.

3.11 Confirmed Hazardous Areas vs “Cancelled” Suspected Hazardous Areas

As we explain in detail in the Data Appendix and briefly in the main text, the verification check of whether a suspected hazardous areas (SHA) was indeed contaminated (and consequently classified as a CHA) frequently resulted in the cancellation of the suspected threat. Naturally, one may wonder whether the sheer reclassification of false positives was important for local economic activity. To answer this question we distinguish between hazardous areas where contamination was confirmed (CHAs) and those hazardous areas that were suspected of being contaminated, but upon closer examination by the surveyors were “cancelled” on the basis of false or inaccurate information (canceled SHA). We then test whether luminosity correlates with the actual detonation of landmines or whether the correlation is also present when the fear of potential contamination is dispelled.

Before discussing the panel estimates, a note of caution is in order. Reading over the reports of “cancelled” SHAs reveals that the local community was often aware that the presumed area was in fact not contaminated, as often it was already in use. For example, in Nunge (Cabo Delgado) HALO Trust team visited a suspected hazardous area in 2002 and, after interviewing the local population, cancelled the SHA because “*locals stated that landmines were never affected the community and the SHA was on a parcel of land that was cultivated*”. So, often the “cancelled” SHAs reflected inefficient initial surveying rather than a true misunderstanding of the locals regarding the presence of mines. Keeping these caveats into account, we added to the 7,423 CHAs interventions, an additional 1,994 SHAs that were canceled. For each of these SHAs, we have information on the date of “cancellation”.

So we run the baseline empirical panel models, associating luminosity with both the log of $(1 +$

number of cleared CHAs) and the log (1 + number of cancelled SHAs). Table 13 reports the results. The log number of CHA continues to enter with a significantly positive coefficient; the estimate is also quite similar to the one in Table 2. In contrast, luminosity is not systematically related to cancelled SHA that were based on inaccurate information. The estimate on the “cancelled” suspected hazardous areas variable is small, changes, sign and does not pass standard significance levels in any of the perturbations.

4 Heterogeneity

In this section, we first show that the GIS-based heterogeneity of landmine clearance on local development-urbanization -presented in Table 4 of the main paper- are robust to different distance cutoffs for the definition of the non-mutually exclusive GIS categories of confirmed hazardous areas. Second, we present estimates exploring heterogeneity of landmine clearance on luminosity with respect to locality features. Third, we explore heterogeneity of the luminosity -clearance correlation using the CHA reports of clearance.

4.1 Alternative GIS Classification Thresholds

We examined whether the findings of Table 4 in the main body revealing sizable heterogeneity of landmine clearance on luminosity are robust to altering the distance cutoffs in how we classify landmine contamination. Specifically, we double the thresholds of all 7 non-mutually exclusive categories, namely: (i) landmines close to roads and railroads (200 meters); (ii) CHA close to the national border (2 kilometers); (iii) landmine and UXO sites close to commercial hubs (2 kilometers); (iv) landmine threats close to areas experiencing major civil war incidents (2 kilometers); (v) CHA close to rivers (200 meters); (vi) CHA close to electricity pylons (200 meters); (vii) CHA close to major villages or towns (2 kilometers); and (viii) a residual category. Table 14 reports the results. The patterns are similar to those shown in Table 4. Landmine clearance along roads and railways enters with a significantly positive estimate (with “beta coefficients” that are somewhat larger than the ones in Table 4). The within-locality correlation between luminosity and CHA clearance is also stronger for demining operations clearing villages/towns and colonial commercial harbors (*cantinas*). In contrast, clearance operations in proximate to borders areas and rural places (the residual category) are associated with falls in luminosity. This is in line with the narrative that clearing border areas allowed internally

displaced people and refugees residing in camps at the border to return of their hometowns.

4.2 Locality Features

As discussed in the main part of the paper, we also explored heterogeneity with respect to *locality* features. To do so, we split the sample of localities into subsamples based on local features (connectivity to the pre-independence transportation network, pre-civil war population, surveyed or not) and repeated the panel estimation. Table 15 presents the results.

Connected - Non-Connected Localities First, we examined whether the influence of clearance on local development-urbanization (as reflected in luminosity) is larger for localities that were connected to the colonial transportation network in 1973. To do so, we split the sample into a “Connected” subsample consisting of 888 localities that had some type of transportation mode in 1973 and a “Non-Connected” subsample consisting of the remaining 299 localities that were not crossed by the 1973 transportation network nodes and repeated estimation in the two sub-samples. We run separate panel regressions in the two subsamples to allow each subset of localities to have its own growth trajectory. Column (1) shows that clearing a connected locality increases the probability of lit by 3.7%; this estimate is similar to the baseline estimate in Table 2 of the main paper. Conversely, the specification in column (2) shows that the effect of demining in non-connected localities is small (coefficient 0.05) and indistinguishable from zero. As the quality of connection varies for the different elements of the colonial transportation network, we defined indicator variables reflecting whether a connected locality was crossed by *i*) a paved road, *ii*) an unpaved road, *iii*) a trail, and *iv*) and a railway. Column (3) reports panel estimates in the subsample of connected to the 1973 localities (same subsample as in column (1)). Among connected localities demining those hosting a paved road and a railroad enjoyed the largest increase in luminosity. The probability of lit increases by 6.2% for localities with a paved road in 1973 and for those with a colonial railway. Clearance of localities with unpaved roads is also associated with increases in luminosity, though the estimate (0.049) is imprecise and does not pass standard significance thresholds.

Population Density Second, we examined whether the correlation between luminosity and landmine clearance differs with respect to pre-civil-war population density. We split the sample of 1107 localities into five subgroups based on the 1980 population count and rerun the baseline panel specification in each of the five quintiles. Table 15 columns (4)-(8) give the results. The luminosity -

landmine clearance association is strong (and precisely) estimated in more densely populated localities. The estimate in the largest quintile is 0.064, implying sizable effects of landmine clearance on local development-urbanization. The estimate is around 0.04 – 0.045 for localities in the fourth, third, and second quintile. The estimate is small (0.02) and statistically insignificant in the subsample of low population density localities.

Surveyed and Non-Surveyed Localities Third, we distinguished between localities whose CHAs were indicated in the 1994 SHAMAN or the 2001 MLIS surveys and those that were not. Finding that the link between demining CHAs and luminosity is robust in both samples would alleviate concerns that the observed relationship is driven by the sample of demining in initially (non) surveyed localities. Table 15 columns (9)-(10) give the results in the two subsamples. Landmine clearing is predictive of increases in luminosity in both subsamples.³

4.3 Report-Based Categorization of CHAs

An alternative way to group clearance activities into different categories is from reading each technical and completion report. Going over 7,243 interventions we classified demining operations into 10 non-mutually exclusive categories. In Table we report the breakdown. The largest categories concern contamination of electricity pylons (13%), footpaths (11.5%), farm (9%), CHAs in residential areas (9%), roads, railways, and bridges (7.7%) and in areas of military importance (7%). Appendix Table 16 mirrors Table 4 of the main body. The difference is that now instead of classifying CHAs by locating them along key features of the country’s infrastructure, we use the report-based classification described above and allow the coefficient of clearance to vary for each type. Similar, to what we found in Table 3 clearing borders seems to negatively impact luminosity in the year of the clearance (but not over the 7-year horizon).

Also, demining of residential places as well as of public infrastructure-related CHAs increases economic activity as captured by images of satellite light density at night. The correlation between clearing CHAs along roads and railroads has a insignificant positive impact on lit (dummy). The report-based category that has a consistently positive impact on local development concerns interventions that the reports did not indicate what was the type of contamination (Not Classified). This are interventions for which the report description was either left blank or not useful to derive a classification. In an

³The median contamination across surveyed localities is 6 threats whereas the respective statistic is zero for the non-surveyed ones which may explain the slightly stronger impact of demining for surveyed localities.

effort to better understand what type of CHAs were not classified in the reports we cross-tabulated the GIS-based classification with the report-based one. There are a total of 2,926 CHAs for which the reports do not mention the type of the affected area. When we look where these unclassified areas of contamination belong to, according to the GIS categorization, it becomes apparent why the former enter in the regression with a consistently positive sign. Around 42% of these 2,659 “unclassified” CHAs can be found along roads, railroads, points of commercial importance and in towns and villages.

We would have liked to use the report-based classification to guide our analysis on heterogeneity. However, the fact that for about 40% of the interventions on CHAs we have no information on the affected areas and it is precisely these contaminated points whose clearance matters most for regional development (and that the majority of these unclassified areas could be binned into meaningful categories based on their actual location) that we decided to use the location-based categorization.

Tables

Table 1: **Long-Run Differences, 2007-1980. Population as Outcome**

	Δ Log Pop	Δ Log Pop	Δ Log Pop	Δ Log Pop
	(1)	(2)	(3)	(4)
Δ Cleared Threats	0.063*** (0.021) [0.077]		0.081*** (0.025) [0.099]	
Cleared (dummy)		0.076 (0.054) [0.046]		0.021 (0.048) [0.013]
Paved Road 1973 (dummy)			0.452*** (0.059) [0.218]	0.477*** (0.060) [0.230]
Unpaved Road 1973 (dummy)			0.220* (0.132) [0.040]	0.242* (0.130) [0.044]
Trail 1973 (dummy)			0.216*** (0.053) [0.127]	0.238*** (0.053) [0.140]
Railway 1973 (dummy)			0.157** (0.079) [0.066]	0.175** (0.079) [0.074]
Navigable River (dummy)			0.002 (0.066) [0.001]	0.006 (0.066) [0.003]
Civil War (dummy)			0.153*** (0.051) [0.071]	0.192*** (0.049) [0.089]
Cantinas (dummy)			0.115** (0.047) [0.070]	0.118** (0.047) [0.072]
Log - Population Density 1980			-0.471*** (0.038) [-0.903]	-0.461*** (0.037) [-0.884]
Log - Luminosity 1992			0.043*** (0.010) [0.160]	0.041*** (0.010) [0.154]
Log - Land			-0.494*** (0.050) [-0.706]	-0.468*** (0.048) [-0.669]
Province FE	Yes	Yes	Yes	Yes
R-squared	.124	.12	.417	.41
Observations	1,077	1,077	1,077	1,077

Notes: The table reports long-run difference OLS specification estimates associating changes in log population (over the period 2007-1980) with demining activities and various control variables. In all specifications, the dependent variable is the change in the logarithm of population between 2007 and 1980. Columns (1) and (2) give unconditional specification estimates. Columns (3)-(6) include a rich set of control variables, namely: indicator (dummy) variables that take the value of one when a locality is crossed by the key elements of the 1973 transportation network (Paved Road, Unpaved Road, Trails, and Railway); indicator variables for the presence of navigable river, the presence of colonial commercial harbour (*Cantinas*), and for localities affected by major civil war incidents. The set of control variables also include log population density (using the 1980 census), log luminosity in 1992 (before landmine clearance operations commence), and log land area. All specifications include province fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses and standardized beta coefficients (in squared brackets)). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 2: New Roads and Old Network Improvement

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	New Road (dummy)		Old Net Improvement (dummy)	
	(1)	(2)	(3)	(4)
Cleared Threats	0.039*** (0.010) [0.084]		0.080*** (0.011) [0.159]	
Cleared (dummy)		-0.001 (0.018) [-0.001]		0.069*** (0.019) [0.065]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.351	.346	.441	.432
Observations	4,748	4,748	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating new road construction (in columns (1)-(2)) and improvement over the pre-independence road network (in columns (3)-(4)) with landmine clearance operations. Estimation is run at the three main periods of landmine clearance (1992-1999, 2000-2007, and 2008-2015). In columns (1) and (2), the dependent variable is an indicator that takes the value of one in the period and all subsequent periods of a new road construction in a given locality. In columns (3)-(4), the dependent variable is an indicator variable that takes the value of one in the period and all subsequent periods following the improvement/expansion of an old road (corresponding to the 1973 road infrastructure network). Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable that takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 3: **Land Mine Removal and Local Development. Controlling for New Road**

	Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Cleared Threats	0.433*** (0.097) [0.099]		0.053*** (0.011) [0.119]	
Cleared (dummy)		0.719*** (0.180) [0.079]		0.079*** (0.020) [0.084]
New Road (dummy)	0.003 (0.204) [0.000]	0.080 (0.204) [0.009]	0.017 (0.023) [0.017]	0.026 (0.023) [0.027]
Old Network Improved (dummy)	0.448** (0.184) [0.052]	0.521*** (0.182) [0.060]	0.044** (0.020) [0.050]	0.054*** (0.020) [0.060]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.242	.241	.225	.222
Observations	4,748	4,748	4,748	4,748

Notes: The table reports FE effects estimates associating luminosity with demining activities, controlling for the construction of new roads and improvements over the old road network. In columns (1) and (2), we control for an indicator that equals one when a new road was built; in columns (3)-(4), we include a dummy equals one if an old road was improved. All specifications include Locality and Province \times Period fixed effects. Standard errors in parentheses are clustered at the District (admin 2) level. Beta coefficients are reported in squared brackets. Squared ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 4: Land Mine Removal and Local Development. Dropping Maputo Province

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.358*** (0.075) [0.080]		0.042*** (0.007) [0.092]		0.512*** (0.104) [0.121]		0.064*** (0.011) [0.146]	
Cleared (dummy)		0.386*** (0.114) [0.041]		0.039*** (0.011) [0.041]		0.756*** (0.187) [0.088]		0.084*** (0.021) [0.093]
Number of Localities	1,109	1,109	1,109	1,109	1,109	1,109	1,109	1,109
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.162	.159	.124	.12	.237	.233	.226	.22
Observations	25,507	25,507	25,507	25,507	4,436	4,436	4,436	4,436

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, dropping localities in the Maputo Province. The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 5: **Land Mine Removal and Local Development. Dropping Maputo, Beira, and Nacala**

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.330*** (0.073) [0.072]		0.037*** (0.007) [0.081]		0.469*** (0.099) [0.108]		0.058*** (0.011) [0.130]	
Cleared (dummy)		0.375*** (0.109) [0.037]		0.038*** (0.011) [0.038]		0.757*** (0.182) [0.083]		0.083*** (0.020) [0.089]
Number of Localities	1,184	1,184	1,184	1,184	1,184	1,184	1,184	1,184
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.169	.166	.124	.121	.241	.238	.225	.22
Observations	27,232	27,232	27,232	27,232	4,736	4,736	4,736	4,736

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, dropping the largest city in the South (Maputo), Centre (Beira), and North (Nacala). The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 6: Land Mine Removal and Local Development. Only North

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.345*** (0.077) [0.090]		0.036*** (0.008) [0.093]		0.564*** (0.109) [0.146]		0.065*** (0.013) [0.156]	
Cleared (dummy)		0.342*** (0.116) [0.046]		0.033** (0.013) [0.044]		0.666*** (0.214) [0.091]		0.071*** (0.025) [0.091]
Number of Localities	590	590	590	590	590	590	590	590
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.118	.114	.105	.101	.197	.189	.199	.191
Observations	13,570	13,570	13,570	13,570	2,360	2,360	2,360	2,360

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, focusing on the 590 localities of the 4 Northern Provinces (Zambezia, Nampula, Niassa, and Cabo Delgado). The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 7: Land Mine Removal and Local Development. Stopping in 2013

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.291*** (0.073) [0.062]		0.031*** (0.007) [0.067]		0.360*** (0.098) [0.080]		0.038*** (0.011) [0.088]	
Cleared (dummy)		0.306*** (0.111) [0.029]		0.029*** (0.011) [0.028]		0.349** (0.176) [0.037]		0.031* (0.018) [0.033]
Number of Localities	1,187	1,187	1,187	1,187	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.157	.154	.105	.103	.221	.217	.176	.172
Observations	26,114	26,114	26,114	26,114	4,748	4,748	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, stopping in 2013 and using the value of luminosity as detected by the Defense Meteorological Satellite Program's Operational Linescan System satellite. The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 8: **Land Mines Removal and Local Development. Dynamic Panel**

	Yearly			
	Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Cleared Threats	0.156*** (0.037) [0.033]		0.019*** (0.004) [0.042]	
Cleared (dummy)		0.163*** (0.058) [0.016]		0.018*** (0.007) [0.018]
Log - Luminosity First Lag	0.504*** (0.019) [0.491]	0.505*** (0.019) [0.492]		
Lit (dummy) First Lag			0.387*** (0.018) [0.380]	0.389*** (0.018) [0.381]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.362	.361	.229	.228
Observations	24,927	24,927	24,927	24,927

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, controlling for the lagged value of luminosity in all specification. The dependent variable in columns (1)-(2) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 9: Land Mine Removal and Local Development. Intermediate Period

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
First Intervention (dummy)	-0.103 (0.084) [-0.012]	-0.010 (0.009) [-0.012]	-0.351** (0.149) [-0.042]	-0.039** (0.018) [-0.045]
Cleared (dummy)	0.421*** (0.118) [0.042]	0.043*** (0.012) [0.043]	0.972*** (0.197) [0.106]	0.107*** (0.023) [0.114]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.166	.121	.239	.22
Observations	27,301	27,301	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, distinguishing between first intervention and last intervention at the locality level. The dependent variable in columns (1)-(3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable that takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 10: **Land Mine Removal and Local Development. Affected Only.**

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.337*** (0.089) [0.074]		0.038*** (0.009) [0.084]		0.511*** (0.116) [0.120]		0.062*** (0.013) [0.143]	
Cleared (dummy)		0.246* (0.133) [0.026]		0.024* (0.013) [0.025]		0.747*** (0.229) [0.086]		0.067** (0.026) [0.075]
Number of Localities	855	855	855	855	855	855	855	855
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.178	.175	.133	.13	.264	.259	.248	.241
Observations	19,665	19,665	19,665	19,665	3,420	3,420	3,420	3,420

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, focusing on the 855 (786) contaminated localities. The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable the takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 11: Land Mine Removal and Local Development. Collapsing Interventions at Site Level

	Yearly				4 Years (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Number of Accumulated Cleared Threats	0.335*** (0.078) [0.069]		0.037*** (0.008) [0.078]		0.488*** (0.105) [0.108]		0.060*** (0.011) [0.130]	
Cleared (dummy)		0.367*** (0.109) [0.036]		0.037*** (0.011) [0.037]		0.722*** (0.180) [0.079]		0.080*** (0.020) [0.086]
Number of Localities	1,187	1,187	1,187	1,187	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.168	.166	.124	.121	.241	.238	.224	.219
Observations	27,301	27,301	27,301	27,301	4,748	4,748	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, after collapsing demining interventions at the site level. The dependent variable in columns (1)-(2) and (5)-(6) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (3)-(4) and (7)-(8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(4) report yearly specification estimates (1992-2015). Columns (5)-(8) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable that takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 12: Land Mine Removal and Local Development. Admin 3 Estimates.

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats	0.398*** (0.108) [0.101]	0.041*** (0.012) [0.104]	0.532*** (0.147) [0.144]	0.057*** (0.017) [0.151]
Number of Postos	417	417	417	417
Posto FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.24	.167	.381	.339
Observations	9,591	9,591	1,668	1,668

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, using the 417 Posto (admin 3) as unit of observations. The dependent variable in columns (1)-(3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cleared is an indicator variable that takes the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

**Table 13: Land Mine Removal and Local Development.
Suspected and Confirmed Hazardous Areas**

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats	0.336*** (0.076) [0.072]	0.036*** (0.007) [0.077]	0.506*** (0.109) [0.116]	0.057*** (0.012) [0.128]
Cancelled Threats	-0.045 (0.112) [-0.007]	0.008 (0.011) [0.012]	-0.163 (0.147) [-0.024]	0.002 (0.016) [0.003]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.168	.124	.241	.224
Observations	27,301	27,301	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with landmine clearance, distinguishing between cleared Confirmed Hazardous Areas (CHAs) and “cancelled Suspected Hazardous Areas (SHAs). The dependent variable in columns (1)-(3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. Cleared Threats is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given year (period). Cancelled Threats is the logarithm of one plus the number of cumulated cancelled suspected hazardous areas (SHA) in the locality in given year (period). All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 14: **Heterogeneity. GIS-based Categories. Doubling Thresholds**

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats:				
- Road and Railway (200m)	0.313** (0.136) [0.041]	0.033** (0.015) [0.044]	0.398** (0.187) [0.055]	0.049** (0.022) [0.066]
- Border (20000m)	-0.651*** (0.173) [-0.057]	-0.057*** (0.018) [-0.050]	-0.656*** (0.216) [-0.061]	-0.052** (0.025) [-0.047]
- Cantinas (2000m)	0.322* (0.175) [0.035]	0.043** (0.017) [0.047]	0.586*** (0.200) [0.067]	0.069*** (0.022) [0.076]
- Civil War (2000m)	0.589*** (0.222) [0.051]	0.030 (0.021) [0.026]	0.749** (0.296) [0.068]	0.041 (0.029) [0.036]
- River (200m)	0.262 (0.537) [0.008]	0.026 (0.058) [0.008]	0.030 (0.614) [0.001]	0.011 (0.068) [0.004]
- Village (2000m)	0.427*** (0.114) [0.065]	0.038*** (0.012) [0.058]	0.534*** (0.144) [0.085]	0.048*** (0.016) [0.075]
- Electricity Grid (200m)	0.420 (0.286) [0.021]	0.036 (0.029) [0.018]	0.332 (0.286) [0.018]	0.020 (0.032) [0.011]
- Residual	-0.255*** (0.084) [-0.038]	-0.014 (0.009) [-0.021]	-0.316*** (0.108) [-0.051]	-0.014 (0.012) [-0.022]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.189	.136	.271	.242
Observations	27,301	27,301	4,748	4,748

Notes. The table reports reports panel fixed-effects OLS estimates exploring the heterogeneity of the effect of demining activities on local development according on the type of CHA categories. The dependent variable in columns (1)-(2) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. We split our variable of Number of Accumulated Cleared Threats into seven non-mutually exclusive categories, according to some GIS-based distance thresholds. We classify the different categories in the following way: i) Roads and Railways if the centroids of the threats is in a buffer of 200m from a road or a railway; ii) Border if the centroids of threats is less than 20000m from the country border; iii) Cantinas if the centroids of threats is less than 2000m from a village with a colonial commercial hub; iv) Civil War if the centroids of the threat is in a buffer of 2000m from an event of the Civil War; v) River if the centroids of the threat is less than 200m distant form a river or lake; vi) Village if the threat centroid is in a buffer of 2000m from a village; and Electricity Grid if the centroid of the threat is in a buffer of 200m from the electric grid and pylons. The Residual category includes all the remaining threats. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 15: Heterogeneity on Municipality Characteristics

	Transportation Network			Population Density 1980					Survey	
	Connected Lit (1)	Non Connected Lit (2)	Connected Lit (3)	1st Q Lit (4)	2nd Q Lit (5)	3rd Q Lit (6)	4th Q Lit (7)	5th Q Lit (8)	Survey Lit (9)	No Survey Lit (10)
Cleared (dummy)	0.036*** (0.013) [0.035]	0.005 (0.016) [0.006]		0.020 (0.013) [0.030]	0.042* (0.023) [0.053]	0.039 (0.025) [0.040]	0.046** (0.022) [0.044]	0.064* (0.032) [0.050]	0.041*** (0.014) [0.043]	0.032* (0.017) [0.030]
Cleared (dummy) × Paved 1973 (dummy)			0.062** (0.028) [0.030]							
Cleared (dummy) × Unpaved 1973 (dummy)			0.049 (0.069) [0.008]							
Cleared (dummy) × Trail 1973(dummy)			-0.000 (0.014) [-0.000]							
Cleared (dummy) × Rail (dummy)			0.062** (0.031) [0.028]							
Number of Localities	888	299	888	216	215	216	215	215	659	528
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.14	.0623	.142	.0715	.131	.13	.153	.197	.135	.104
Observations	20,424	6,877	20,424	4,968	4,945	4,968	4,945	4,945	15,157	12,144

Notes: The table reports FE effects estimates associating luminosity with demining activities, allowing for heterogeneity at locality characteristics such as i) localities connected [columns(1) and (3)] and non-connected [column (2)] colonial transportation network, ii) population density quintiles [columns (4)-(8)]; iii) and localities that were surveyed by the SHAMAN (1994) or the MLIS (2001) [column (9)] and those that were not surveyed [column (10)]. In all specification, the dependent variable is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(10) report yearly specification estimates (1992-2015). Cleared is an indicator variable that takes on the value of 0 when the locality is contaminated and equals one following a locality's clearance of all confirmed hazardous areas (CHA); the indicator equals zero for all localities that were not contaminated. In column (3), we interacted the Cleared dummy with each element of the transportation network (paved, unpaved, trail, and rail). All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 16: **Heterogeneity. Report-based Categories.**

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
	Log Luminosity	Lit	Log Luminosity	Lit
Cleared Threats:				
- Road, Railway, Bridges	-0.036 (0.162) [-0.003]	0.010 (0.017) [0.009]	-0.160 (0.234) [-0.014]	0.001 (0.026) [0.001]
- Military	0.459** (0.219) [0.035]	0.048** (0.023) [0.038]	0.375 (0.243) [0.030]	0.036 (0.028) [0.029]
- Protection Ring & Residential	0.107 (0.125) [0.012]	0.008 (0.014) [0.009]	0.329** (0.141) [0.039]	0.031* (0.016) [0.036]
- Forest & Bush	-0.046 (0.214) [-0.002]	0.011 (0.022) [0.005]	-0.020 (0.313) [-0.001]	0.013 (0.037) [0.007]
- Footpath	-0.270* (0.158) [-0.023]	-0.007 (0.017) [-0.006]	-0.432** (0.208) [-0.040]	-0.027 (0.023) [-0.024]
- Farm	0.155 (0.180) [0.012]	0.015 (0.018) [0.012]	0.253 (0.218) [0.021]	0.035 (0.025) [0.028]
- Water Supply	-0.508 (0.426) [-0.020]	-0.054 (0.043) [-0.021]	-0.745 (0.480) [-0.030]	-0.089 (0.054) [-0.035]
- Electricity Pylons	0.291 (0.207) [0.012]	0.012 (0.019) [0.005]	0.108 (0.199) [0.006]	-0.002 (0.022) [-0.001]
- Public Infrastructure	0.436* (0.261) [0.031]	0.033 (0.026) [0.024]	0.710** (0.309) [0.053]	0.079** (0.032) [0.057]
- River	0.184 (0.276) [0.009]	0.015 (0.027) [0.007]	0.544* (0.319) [0.027]	0.047 (0.034) [0.023]
- Border	-1.175* (0.709) [-0.020]	-0.120 (0.077) [-0.021]	-0.452 (0.884) [-0.009]	-0.037 (0.114) [-0.007]
- Not Classified	0.256** (0.109) [0.040]	0.025** (0.010) [0.039]	0.351** (0.154) [0.058]	0.039** (0.016) [0.064]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.173	.127	.248	.23
Observations	27,301	27,301	4,748	4,748

Notes. The table reports reports panel fixed-effects OLS estimates exploring the heterogeneity of the effect of demining activities on local development according on the type of CHA categories. The dependent variable in columns (1)-(2) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (3)-(4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). Columns (1)-(2) report yearly specification estimates (1992-2015). Columns (3)-(4) give (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. We split our variable of Number of Accumulated Cleared Threats into twelve non-mutually exclusive categories, according to report-based classification. We classify the different categories in the following way: i) Roads, Railways, and Bridges; ii) Military iii) Protection Ring & Residential ; iv) Forest and Bush; v) Footpath vi) Farm; vii) Water Supply; viii) Electricity Pylons; ix) Public Infrastructure; x) River; xi) Border; xii) Not Classified. The Not Classified category includes all the remaining threats for which a report description was not provided. All specifications include locality fixed-effects and province-specific year (or period) fixed effects (constants not reported).

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Landmines and Spatial Development

Appendix VII

Details and Sensitivity Analysis, Market Access Effects*

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Abstract

This Appendix first briefly discusses the theoretical insights of the Market Access approach. Second, we provide detailed information on the creation of the network database and the calculation of bilateral transportation costs we use to derive the market access measures. Third, we presents various sensitivity checks and graphical illustrations of the within-locality relationship between aggregate development and market access.

*Additional material can be found at www.land-mines.com

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Contents

1	Theoretical Background	3
2	Construction of Market Access	5
2.1	Bilateral Transportation Costs	5
2.1.1	Building the Network	5
2.1.2	Network Parametrization	8
2.1.3	Landmines and Transportation Cost	9
2.1.4	Lowest-Cost Calculation	10
3	Sensitivity	12
3.1	Trade Elasticity	12
3.2	Average Transportation Cost	14
3.3	Market Potential	14
3.4	Inflating Luminosity of the Largest Cities	14
3.5	Different Parameterization of Transportation Routes (Jedwab and Storeygard, 2018)	15
3.6	Removing Railways	16
3.7	Relaxing the Assumption of Blocking	16
3.8	Accounting for Local Changes in Market Access	17
3.9	Long-Run Differences	17

Market Access

In this section we provide a brief overview on the theoretical underpinning of the market-access approach. Donaldson (2015) provides an eloquent review of this body of research and our discussion follows his synthesis. Costinot and Rodriguez-Clare (2014) discuss the recent quantitative works on trade across and within countries.

1 Theoretical Background

Our empirical framework follows Donaldson and Hornbeck (2016) and other recent works (e.g., Donaldson (2018), Alder (2017), Pérez-Cervantes (2014)) that, building on Eaton and Kortum (2002), develop Ricardian spatial general equilibrium models of inter-district trade and spatial development.¹ These models yield a "gravity equation" where trade between districts o (origin) and d (destination) is a function of district-specific terms capturing size, productivity, demand, population ($A_o(X, \tau)$ and $B_d(X, \tau)$) and bilateral costs ($\tau_{o,d} \geq 1$).

$$\ln X_{o,d} = A_o(X, \tau) + B_d(X, \tau) - \theta \tau_{o,d}.$$

$X_{o,d}$ denotes the value of total bilateral trade from origin to destination district. θ is the "trade elasticity" that reflects (under symmetry) the common-to-all-district pairs sensitivity of trade flows to transportation costs. The above gravity equation can be derived from a broad class of theoretical models.

- Perfect competition Ricardian models of comparative advantage (with or without labor mobility) in the spirit of Eaton and Kortum (2002), where a region's productivity for a given good (variety) is drawn from a Fréchet distribution with parameter θ (smaller values imply stronger heterogeneity and hence increased comparative advantage).
- Good differentiation by region (Anderson (1979) and Anderson and Van Wincoop (2003)) and love-for-variety (Dixit-Stiglitz) preferences over differentiated by origin goods. In these models the "trade elasticity" θ is one minus the elasticity of substitution across goods/varieties.

¹Costinot and Rodriguez-Clare (2014), Allen and Arkolakis (2014) and Arkolakis, Costinot, and Rodríguez-Clare (2012) extend this analysis to other setups, including that of firm-level heterogeneity, Melitz (2003).

- Monopolistic competition models with firm heterogeneity and fixed costs in production, like Melitz (2003) or Eaton, Kortum, and Kramarz (2011) or Chaney (2008), where θ is the parameter of the Pareto distribution shaping firm productivity (lower values imply higher heterogeneity).

Under certain commonly-invoked assumptions (e.g., homothetic preferences, symmetry, balanced trade, costs of trade are paid at the destination), one can derive from these models a reduced-form relationship linking aggregate changes in welfare (income) to improvements in a district’s market access (Arkolakis, Costinot, and Rodríguez-Clare (2012)). The derived expression reflects district’s connectivity via the transportation network (railroads, primary paved roads, non-paved roads, navigable rivers) to all other districts; market access is a function of location (district-specific) characteristics and its ”distance” to all other districts, weighted by their market size. As shown by Donaldson and Hornbeck (2016) in the context of a Ricardian model of trade across districts with labor mobility (see also Allen and Arkolakis (2014)) a district’s market access can be expressed as:

$$FMA_o = \sum_{d=1}^D \tau_{o,d}^{-\theta} CMA_d^{-1} Y_d$$

The market access for firms (producers) in origin district o , FMA_o , is the sum of its ”proximity” (captured by the transportation costs $\tau_{o,d}$) to all other destination districts d , scaled by their income (Y_d) and consumers’ market access (CMA_d). Alternatively, market access for a given district is the sum of the income of all other districts (which are potential trading partners), effectively discounted by bilateral trade costs and by the destination’s district market access. Consumers’ and producers’ market access are related ($FMA_o = \delta CMA_o$) as they both decline in trade costs and increase in a district’s proximity to large markets (the ”gravity equation”). Hence, under a given parameterization of the ”trade elasticity” θ , one can approximate a region’s market access with the following expression:

$$MA_o \approx \sum_{d=1}^D \tau_{o,d}^{-\theta} N_d(Y_d) \quad (1)$$

where N_d and Y_d reflect total population and total output of all but the origin district (see Donaldson and Hornbeck (2016) and Alder (2017)).

Therefore, calculating a locality’s market access requires a value of θ and the estimation of bilateral costs across all locality-pairs in Mozambique. Below we discuss the components used in the construction of the market access index, namely the bilateral costs and the trade elasticity.

2 Construction of Market Access

2.1 Bilateral Transportation Costs

This section details the four steps involved in the bilateral transportation cost (τ_{od}) calculation.

2.1.1 Building the Network

The first step entails the creation of the transportation network that consists of railroads, paved roads, unpaved roads, trails, and navigable rivers during the three phases of demining.

The National Road Administration (ANE) kindly provided a georeferenced database of Mozambican roads in 2011 (1, Panel *B*) The database gives details on the segments of all paved and unpaved roads, as well as trails. ANE also shared similar maps delineating the condition and quality of roads for 1998 and 2003, which we digitized and merged with the digital map of 2011.

Information on the railways network comes from the Ministry of Transport and Communication. For each of the railways, we identify the name and the length of each segment. There are five main railways, all connecting the coastal areas in the Indian Ocean to inland: the Northern line links Nacala to Malawi (Niassa); the central line connects Beira to Zimbabwe; and the Southern routes connect capital Maputo to South Africa (Ressano line), Zimbabwe (Limpopo line), and Swaziland (Goba line). This peculiar feature of the Mozambican rail network is linked to its colonial experience, as the three main regions were ruled differently; the South by the Portuguese and the Centre and the North by French and British concessionary companies that built the railways.

We obtained data on navigable rivers from the Ministry of Transportation. We count 12 navigable rivers in Mozambique.² With the exception of the Zambezi river that crosses the country in the middle, Mozambican navigable rivers do not allow large or medium-sized boats to sail and are far less utilized compared to road and rail.

We then digitized the transportation network at the end of the colonial era, so as to have a mapping of transportation before clearance. We accessed a map from the colonial archives in Maputo depicting the road and the railroad infrastructure in 1973, just two years before independence (Figure 1, Panel *A*). We complemented the maps from the colonial archives with information we collected on railroad conditions and status (functioning or destroyed) at the end of the Civil War in 1992.³ After retrieving detailed information on the conditions of roads and railroads in 1973, we reconstructed the

²Buzi, Chinde, Incomati, Limpopo, Lugenda, Lurio, Messalo, Pungwe, Ruvuma, Save, Tembe, Zambezi

³We interviewed several experts and consulted the archives of the Ministry of Transportation in Maputo.

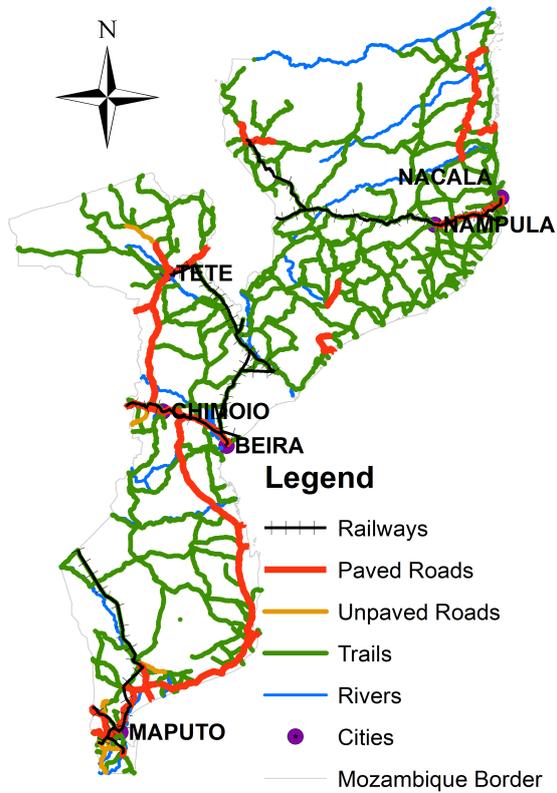
classification of the colonial road network into paved, unpaved or trail, so as to be consistent with the post-colonial classification.

Figure 1, Panels *A* and *B*, depicts Mozambique’s transportation network in 1973 and 2011. Since the end of the civil war, there have been significant improvements of the pre-existing road network (e.g., from trail to unpaved roads). Panels *C* and *D* of Figure 1 zoom in on the Central region surrounding the ”Beira corridor”. The rehabilitation of the three colonial bridges (Dona Ana, Samora Machel, Cahora Bassa) in 2010 allowed the Southern provinces to reconnect with the Northern ones. This connection was lost during the civil war as RENAMO mined and damaged the bridges. The destroyed railway line from Sena to Moatize was reopened in 2006 and further developed in 2010. The main National road (*N1*) was expanded to the North of Beira. Table 1 gives the statistics of the road network at 4 different points in time (1973, 1998, 2003, 2011) for each of the ten provinces.

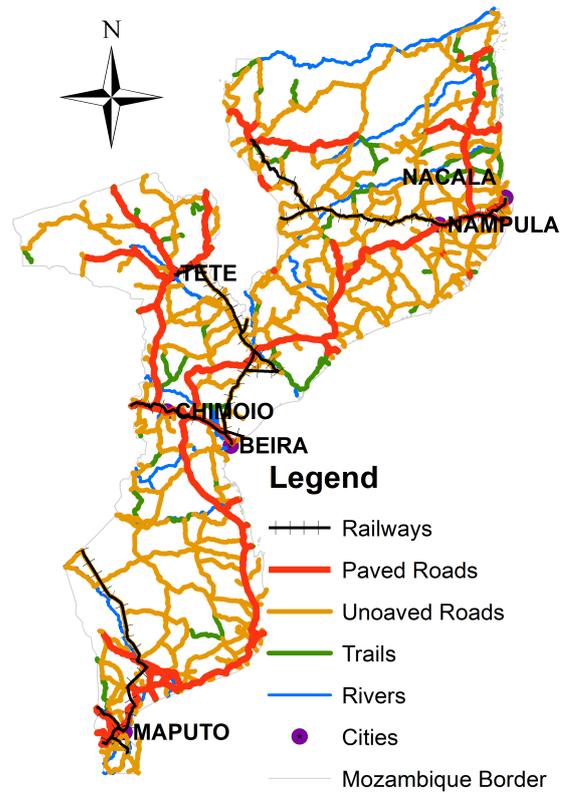
We then connected the 1,187 localities (admin-4 units) to the transportation network in each period (1973, 1998, 2003, and 2011). We linked the centroid of each locality to the closest feature of the transportation network (road, railway, and navigable river). Following Donaldson and Hornbeck (2016), we allow for the possibility of straight-line like connection on foot (walking) among localities’ centroids, linking any two centroids within a distance of 300km.⁴ So, we do not allow travel/trade via Malawi in the North-East for connecting localities within Mozambique. We also do not allow for crossing the Zambezi river before 2010, as the three main bridges were closed.

In late 2014, a new 715-meters long bridge connecting the city of Tete to Moatize opened up. Rendering the Zambezi river non-crossable splits the country in two subsets: a 499 x 499 set of connections across localities in the North; and a 688 x 688 South of the Zambezi. For the 2015 network, following the reopening of the bridges on the Zambezi, we have a full 1187 x 1187 matrix. We do not allow for maritime transportation across coastal districts, as Mozambican port data, historical evidence, and our interviews with officials of the Ministry of Transportation (and others) all suggest the limited importance of sea connectivity. As there are no commercial ports along navigable lakes, which could be relevant for localities around lake Niassa/Malawi in the North-West, we do not allow for transportation/trade across by-the-lake localities.

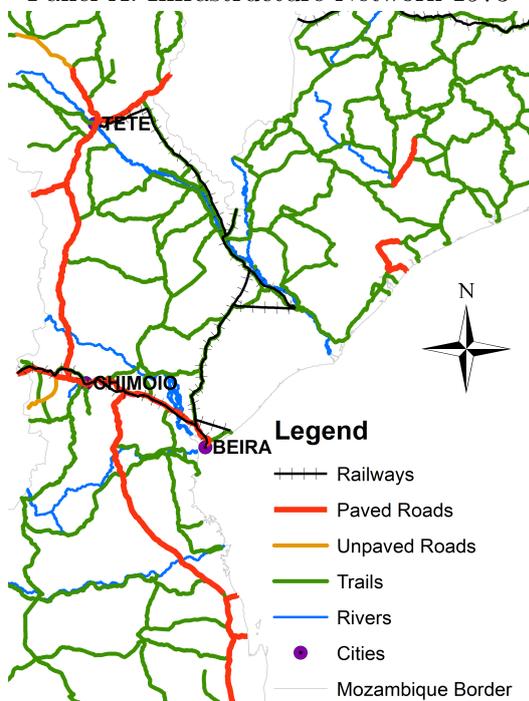
⁴Allowing for centroid to centroid connection is important in our application as landmines’ presence often limits substantially connectivity via the transportation network. For example, a locality’s centroid connection to all nearest network elements can be blocked by landmines. In our context, not allowing for a centroid-to-centroid connection would imply i) full isolation for 26 localities ii) 37 localities would be connected to less than 10 destinations iii) The maximum number of centroid-to-centroid connection for a given is 275 in the North of the Zambese and 588 South of the river.



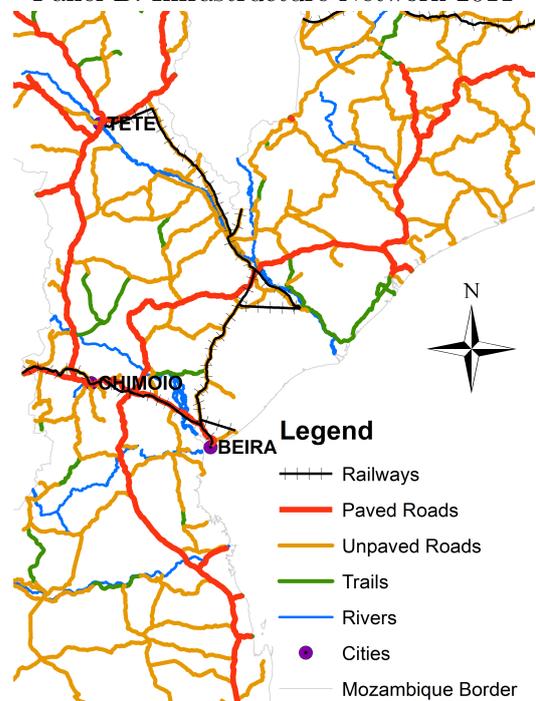
Panel A: Infrastructure Network 1973



Panel B: Infrastructure Network 2011



Panel C: Infrastructure Network 1973



Panel D: Infrastructure Network 2011

Figure 1: Evolution of Transportation Network: 1973 and 2011

2.1.2 Network Parametrization

Second, we parameterize the relative cost of the network's elements. To calculate the cost of each network element, we multiply the length in kilometer with the corresponding relative-cost parameter. We try to tie our hands following closely earlier and parallel works (Donaldson (2018), Donaldson and Hornbeck (2016), Alder (2017), and Jedwab and Storeygard (2018)).

- As in Donaldson (2018), the most efficient (trade) technology is the railway, whose cost is normalized to 1.
- As earlier and parallel works, we distinguish between paved and unpaved roads. World Bank reports (e.g., Raballand and Teravaninthorn (2009)) suggest that road condition is an important determinant of trade costs. Storeygard (2016) also underlines the importance of paved versus unpaved road for oil shock propagation within African countries, while Jedwab and Storeygard (2018) also distinguish between paved and unpaved roads in their careful examination of their role on African urbanization post independence.
 - Paved roads are the second most efficient means of transportation and trade. Following Donaldson (2018), we impose a (relative-to-railway) cost of 2.
 - We assign a relative-to-rail cost of 4 to unpaved roads. This builds on works calculating that the cost of transportation via unpaved roads is often double than that of paved road (Kim, Molini, and Monchuk (2012)). This relative cost parameterization is also consistent with studies on the Mozambique maize market in early 2000s (Alemu and Van Schalkwyk (2008)).
- We set the relative costs of trails to 10. This is similar to Jedwab and Storeygard (2018) and Alemu and Van Schalkwyk (2008), who reports a relative cost that is 2.5 higher than unpaved roads. Even today, trails -that typically connect roads to villages and small towns are in poor conditions, impeding commerce.
- Following Donaldson and Hornbeck (2016), we assign a relative cost of 20 to the least efficient technology, namely walking. This parameter is assigned to centroid-to-centroid connections as well as to the centroid to the transportation network elements.

- The last component of the network are navigable rivers, which play a tiny role on local commerce.⁵ Given their minimal importance, the absence of ports, and the poor conditions of boats, we impose a relative cost of 15.⁶

The exact values of the cost parameterization are not particularly important. But the relative costs (of say using a paved road versus a trail) are and therefore we explore the stability of our estimates to alternative parameter settings in the sensitivity analysis below.

2.1.3 Landmines and Transportation Cost

Third, regarding the role of landmines, we assume that the presence of a confirmed hazardous area (CHA) within 100 meters of a road/railroad/trail and a navigable river is blocking access to that particular segment. The 100-meters buffer is motivated by the fact that there is non-trivial measurement error both in the coordinates found in the demining reports and in the exact location of the digitized colonial and post-colonial transportation network.⁷

The assumption that landmine contamination prevents the usage of transportation elements is widely shared among practitioners. For example, mined transport routes increase massively the cost of the humanitarian operations all around the world (LandmineMonitor (2015)). In several instances, the only alternative to a mined road for the distribution of relief aid is air shipping, raising the cost by as much as 10 to 20 times. The Red Cross report argues: *“In areas where road access has been cut off by AV (Anti-Vehicle) mines the population cannot trade, cannot purchase supplies and do not have access to medical facilities. [...] At best people have to walk miles to collect any basic provisions which they cannot produce themselves”*, ICRC (2002).

Isolation and fragmentation is a common phenomenon of landmine-ridden areas. According to the UN Mine Action Programme for Afghanistan, mined roads remained unusable for 9 years *on average*. Our interviews suggest that Mozambique was no different. For example, according to HALO Trust, a mined road linking two district capitals, Milange and Morrumbala in the Zambezia province, was not used for 10 years, ICRC (2002). The alternative trail that locals were using was flooded during the rainy season, cutting off the districts from the rest of the country during this period every year.

⁵As river transportation is almost absent in Mozambique, we abstract from modeling transshipment costs across railways and river transportation modes (Donaldson and Hornbeck, 2016).

⁶The fact we impose the Zambesi is uncrossable until 2015 restrict the possibility of sailing to the 11 medium-small rivers.

⁷In the earlier draft of the paper we used a wider 250 meter radius, finding similar results.

Only once HALO Trust cleared the main road, people in the small towns of Milange, Marrumbala, Chire, and Morire had a reliable connection to the transportation network throughout the year, ICRC (2002).

Another example comes from the 1993 *GSG* interventions that cleared 33 kilometers of road connecting Sena with Moracca in the central provinces. The report, reproduced below (Figure 2), states that “*the road had not been travelled by vehicles or foot for several years owing to the presence of mines*”.

In light of this, we assume that mines render the road segment between two successive nodes (entry points) unusable, and hence it is not used in the calculation of the lowest-cost route. Figure 3 provides an illustration zooming in 2007 on the provinces of Manica and Tete and focusing on the main road connecting the city of Tete (province capital in the Zambezi river) with Chimoio (a district capital on the Beira corridor). Panel A of Figure 3 depicts road conditions and landmine contamination as of 2007; Panel B Figure 3 visualizes which road segments precisely are blocked by landmines in 2007. Landmine contamination along a road (100m radius) blocks the particular road segment between two successive nodes. The same reasoning applies to railways. Landmine contamination blocks the segment of railways between two train stations.⁸

Table 2 tabulates the length of roads blocked for each province in each period. In 1973, under the assumption that mines block the respective transportation segments implies that 11,225 km (47% of the total 23,501 km) of roads were not usable. Specifically, (i) 2013 km (63% of the total 3,213 km) of paved road are blocked, (ii) 168 km (42% of the total 399 km) of unpaved road are blocked and (iii) 9,043 km of trails (45% of the total 19,888 km) are not used in the algorithm.

In the sensitivity analysis we experiment with different distance thresholds beyond which a CHA does not impede access to the transportation network and also relax the blocking assumption.

2.1.4 Lowest-Cost Calculation

Fourth, we construct the time required to travel from each locality to any other locality using Dijkstra’s algorithm. This algorithm that has been recently used by many empirical applications assessing the role of transportation infrastructure (e.g., Alder (2017), Donaldson and Hornbeck (2016), Donaldson (2018), Dell (2015) solve for the lowest-cost path between any two localities’ centroids. We compute the shortest paths in: (i) 1992 using the 1973 transportation network and the universe of CHA (as no

⁸We retrieve and georeferenced the distribution of railway stations in all periods.

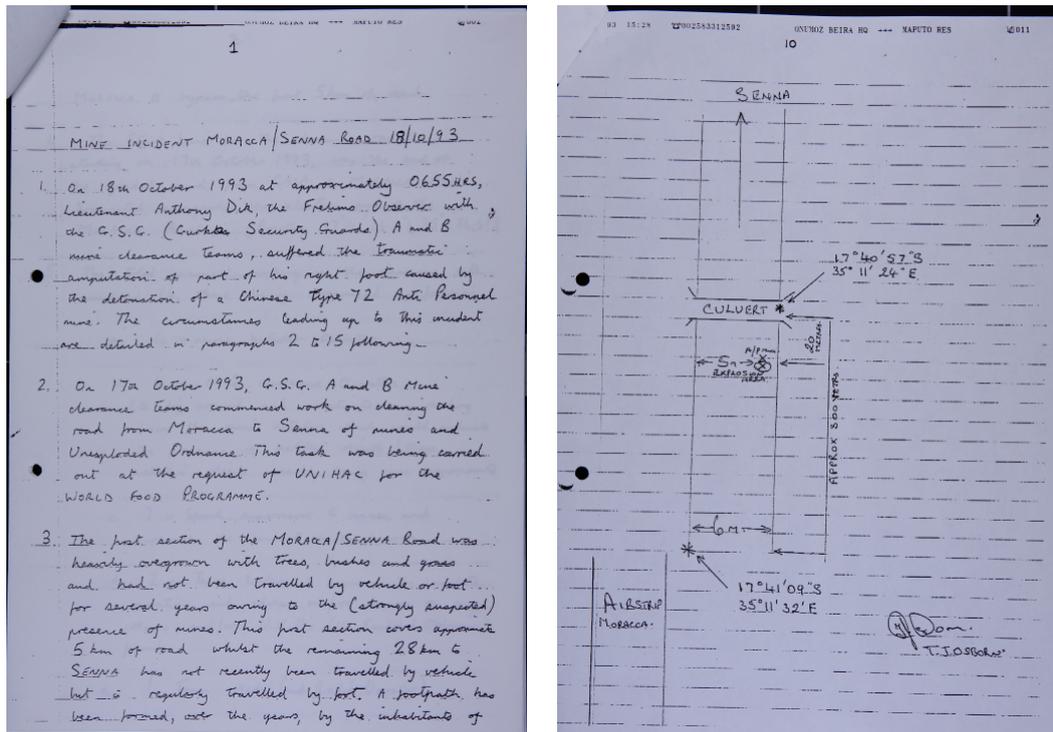


Figure 2: GSG report 1993

clearance intervention had taken place); (ii) in 1999, the end of the first phase of demining using the 1998 transportation network and clearance operations up until that year; (iii) in 2007 using the 2003 transportation network and all intervention up until the end of the second phase of demining; and (iv) in 2015 when all CHA had been cleared using the 2011 infrastructure network. Figure 4 illustrates the algorithm-derived optimal route between Maputo and Funhalouro (Muchuhuine), a locality 600 km north of the country's capital. Figure 3B shows the optimal path in 2015. As all hazardous areas have been cleared, the algorithm employs the most efficient network elements, yielding a cost of 6272.325. Reassuringly, the solution to the algorithm is identical to the one obtained by Google Map, yielding a 9-hours journey. The route for 1992, illustrated in Figure 3A, is very different. As the main primary road (highway N1 connecting the capital to the Central districts along the Indian Ocean and the secondary road linking Funhalouro to N1 are blocked by dozens of minefields, the algorithm relies on unpaved roads and trails, resulting into a significantly costlier (lengthier) route. The shortest-path algorithm suggests an almost four-fold increase in the estimated cost or roughly 32 hours.

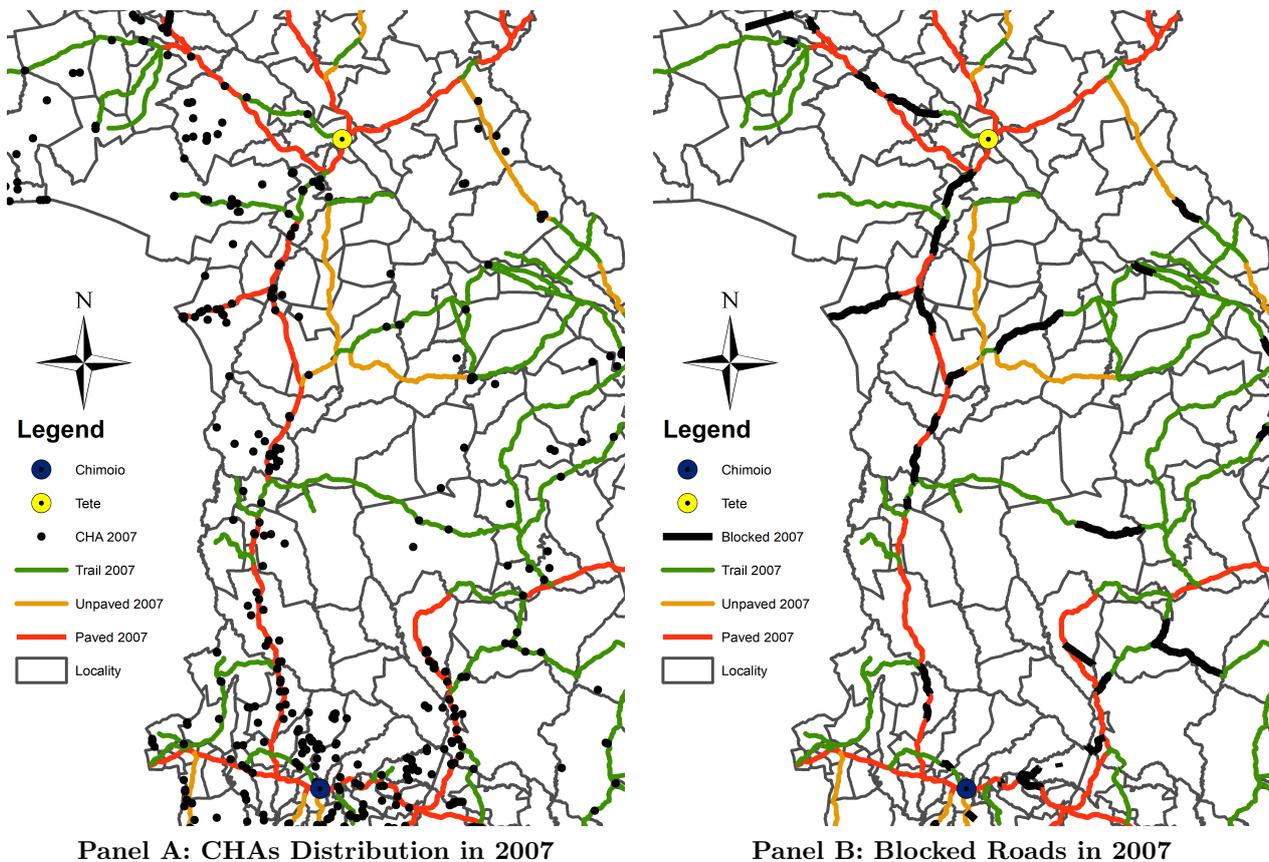


Figure 3: Land mines contamination and Blocked Roads

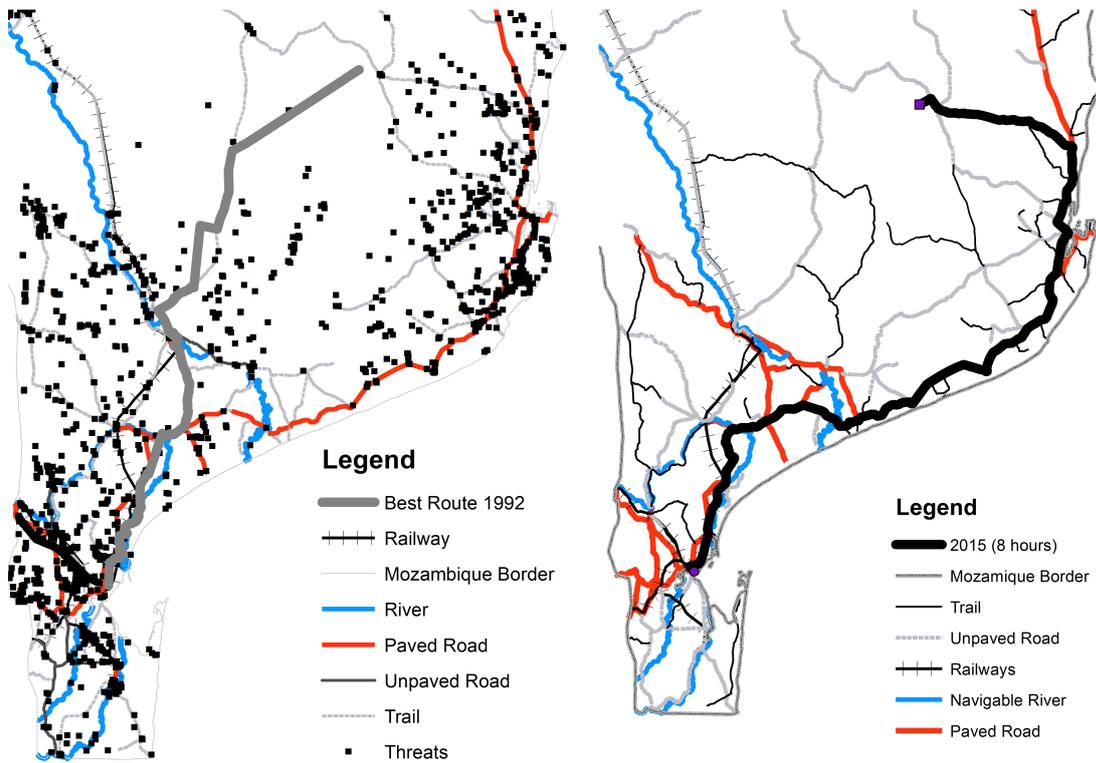
3 Sensitivity

In this section we report the results of the various sensitivity checks examining the robustness of the within-locality, over time relationship between luminosity, and its "market access".

3.1 Trade Elasticity

First, we use alternative values for the trade elasticity (θ) that quantifies the role of transportation costs. For our baseline estimates (reported in the paper), we used a value of 3.88 that closely follows the similar-to-the Mozambique agriculture-based setting of India during the late colonial times, Donaldson (2018), and that of the United States during the late 19th century, Donaldson and Hornbeck (2016). Our baseline parameterization is also almost identical to the one of Jedwab and Storeygard (2017), who look at the role of African roads on urbanization.

We explored the sensitivity of our results to other parameterization relying on recent works that



Panel A: Optimal Route 2015

Panel B: Optimal Route 1992

Figure 4: Least-Cost Route according to Dijkstra's Algorithm

calculate the trade elasticity parameter. Simonovska and Waugh (2014a,b) report trade elasticity estimates around 4 for agriculture-based comparative advantage theoretical models of trade. They also report a range from 2.7 to 5.23 (where lower values imply stronger comparative advantage across regions). We thus repeated the analysis using their low and high values. Table 3 reports the results. Panel A gives estimates parameterizing the trade elasticity to 2.7. Panel B reports analogous estimates using 5.23. The luminosity - market access elasticity is positive and highly significant across all perturbations. The luminosity-based-market-access measures focusing on the pre-civil-war transportation networks (in columns (5)-(6)) the standardized "beta" coefficient is around 0.20, quite close to the baseline estimates.

Table 3 - Panel C gives analogous estimates using an even higher value of trade elasticity, 8.22, a value that follows the sensitivity analysis of Donaldson and Hornbeck (2016). While this parametrization is more suitable for mostly-manufacturing based models with high degree of differentiation (Simonovska and Waugh (2014a,b)), our results remain intact.

3.2 Average Transportation Cost

Second, we ignored demand effects, reflected in the size of a locality’s population or income-luminosity in the market access measures and focused only on changes in transportation costs; we do so, using a simple measure that captures a locality’s connectivity to all other localities. At each point in time (in 1992, 1999, 2007, and 2015, we set the trade elasticity (*theta*) to one and we calculate the average cost of each locality across all shortest bilateral paths via the accessible transportation infrastructure. By not taking into account market size (population or luminosity), this approach isolates the impact of landmine clearance from the role of population-income.

Table 4 reports the panel estimates, associating localities luminosity with transportation costs and the log number of cleared hazardous areas that captures the local effect of demining. The log number of cleared threats enters with a positive and highly significant estimate, that is quite similar to the baseline estimates. On top of the direct effect of landmine clearance, there is a significant negative association between localities’ average transportation costs (to all other localities) and development. This finding reveals that the estimates derived in the main paper are neither driven by the particular parameterization of the market access measure nor contingent upon the underlying theory-imposed structure. Improving accessibility and connectivity via demining the contaminated transportation network entails a strong positive influence on local luminosity.

3.3 Market Potential

Third, we experiment with Harris’ (1954) “market potential” measure that equals $\sum_{d=1}^D \tau_{o,d}^{-1} N_d$; effectively this is the market access measure with a trade elasticity of 1, implying strong specialization across Mozambican localities. Table 5 reports the results. The luminosity - market potential nexus is highly significant. The elasticity is more than three standard errors larger than zero both when we use the contemporaneous transportation network (in (1)-(2)) and when we use the 1973 transportation network (in (3)-(4)). The standardized “beta” coefficient is 0.3 – 0.5, larger than with the baseline market access trade elasticity parametrization.

3.4 Inflating Luminosity of the Largest Cities

Fourth, given the importance of Maputo, Beira, and Nampula-Nacala for Southern, Central, and Northern Mozambican trade, we inflate the population/luminosity of the port cities adding the values of Johannesburg (South Africa), Harare (Zimbabwe), and Lilongwe (Malawi), respectively. Each of

the three port cities is linked to the corresponding capital of the neighboring country by a transportation corridor. Following Donaldson and Hornbeck (2016), we assume that the benefits of being connected are enjoyed by the terminal large city of the corridor. For each period, we computed the total luminosity (population) of all administrative divisions of Johannesburg, Harare, and Lilongwe and we added them to Maputo, Beira, and Nacala, respectively. Then we recalculated the market access measures using the inflated values for the three cities and repeated estimation.

Table 6 gives the results. The estimates on the market access and corresponding standardized coefficients are quiet similar to the baseline estimates in Table 6 of the paper’s main body. This is because connectivity to these three big cities is already quite important, given their relatively high levels of luminosity and population. The log number of cumulated CHA also continue entering with a highly significant positive estimate suggesting that landmine clearance entails both local and economy-wide effects.

3.5 Different Parameterization of Transportation Routes (Jedwab and Storeygard, 2018)

Fifth, we examine robustness to alternative parameterization of transportation costs. We have performed various checks. In Table 7 we report the one where we closely follow the concurrent work of Jedwab and Storeygard (2017). Their parameterization is somewhat different than ours. The most efficient means of transportation are highways, normalized to 1. The relative cost for railroads and paved roads is 1.33; the relative cost (vis a vis highways) for unpaved roads is 2; the relative costs for trails (earthen roads) is 6.66, and the relative cost of walking in places with no roads/trails is 13.33. The main difference between our parameterization and theirs is that in their case railroads are somewhat costlier than primary paved roads. Table 7 gives the results. The luminosity - market access elasticity is positive and significant in all but one specification (with the population-based market access measures that does not reflect developments in the last phase of demining as the population data stop in 2007). Most importantly, the market access coefficients are highly significant when we look at the pre-independence transportation network and fix the distribution of lights/population in the end-of-war period (in 1992 and 1980, respectively) that allows isolating the market access role of landmine clearance. The log number of cumulated CHA variable also retains its economic and statistical significance.

3.6 Removing Railways

Sixth, since given alternative parametrizations in the literature (see Jedwab and Storeygard (2018)) on whether railways or primary roads is the most efficient transportation mean in Africa and in Mozambique, we examined the relationship between luminosity and market access, erasing railways from the transportation network. Moreover, eliminating railways from the network allows us to minimize measure error on the timing of opening/closing of each railway segment. Dropping railways is also useful, as their role on intra-country trade is limited (though no zero). Table 8 reports the results. The estimates on the market access proxies and the number of cleared hazardous areas are positive and highly significant, suggesting that the exact parameterization of railroads does not affect our estimates. This is because in most cases paved roads run in parallel to the main railroads.

3.7 Relaxing the Assumption of Blocking

Sixth, although the idea that landmine contamination renders transportation segments virtually inaccessible is consistent with the view of demining actors (we obtained from dozens of interviews we conducted) that it was extremely unlikely that locals would use mined roads for commerce (or even regular commute), we estimate the relationship between luminosity and market access, relaxing the assumption that mines entirely block the use of an affected transportation segment (road, railway, and river). Specifically, we impose that the presence of landmines doubles the cost of using that particular segment (rail, paved and unpaved roads, trails). For example, suppose the contaminated road segment of a paved road is 5 kilometers. While in our baseline estimates, this road was inaccessible for commute and trade, now locals can use the road. The resulting cost from landmine contamination is 20 (2 (parameter for paved road) \times 5 (kilometer length) \times 2 (because of landmine presence)).

Table 9 reports the results. Columns (1)-(4) give estimates with the contemporaneous market access measures; columns (5)-(8) employ the perturbed market access measures fixing the transportation network and luminosity/population to the pre-clearance levels (in 1992 and 1980, respectively), as this allows examining the association between changes in luminosity and changes in market access stemming from the removal of landmines in the pre-war transportation network (in 1973) and looking in the pre-intervention distribution of development and population. The elasticity is positive and highly significant when we use the baseline luminosity-based market access measure. This applies to the contemporaneous estimates (in (1)-(2)) and when we fix initial conditions when calculating market access (transportation network and development).

The estimates remain positive but statistically insignificant when we use the contemporaneous population-based market access measure (in (3)-(4)), most likely because this measure does not capture development during the third phase of demining (last population census available is that of 2007). The estimates on the population-based market access measure turn highly significant when we solely examine changes due to the removal of landmines blocking the 1973 transportation network and imposing the pre-clearance distribution of population (using the 1980 census) in columns (7)-(8). The log number of cumulative cleared hazardous areas enters with a highly significant estimate in all specifications, further showing that clearance entails both local and general equilibrium, indirect effects operating via improved accessibility to the transportation network.

3.8 Accounting for Local Changes in Market Access

Seventh, we repeat the analysis using of market access measures that exclude adjacent localities. The perturbed market access variables reflect the removal of CHA along the pre-independence transportation network, quite far from the locality, and thus further assuage endogeneity concerns (Donaldson and Hornbeck (2016)). Table 10 gives the results. We continue to control for the extent of local CHA clearance during each period to account for the local impact of demining. And in columns (5)-(8) we also control for new roads-railroads and improvements of the 1973 transportation network. Eliminating any beneficial impact from demining the immediate neighbors explores whether clearance of the mined transportation routes far from one locality have a bearing on a given locality through changes in the market access. The estimates on market access are only slightly attenuated and remain statistically significant; this suggests considerable positive effects on economic activity of demining via the declines in the bilateral transportation costs with localities further away from the immediately adjacent ones.

3.9 Long-Run Differences

Eight, we estimate the market-access specification in long-run differences, as this allows to further control for pre-clearance, locality-specific features. Table 11 gives the results. Panel *A* reports unconditional estimates (with province fixed effects only). Panel *B* gives similar estimates conditioning on a rich set of controls. The luminosity - market access elasticity continues to be highly significant. This is both when we use the contemporaneous market access measures in columns (1)-(4) and when we use the market access measures imposing the pre-clearance transportation network (1973) and devel-

opment/population (in 1992 and 1980 population, respectively) in columns (5)-(8). The coefficients on the market-access proxies are not much effected by the inclusion of the various pre-1992 controls (paved and unpaved roads, railroads, presence of cantinas, civil war intensity, etc.), although these variables strongly correlate with post-1992 changes in luminosity. The model fit (R^2) improves, when we add the rich set of controls, but the market access elasticity remains intact. The standardized “beta” coefficient is around 0.15 – 0.20 quite similar to the panel estimates.

Changes in Market Access and Changes in Luminosity; Graphical Illustration To better illustrate the regression estimates, we did the following. First, we split localities into four groups based on their status on being lit in the beginning of the clearance operations in 1992 and at the end of the demining process in 2015.

- Localities that were lit in 1992, but unlit in 2015. These are just 19 localities, mostly along the border with Zimbabwe.
- Localities that were unlit both in 1992 and in 2015. There are 667 localities, spread across all provinces.
- Unlit in 1992 localities that in 2015 were lit. There are 404 such localities, again spread across across the country.
- Lit both in 1992 and in 2015 localities. Overall there are 97 localities, mostly close to the three main cities.

For each group of localities, we calculated the initial (1992) log market access and its change between 2015 and 1992. We do so both for the contemporaneous market-access measures and for the market-access measures that fix initial conditions.

Figure 5 - Panel A plots the changes in the luminosity-based market-access measure over 2015–1992 (top) and the market access levels in 1992 for the four groups of localities (bottom). Figure 5 - Panel B reporting changes and the 1992 level of the market access measure fixing the transportation network to its colonial conditions and luminosity at the end of the civil war, before the commencement of any demining. The following patterns emerge:

First, localities that were lit at the end of the civil war had on average a higher level of market access in 1992. However, the localities that remain lit in 2015 experience considerably higher increases

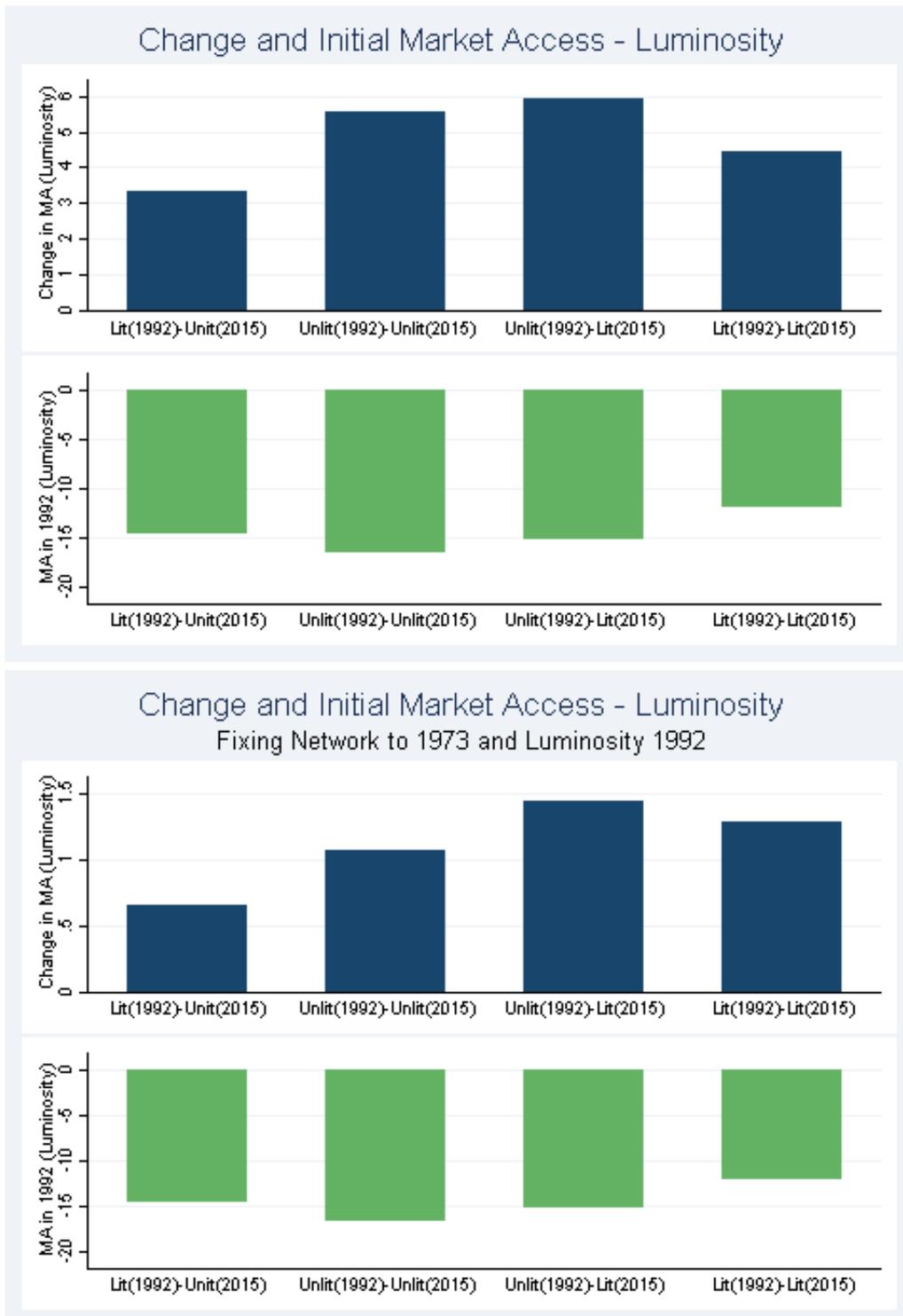


Figure 5: Changes in Market Access and Changes in Luminosity

in market access over 2015 – 1992. This applies both to the contemporaneous market-access measures (Panel *A*) and most importantly with the market-access measure that fix initial condition to the pre-clearance period (Panel *B*).

Second, the two sets of localities that were unlit in 1992 have similar market access values in 1992. However, those unlit in 1992 but lit in 2015 localities experienced larger increases in market access (39%) as compared to the ones that were unlit in 1992 and remain unlit in 2015 (33%). This is especially the case when we look at the market-access measure that isolated landmine clearance operations of the pre-clearance transportation network and imposing the 1992 level of development. The localities unlit in 1992 but lit in 2015 experienced an increase in market access of 9.5% whereas those the were unlit in 1992 and remain unlit in 2015 increased their market access by 6%.

Tables

Table 1: **Evolution of Road Conditions by Province**

Road Condition	Years			
	1973	1998	2003	2011
	Cabo Delgado			
Paved (km)	411.556	435.065	393.673	464.446
Unpaved (km)	0	636.767	418.376	1754.83
Trail (km)	1692.03	782.002	1041.79	365.441
	Gaza			
Paved (km)	237.509	385.219	398.151	470.754
Unpaved (km)	59.4743	910.989	582.047	1355.54
Trail (km)	1719.18	526.885	842.895	26.2131
	Inhambane			
Paved (km)	610.911	560.746	560.746	616.039
Unpaved (km)	0	454.488	177.879	1521.17
Trail (km)	1677.57	914.635	1273.76	218.887
	Manica			
Paved (km)	482.335	516.373	517.403	488.135
Unpaved (km)	64.8113	766.44	601.621	1423.83
Trail (km)	1189.4	339.344	503.133	308.436
	Maputo			
Paved (km)	300.096	309.321	329.944	343.029
Unpaved (km)	191.942	361.879	237.232	839.279
Trail (km)	785.876	495.37	599.395	31.1848
	Nampula			
Paved (km)	180.997	333.129	299.588	317.687
Unpaved (km)	0	1134.78	711.315	3254.96
Trail (km)	3259.31	1580.26	2037.26	524.479
	Niassa			
Paved (km)	128.735	190.182	410.201	456.484
Unpaved (km)	0	460.566	148.696	2089.86
Trail (km)	1968.23	1391.65	1483.5	509.357
	Sofala			
Paved (km)	346.172	333.895	337.094	346.172
Unpaved (km)	0	117.519	227.434	1528.94
Trail (km)	1716.18	1292.79	1179.68	149.191
	Tete			
Paved (km)	351.162	670.049	652.268	719.574
Unpaved (km)	82.6195	487.17	515.547	1327.31
Trail (km)	2214.52	701.128	690.532	197.83
	Zambezia			
Paved (km)	164.22	294.292	488.085	504.09
Unpaved (km)	0	1051.65	389.483	3357.39
Trail (km)	3660.71	2091.17	2559.54	458.896

Notes. Table gives the statistics on evolution of paved roads, unpaved roads, and trails for 1973, 1999, 2007, 2015.

Table 2: **Blocked Road by Province and Period**

Road Blocked Network 1973	Years			
	1992	1999	2007	2015
	Cabo Delgado			
Paved (km)	89.197	89.197	0	0
Unpaved (km)	0	0	0	0
Trail (km)	345.221	345.221	30.861	0
	Gaza			
Paved (km)	46.134	18.362	0	0
Unpaved (km)	0.836	0.836	0	0
Trail (km)	383.391	377.288	209.068	0
	Inhambane			
Paved (km)	424.142	393.620	222.491	0
Unpaved (km)	0	0	0	0
Trail (km)	443.215	437.280	310.042	0
	Manica			
Paved (km)	172.054	172.054	112.351	0
Unpaved (km)	0	0	0	0
Trail (km)	378.109	346.505	295.177	0
	Maputo			
Paved (km)	142.735	115.604	88.532	0
Unpaved (km)	71.734	65.648	35.657	0
Trail (km)	345.984	293.717	190.075	0
	Nampula			
Paved (km)	31.028	31.028	0	0
Unpaved (km)	0	0	0	0
Trail (km)	302.983	254.745	4.443	0
	Niassa			
Paved (km)	16.271	0	0	0
Unpaved (km)	0	0	0	0
Trail (km)	433.486	428.433	100.258	0
	Sofala			
Paved (km)	210.088	202.297	163.023	0
Unpaved (km)	0	0	0	0
Trail (km)	617.858	277.650	132.198	0
	Tete			
Paved (km)	121.612	85.624	85.624	0
Unpaved (km)	0	0	0	0
Trail (km)	252.836	200.538	101.666	0
	Zambezia			
Paved (km)	7.467	7.467	0	0
Unpaved (km)	0	0	0	0
Trail (km)	776.318	666.662	17.668	0

Notes. Table gives the statistics on evolution of blocked paved roads, blocked unpaved roads, and blocked trails for 1973, 1999, 2007, 2015.

Table 3: Market Access. Alternative Paratemtrization of Trade Elasticity

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
Panel A: $\theta = 2.7$								
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.370*** (0.104) [0.236]	0.040*** (0.011) [0.246]			0.385** (0.173) [0.206]	0.039** (0.018) [0.204]		
Log Market Access, Population			0.241** (0.107) [0.104]	0.024** (0.012) [0.102]			0.963*** (0.247) [0.353]	0.089*** (0.026) [0.317]
Cleared Threats	0.408*** (0.093) [0.093]	0.051*** (0.010) [0.114]	0.388*** (0.106) [0.089]	0.050*** (0.011) [0.112]	0.425*** (0.092) [0.097]	0.053*** (0.010) [0.119]	0.334*** (0.105) [0.077]	0.045*** (0.011) [0.102]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.25	.232	.253	.234	.243	.226	.259	.237
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308
Panel B: $\theta = 5.23$								
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.201*** (0.044) [0.234]	0.022*** (0.005) [0.247]			0.204** (0.083) [0.206]	0.018** (0.009) [0.183]		
Log Market Access, Population			0.152*** (0.046) [0.124]	0.013*** (0.005) [0.107]			0.490*** (0.132) [0.361]	0.038*** (0.014) [0.271]
Cleared Threats	0.385*** (0.094) [0.088]	0.049*** (0.010) [0.109]	0.368*** (0.108) [0.084]	0.049*** (0.012) [0.109]	0.420*** (0.093) [0.096]	0.053*** (0.010) [0.119]	0.338*** (0.107) [0.077]	0.047*** (0.012) [0.106]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.254	.236	.255	.234	.243	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Table 1: Market Access. Alternative Paratemtrization of Trade Elasticity

Panel C: $\theta = 8.22$								
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.129*** (0.027) [0.218]	0.014*** (0.003) [0.230]				0.024** (0.012) [0.184]		
Log Market Access, Population			0.095*** (0.028) [0.120]	0.052*** (0.018) [0.284]	0.052*** (0.018) [0.284]		0.643*** (0.173) [0.359]	0.052*** (0.018) [0.284]
Cleared Threats	0.375*** (0.094) [0.086]	0.047*** (0.010) [0.106]	0.374*** (0.107) [0.086]	0.047*** (0.012) [0.104]	0.047*** (0.012) [0.104]	0.053*** (0.010) [0.119]	0.334*** (0.106) [0.077]	0.047*** (0.012) [0.104]
Number of Localities	1,187	1,187	1,077	1,077	1,077	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.253	.235	.255	.236	.236	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,308	4,748	4,308	4,308

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market access, allowing for alternative value of Θ . We follow Simonovska and Waugh (2014) and set the following value of Θ : 2.7 (Panel A), 5.23 (Panel B), and 8.22 Panel (5). The dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-based market-access. In column (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-based market-access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 4: **Average τ**

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	Contemporaneous		Initial Conditions	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Log Average τ	-3.507*** (0.518) [-0.397]	-0.333*** (0.059) [-0.368]	-3.652*** (0.542) [-0.333]	-0.368*** (0.054) [-0.328]
Cleared Threats	0.437*** (0.095) [0.100]	0.055*** (0.010) [0.122]	0.405*** (0.093) [0.093]	0.051*** (0.010) [0.114]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.251	.231	.257	.236
Observations	4,748	4,748	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with average cost of transportation. The dependent variable in columns (1) and (3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (2) and (4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(2), Average is the logarithm of average bilateral transportation cost at the locality level. In column (3) – (4), Average is the logarithm of average bilateral transportation cost at the locality level, fixing the transportation network to. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 5: Market Potential

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	Contemporaneous		Initial Conditions	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Log Market Potential	1.432*** (0.401) [0.306]	0.162*** (0.044) [0.337]	3.986*** (0.504) [0.570]	0.402*** (0.052) [0.561]
Cleared Threats	0.420*** (0.093) [0.096]	0.052*** (0.010) [0.117]	0.355*** (0.093) [0.081]	0.046*** (0.010) [0.103]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.244	.228	.26	.239
Observations	4,748	4,748	4,748	4,748

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market potential. The dependent variable in columns (1) and (3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (2) and (4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(2), Market Potential is the logarithm of measure (that equals $\sum_d = 1^D \tau_{-o, d^{-1} N_d}$). In column (3)-(4), Market Potential is the logarithm of measure (that equals $\sum_d = 1^D \tau_{-o, d^{-1} N_d}$), fixing the transportation network to. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 6: **Market Access. Inflating Luminosity and Population of Maputo, Beira, and Nacala**

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial Conditions			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.263*** (0.061) [0.235]	0.028*** (0.006) [0.245]			0.272** (0.108) [0.213]	0.026** (0.011) [0.197]		
Log Market Access, Population			0.170** (0.068) [0.104]	0.016** (0.007) [0.093]			0.617*** (0.176) [0.336]	0.052*** (0.018) [0.273]
Cleared Threats	0.398*** (0.094) [0.091]	0.050*** (0.010) [0.112]	0.381*** (0.107) [0.087]	0.050*** (0.012) [0.111]	0.421*** (0.093) [0.096]	0.053*** (0.010) [0.119]	0.340*** (0.105) [0.078]	0.047*** (0.011) [0.105]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.253	.235	.253	.234	.244	.226	.258	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market access, inflating the luminosity of Maputo, Beira, and Nacala with those of Johannesburg, Harare, and Lilongwe, respectively. The Dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-based market-access. In column (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-based market-access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 7: Market Access. Different Parameterization of Transportation Routes (Jedwab and Storeygard, 2018)

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.235*** (0.058) [0.213]	0.025*** (0.006) [0.226]			0.259** (0.103) [0.199]	0.024** (0.011) [0.177]		
Log Market Access, Population			0.120* (0.061) [0.075]	0.011 (0.007) [0.066]			0.615*** (0.166) [0.332]	0.048*** (0.018) [0.252]
Cleared Threats	0.395*** (0.093) [0.090]	0.050*** (0.010) [0.111]	0.393*** (0.107) [0.090]	0.051*** (0.012) [0.114]	0.422*** (0.092) [0.097]	0.053*** (0.010) [0.119]	0.337*** (0.105) [0.077]	0.047*** (0.011) [0.105]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.251	.234	.253	.233	.243	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market access, employing an alternative relative costs parametrization from Jedwab and Storeygard (2018). The dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-based market-access. In column (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-based market-access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 8: Market Access. Removing Railways

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.277*** (0.063) [0.245]	0.030*** (0.007) [0.257]			0.295*** (0.110) [0.228]	0.029** (0.012) [0.216]		
Log Market Access, Population			0.190*** (0.067) [0.115]	0.017** (0.007) [0.103]			0.691*** (0.178) [0.374]	0.057*** (0.019) [0.302]
Cleared Threats	0.391*** (0.094) [0.090]	0.049*** (0.010) [0.110]	0.374*** (0.108) [0.086]	0.049*** (0.012) [0.110]	0.420*** (0.093) [0.096]	0.053*** (0.010) [0.118]	0.331*** (0.107) [0.076]	0.046*** (0.012) [0.103]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.254	.236	.254	.234	.244	.226	.259	.237
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market access, dropping railways from the transportation network. The dependent variable in columns (1) and (3) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2) and (4) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specifications report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(2), Market Access, Light is instrumented with the its counterpart when we fix the transportation network to 1973 and we hold all localities' luminosity fixed in its 1992 level. In column (3)-(4), Market Access, Population is instrumented with the its counterpart when we fix the transportation network to 1973 and we hold all localities' population fixed in its 1980 level. In all specifications we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 9: Market Access. Relaxing the Assumption of Blocking

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.276*** (0.073) [0.224]	0.030*** (0.007) [0.236]			0.681*** (0.180) [0.501]	0.073*** (0.021) [0.526]		
Log Market Access, Population			0.069 (0.073) [0.041]	0.008 (0.008) [0.049]			0.761** (0.324) [0.412]	0.085*** (0.031) [0.447]
Cleared Threats	0.430*** (0.095) [0.098]	0.053*** (0.010) [0.119]	0.421*** (0.109) [0.097]	0.053*** (0.012) [0.119]	0.408*** (0.098) [0.093]	0.051*** (0.011) [0.114]	0.384*** (0.111) [0.088]	0.049*** (0.012) [0.110]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.25	.232	.252	.233	.245	.228	.253	.234
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Notes: The table reports panel fixed-effects OLS estimates associating luminosity with market access, relaxing the assumption that land mines impede the use of affected network elements. The dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable is columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specification report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-based market-access. In column (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-based market-access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In all specification we control for the Cleared Threats, that is the logarithm of one plus the number of cumulated cleared confirmed hazardous areas (CHA) in the locality in given period. All specifications include locality fixed-effects and province-specific period fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses) and standardized beta coefficients (in square brackets). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 10: Market Access. Excluding Neighbors

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity	Lit						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.136** (0.054) [0.115]	0.012* (0.006) [0.097]			0.272** (0.109) [0.191]	0.024** (0.012) [0.167]		
Log Market Access, Population			0.208*** (0.072) [0.131]	0.021*** (0.008) [0.132]			0.571*** (0.129) [0.304]	0.052*** (0.014) [0.273]
Cleared Threats	0.436*** (0.093) [0.100]	0.055*** (0.010) [0.122]	0.379*** (0.105) [0.087]	0.049*** (0.011) [0.109]	0.429*** (0.092) [0.098]	0.054*** (0.010) [0.121]	0.345*** (0.104) [0.079]	0.046*** (0.011) [0.104]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes							
Year x Province FE	Yes							
R-squared	.243	.225	.254	.235	.244	.226	.26	.238
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

Notes: The table reports panel fixed effects OLS estimates associating luminosity to market access, excluding adjacent localities in the construction of market-access measures. The dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus half the minimum positive value of luminosity. The dependent variable is columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality is lit. All specifications focus on 4 specific years that correspond to the three main phases of landmine clearance, namely 1992, 1999, 2007 and 2015. In columns (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-weighted market access. In columns (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-weighted market access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In all specifications we control for the Cleared Threats, that is the logarithm of one plus the number of accumulated cleared confirmed hazardous areas (CHA) in the locality in the respective year. All specifications include locality-specific constants and province-year specific fixed effects (constants not reported). Standard errors in parentheses are clustered at the district (admin 2) level and standardized beta coefficients [in brackets]. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Table 11: Market Access. Long-Run Differences, 2015-1992

Panel A: Market Access. Long-Run Differences, 2015-1992. Uncontrolled.								
	Contemporaneous				Initial Conditions			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, Light	0.291** (0.121) [0.132]	0.031** (0.013) [0.128]			0.415** (0.179) [0.116]	0.045** (0.018) [0.114]		
Δ Log - Market Access, Population			0.379*** (0.130) [0.103]	0.036*** (0.013) [0.090]			0.972*** (0.257) [0.179]	0.091*** (0.026) [0.152]
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Initial Controls	No	No	No	No	No	No	No	No
Initial Market Access	No	No	No	No	No	No	No	No
R-squared	.0532	.0423	.0491	.0368	.0485	.0384	.0627	.0461
Observations	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077

Panel B: Market Access. Long-Run Differences, 2015-1992. Controls and Initial Market Access.								
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log - Market Access, Light	0.462*** (0.107) [0.210]	0.057*** (0.012) [0.236]			0.148 (0.121) [0.041]	0.026* (0.014) [0.065]		
Δ Log - Market Access, Population			0.585*** (0.119) [0.159]	0.060*** (0.013) [0.149]			0.689*** (0.164) [0.127]	0.081*** (0.019) [0.135]
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Initial Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Initial Market Access	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.432	.354	.431	.347	.413	.333	.421	.34
Observations	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077

Notes: The table reports long-run difference OLS specification estimates associating changes in luminosity (over the period 2015-1992) with market access and various control variables. The dependent variable in columns (1), (3), (5), and (7) is the log of luminosity plus the half of the minimum value of luminosity. The dependent variable in columns (2), (4), (6), and (8) is an indicator that takes the value of one if the locality emits some detectable from the satellite light (lit). All specifications report the (7-year) period estimates (1992-1999, 2000-2007, 2008-2015) that correspond to the three main phases of landmine clearance. In column (1)-(4), Market Access, Light and Market Access, Population is the logarithm of luminosity (population)-based market-access. In column (5)-(8), Market Access, Light and Market Access, Population is the logarithm of luminosity-based market-access fixing the transportation network to 1973 and holding all localities' luminosity (population) fixed in its 1992 (1980) level. In Panel A we report the uncontrolled estimates. In panel B we control for: indicator (dummy) variables that take the value of one when a locality is crossed by the key elements of the 1973 transportation network (Paved Road, Unpaved Road, Trails, and Railway); indicator variables for the presence of navigable river, the presence of colonial commercial harbour (*Cantinas*), and for localities affected by major civil war incidents. The set of control variables also include log population density (using the 1980 census), log luminosity in 1992 (before landmine clearance operations commence), initial market access, and log land area. All specifications include province fixed effects (constants not reported). The table reports clustered at the district (admin 2) level standard errors (in parentheses and standardized beta coefficients (in squared brackets)). ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

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