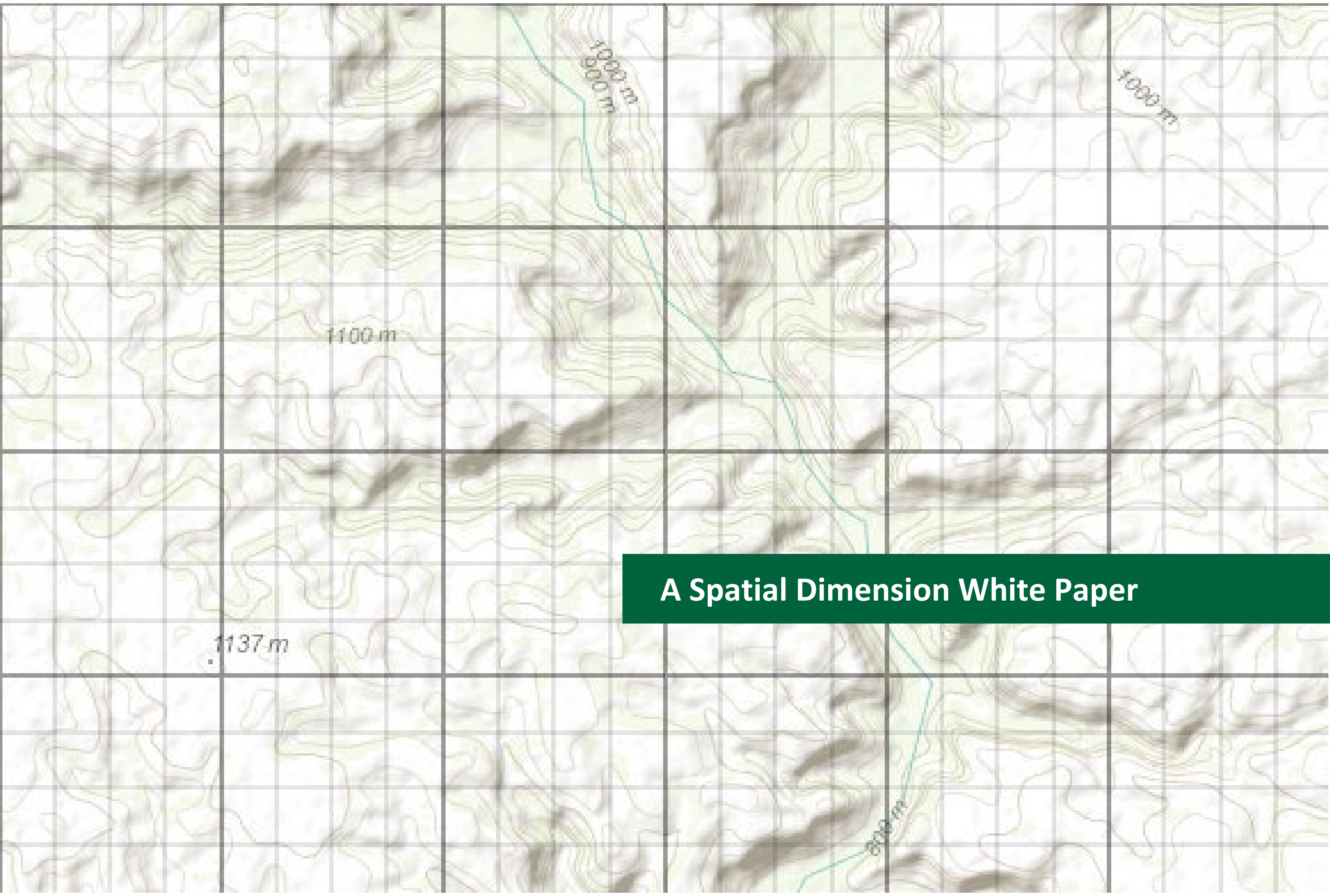
Spatial Dimension



A Spatial Dimension White Paper

Cadastral Grids in Mining

CONSIDERATIONS WHEN IMPLEMENTING CADASTRAL GRIDS

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Contents

1. Introduction

Many countries are currently updating their Mining Laws and Regulations and a common theme in some of the new laws is the implementation on a cadastral grid to regularize the shape of mineral rights.

It is our experience that migrating licenses to a cadastral grid can actually create a negative return on investment in terms of time, money and goodwill.

While our mining cadastre solution, Landfolio (previously known as FlexiCadastre), fully supports a cadastral grid system and has sophisticated tools available to create cadastral grids and migrate existing data, converting a free-form mining cadastre to a cadastral grid can present a number of challenges, and sometimes, a cadastral grid can cause more problems than it would solve.

This document outlines some of the practical challenges experienced when implementing a cadastral grid and proposes various mitigations.

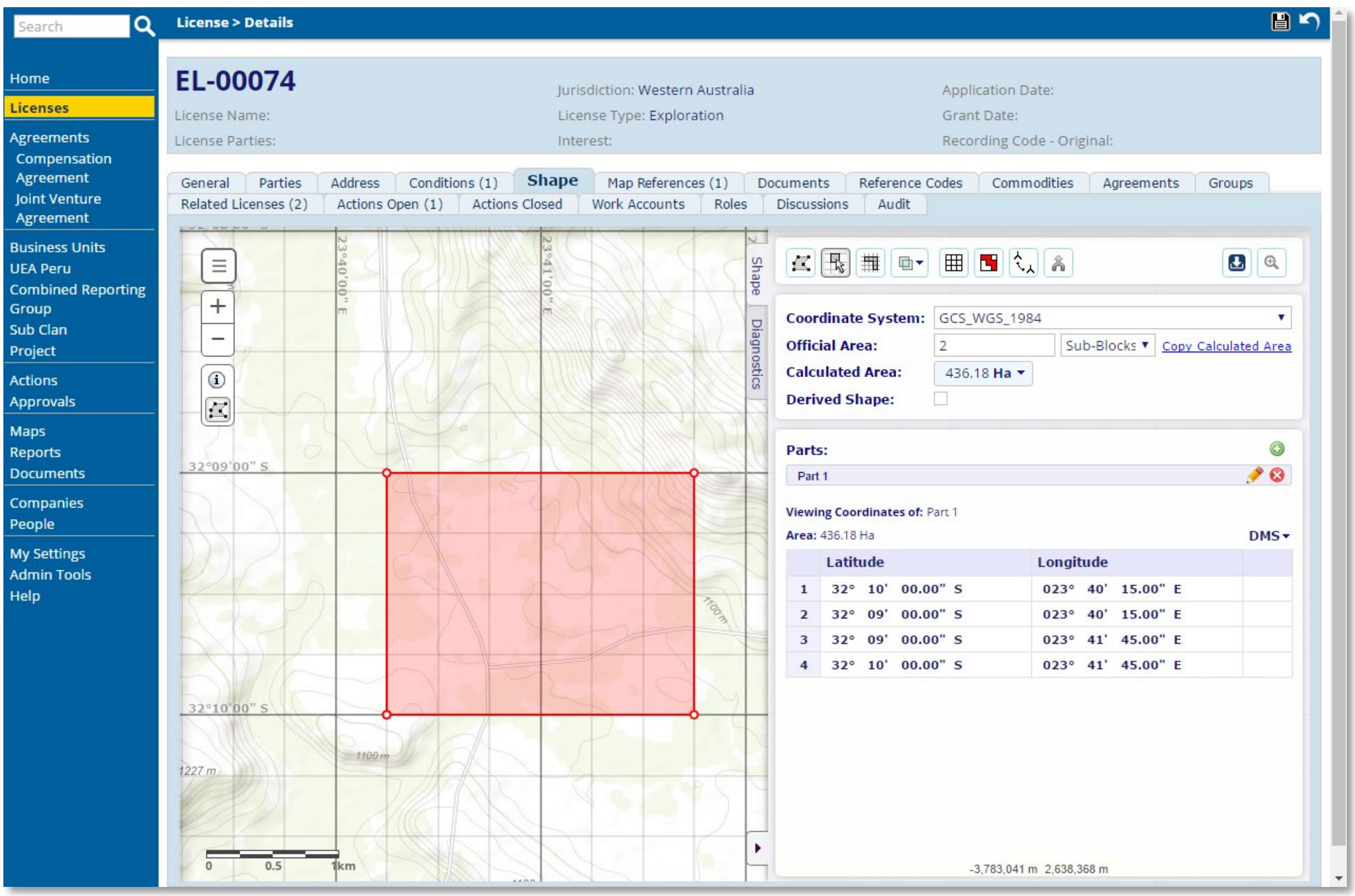

Figure 1 Landfolio map interface showing tools that support a grid system

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2. Why implement a Cadastral Grid?

The concept of aligning mineral rights according to a cadastral grid is thought to have been derived from the Oil and Gas sector. It provides for a neat arrangement of mineral rights.

Globally in the mining sector, the implementation of a cadastral grid has often been conducted as part of the migration from 'ground' or 'stake' based identification of mineral rights to 'map' or 'computer' based identification.

It must be noted that in the Oil and Gas sector the 'blocks' are typically very large in size and are typically predetermined by the Regulatory Authority. Applicants typically do not determine the size or shape of the blocks, unlike the practice in the mining sector.

The screen shots below show the oil and the mining cadastre data for Namibia and Mozambique respectively. Both countries have well respected mining cadastre systems. Namibia continues to use a freeform cadastre while Mozambique implemented a cadastral grid in the early 2000's.

Both countries have attracted sustained investments into their mining sector, not because of the allowed geometry of rights, but because they have stable mining and fiscal policies, prospective geological terrains and modern mining cadastre systems in place.

It is our opinion that a country such as Namibia would get no tangible benefit from the implementation of a cadastral grid.

In fact, it may squander limited resources, both financial and time, and introduce instability and uncertainty into the sector just to create a mining cadastre that looked 'regular' and 'organized'.

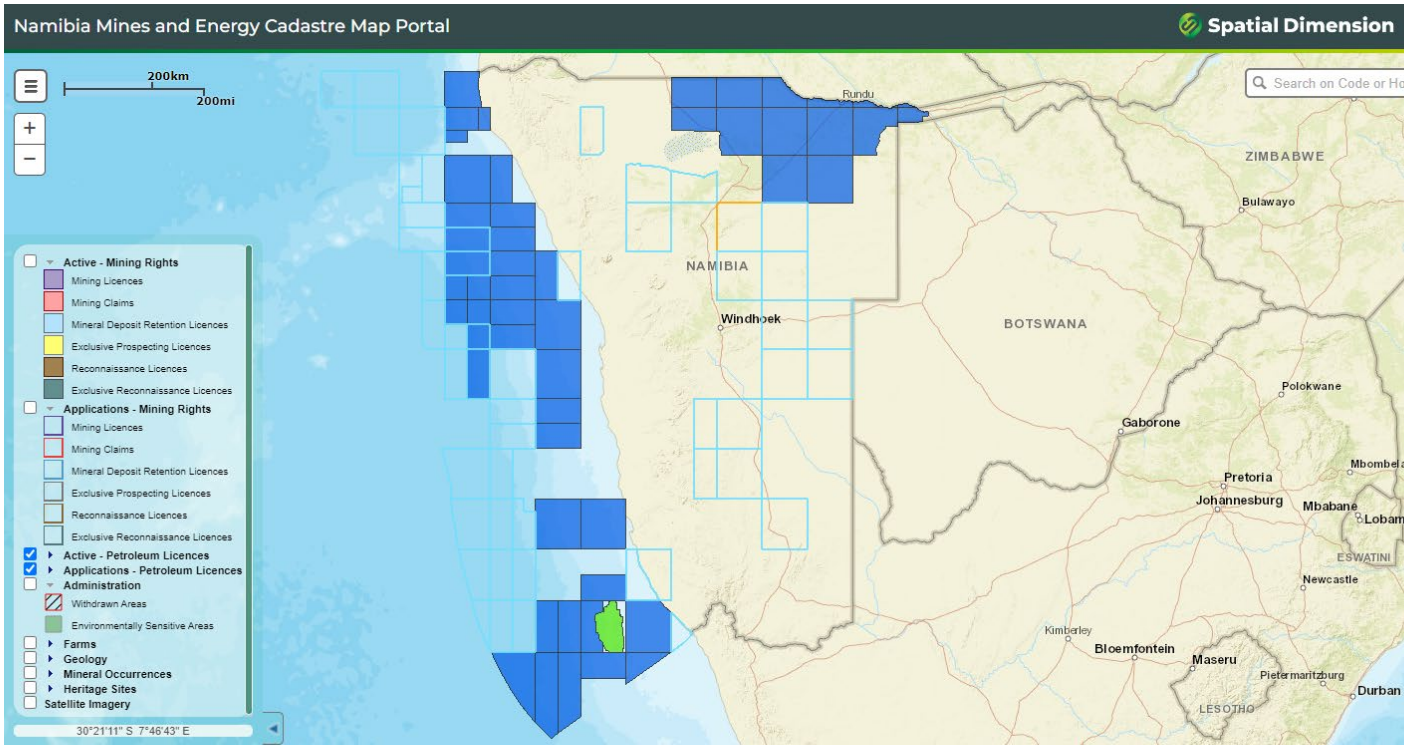

Figure 2 Namibian Oil Cadastre – Large blocks that are predetermined by the Regulatory Authority

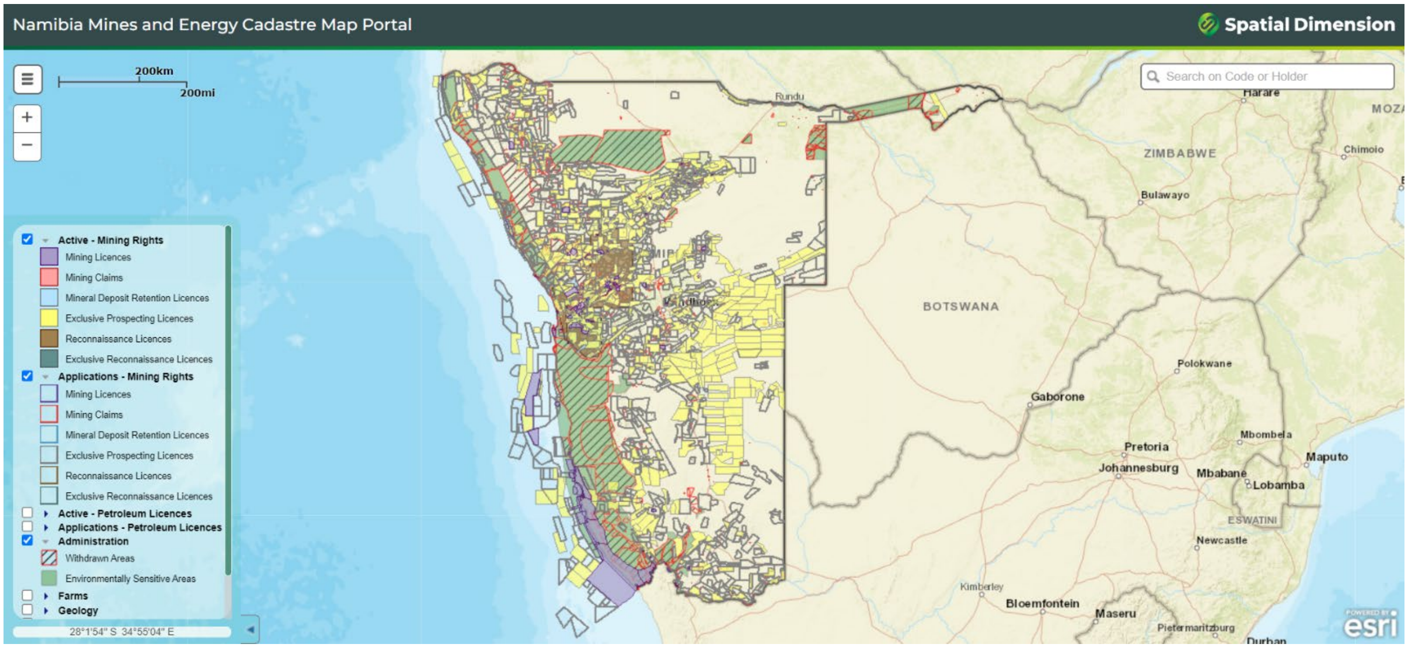

Figure 3 Namibian Mining Cadastre – Freeform shapes that correspond to geological features and/or farm boundaries

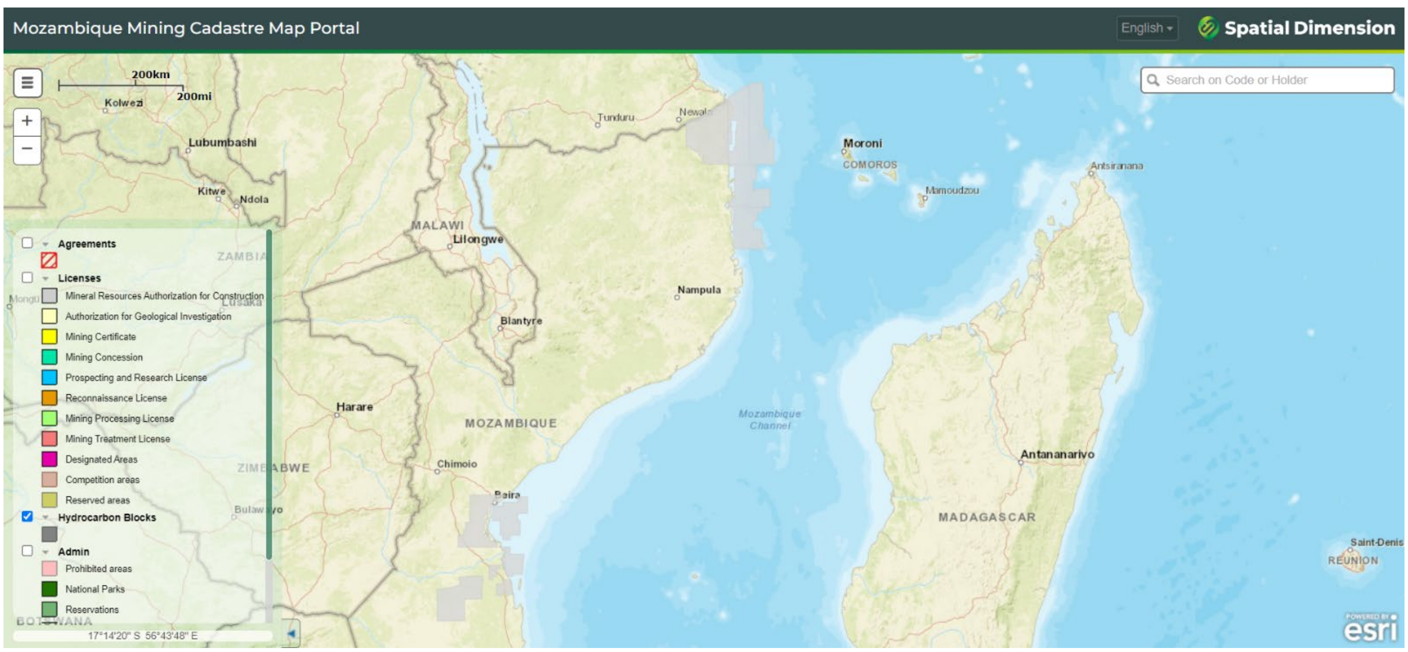

Figure 4 Mozambique Oil Cadastre - Large blocks that are predetermined by the Regulatory Authority

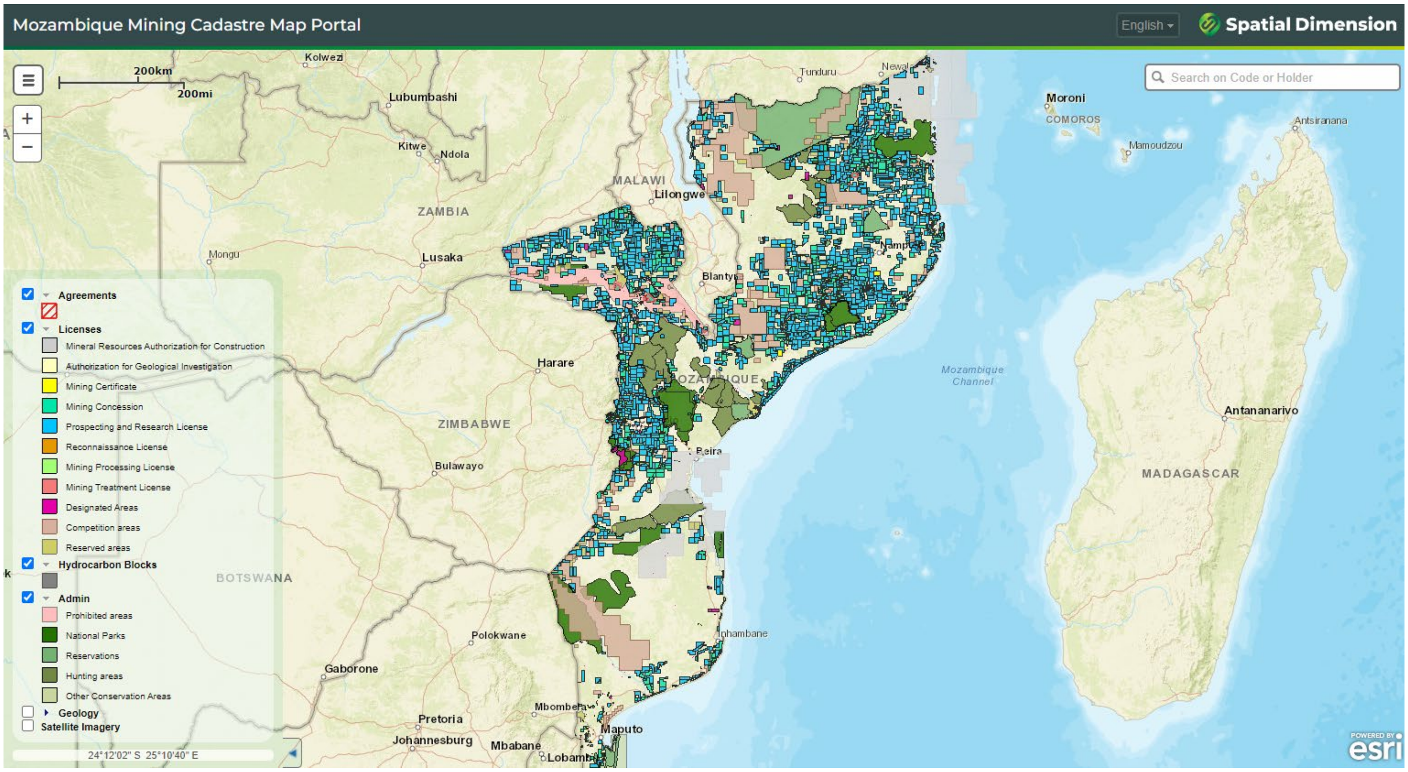

Figure 5 Mozambique Mining Cadastre – Conforming to a Cadastral Grid

3. Implementing a Cadastral Grid

The practical challenges when implementing a cadastral grid should not be underestimated and any such initiative should be carefully analyzed, and all risks mitigated prior to any law being changed.

The primary challenge when migrating to a cadastral grid relates to upholding security of tenure of existing rights during the conversion of these rights to a cadastral grid.

All existing mineral rights that fall within one cadastral unit of each other will be negatively impacted in terms of security of tenure when migrated to a cadastral grid.

Only in a hypothetical situation where no mineral rights exist or mineral rights are not closely adjacent to each other will the implementation of a cadastral grid result in no conflicts in mineral right ownership.

The implementation of a cadastral grid therefore works best in a jurisdiction having few or no existing licenses.

There are typically a number of methodologies available to migrate existing rights to a cadastral grid. These are discussed below.

3.1. Methodology 1: Reduction in Size

In order to prevent mineral right overlaps when migrating existing rights to a cadastral grid, one methodology available is to buffer inwards and snap the old right to cadastral units that are ***fully contained*** within the old right.

While this methodology does not generate any conflicts with other adjacent rights it has the following negative results:

- The new rights are all smaller than the original rights, which contravenes the security of tenure principle (see Figure 6)
- Sterile blocks / slivers will be created between the new rights when migrated to the cadastral grid (see Figure 7)

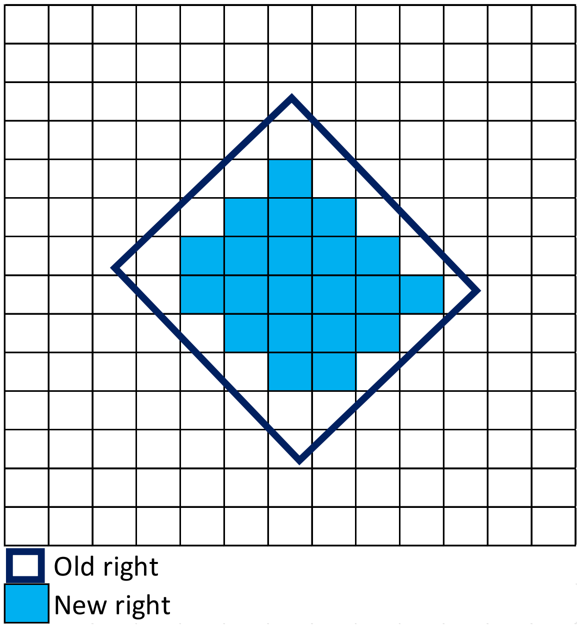

Figure 6 Converted right fully contained by old right resulting in loss of tenure

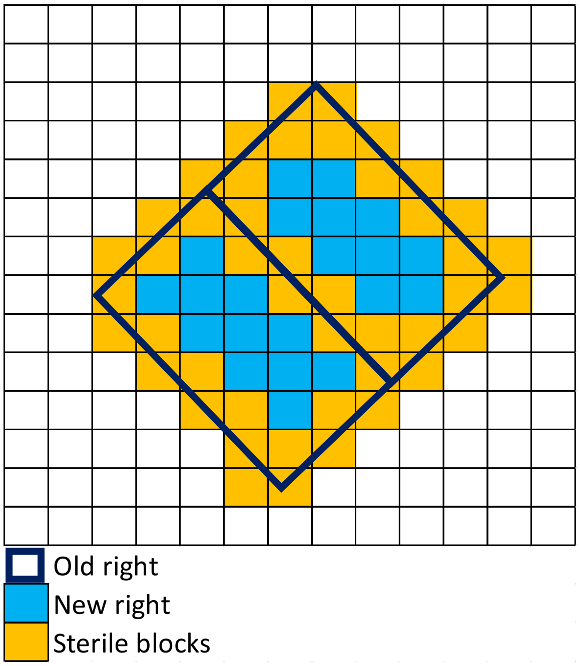

Figure 7 Converted rights fully contained by old rights resulting in loss of tenure and the creation of sterile blocks / slivers between rights

3.2. Methodology 2: Increase in Size

In order to prevent loss of tenure to all existing rights when migrating to a cadastral grid (as described in Section 3.1), another methodology available is to buffer outwards and snap the old right to all cadastral units that ***intersect the old right*** (see Figure 8).

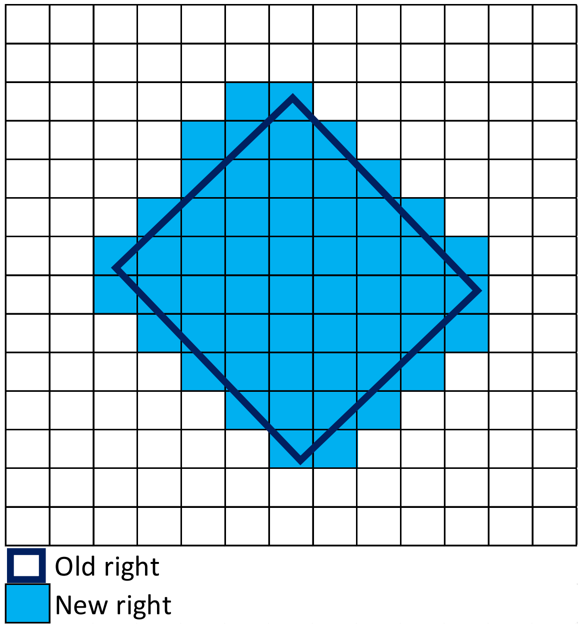

Figure 8 Converted right buffered outwards to the new cadastral grid

While this methodology does not lead to the automatic loss of tenure to all rights, it does have the following negative results:

- Where existing rights are adjacent to, or within one cadastral block of each other, conflicts will be created (see Figure 9 and Figure 10)
- Orphan blocks / slivers will be created between new rights when migrated to the cadastral grid (see Figure 11)

Spatial Dimension

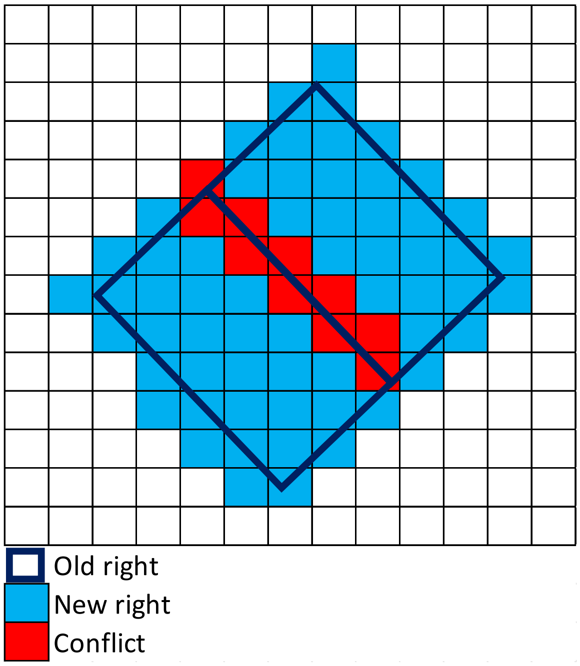

Figure 9 Adjacent rights buffered outwards to the new cadastral grid leading to conflicts

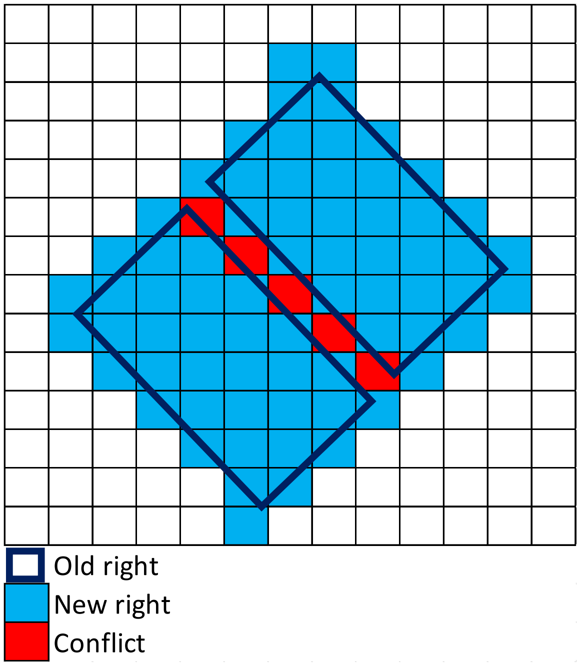

Figure 10 Rights within one cadastral block buffered outwards to the new cadastral grid leading to conflicts

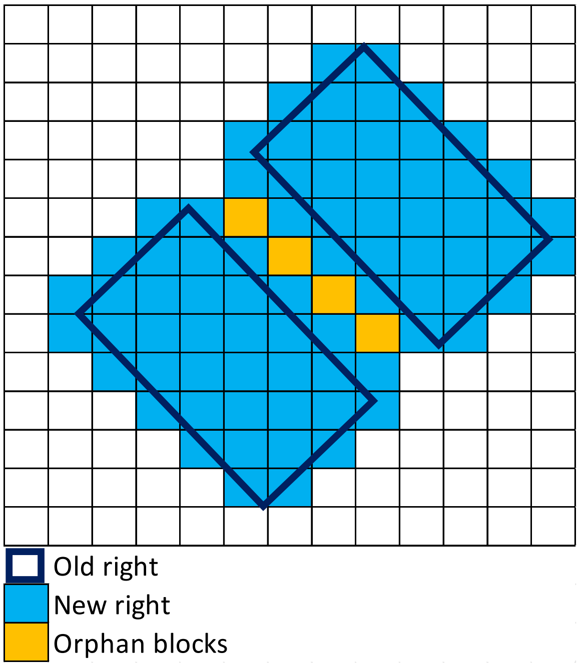

Figure 11 Orphan blocks created by the implementation of cadastral grid

In order to mitigate the impact of the creation of conflicts, the following rules are often applied when attempting to resolve the conflicts created by the implementation of the cadastral grid;

- Where two adjacent rights of the same type have a resultant conflict, the right that was ***granted first*** gets allocated the conflicting block/s.
- Where two adjacent applications of the same type have a resultant conflict, the application that was ***applied for first*** gets allocated the conflicting block/s.
- Where two adjacent rights of a different type have a resultant conflict, the right that is ***more 'advanced'*** gets allocated the conflicting block/s. For instance, a mining or exploitation will trump a prospecting or exploration right.
- In some jurisdictions where two adjacent rights have a resultant conflict, each conflicted block gets allocated to the right that had the largest area of overlap on the conflicted block.
- In some jurisdictions the new Law and Regulations have required that the existing rights holders need to negotiate between themselves as to who gets and who loses the conflicted blocks.

Regardless of which approach is adopted, each conflict will require a consultation process with the rights holders and the Regulatory Authority, and may result in litigation, as security of tenure will be threatened in the overlapping areas.

It is our experience from numerous countries that this process has taken a very long time to regularize and has distracted the Regulatory Authority from conducting their mandated responsibilities.

In summary, there is little or no identified benefit, but it results in a significant disruption for all stakeholders.

3.3. Methodology 3: Hybrid Approach

The third option is a hybrid method, where existing rights remain in their current state, and only new rights / applications conform to the new cadastral grid. This however means that some ground around existing rights will remain sterile until these rights are relinquished. See Figure 12.

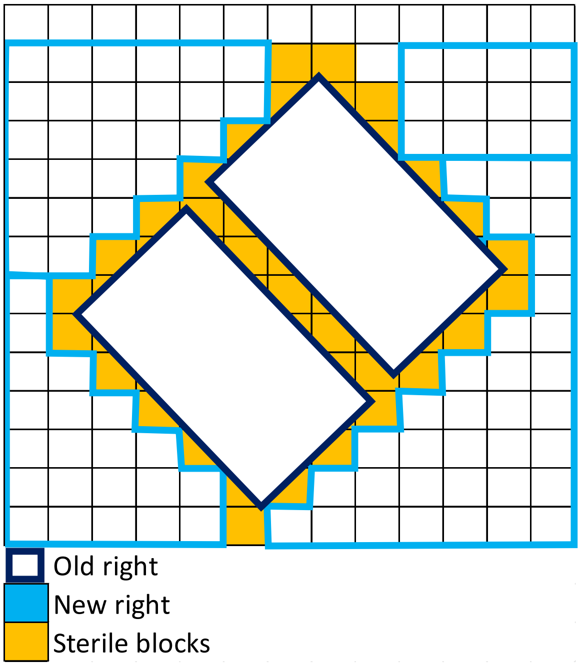

Figure 12 Existing rights remain as-is, new applications/rights snap to grid, leading to sterile blocks around existing rights

A number of countries have adopted this model, but some have required that existing rights conform to the cadastral grid on their next renewal. This approach will again create conflicts with adjacent rights – but at least allows the Regulatory Authority to resolve the conflicts as and when the renewals occur, rather than all at the same time.

4. Other Implications of Implementing a Cadastral Grid

Regardless of the methodology chosen to implement a cadastral grid, as detailed in Section 3, other negative implications need to be addressed, understood and mitigated. Some of these are addressed below.

4.1. Cadastral Block Size

Key to the successful implementation of a cadastral grid is the selection of a suitable grid size.

The block size ideally needs to accommodate all types of rights, ranging from very small artisanal mining rights to very large prospecting rights.

The smaller the block size, the more complicated both the initial implementation and the future management becomes.

However a smaller block size does reduce the total area of conflicts introduced by the migration, but does not eliminate conflicts where existing rights are adjacent to or within one cadastral block of each other.

In the figures below, the impact of reducing the block size on the number of vertices is shown.

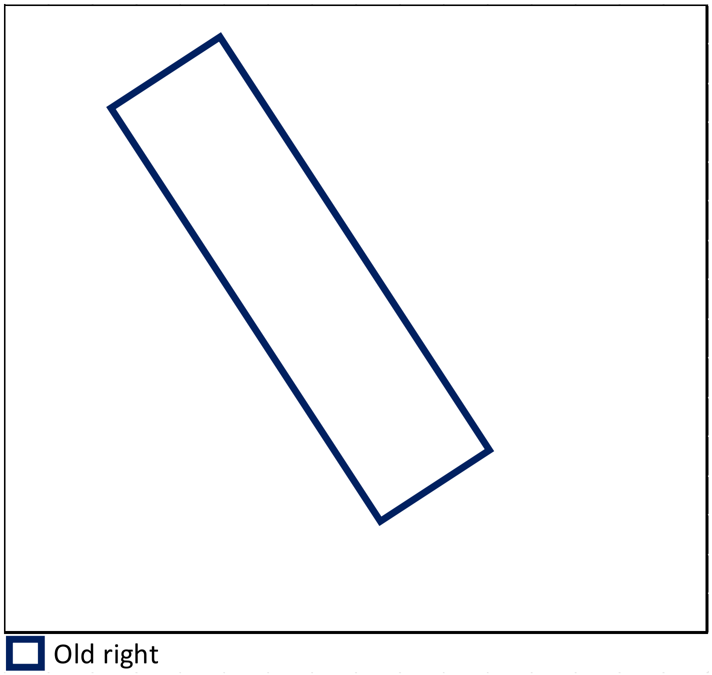

Figure 13 Original right (4 Vertices)

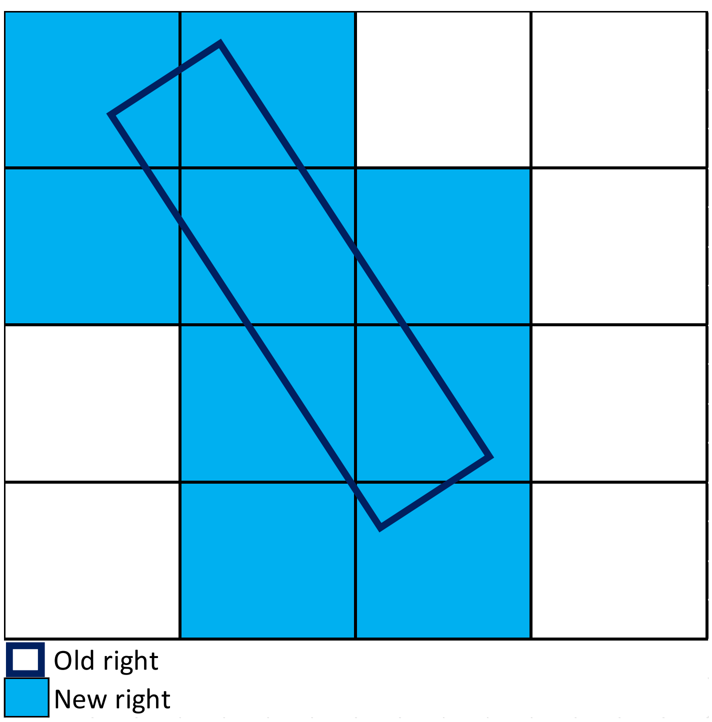

Figure 14 New right migrated to a cadastral grid with large blocks (8 Vertices)

Spatial Dimension

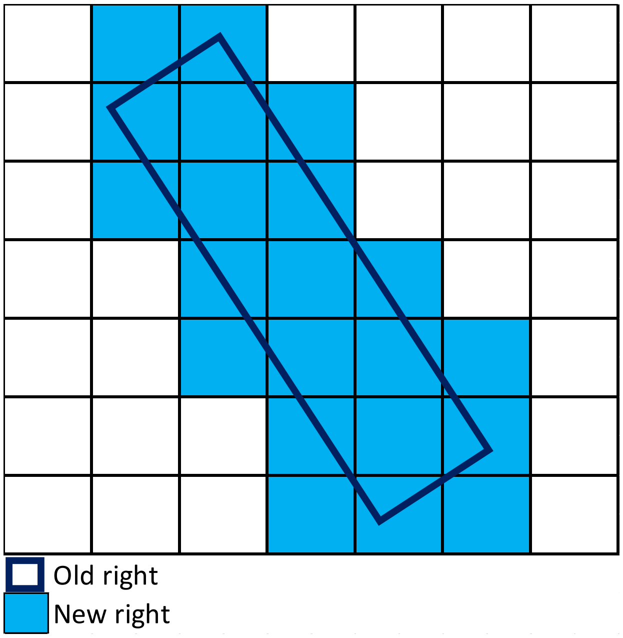

Figure 15 New right migrated to a cadastral grid with medium sized blocks (14 Vertices)

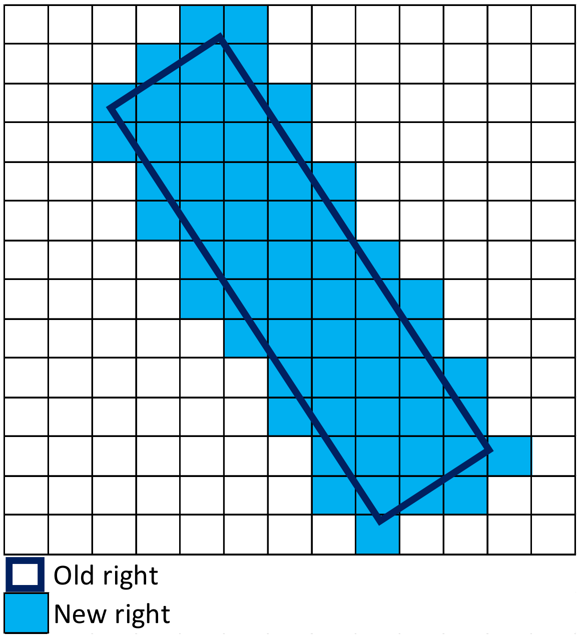

Figure 16 New right migrated to a cadastral grid with small sized blocks (37 Vertices)

In the figures below, the impact of reducing the block size on the number and total area of conflicts is shown.

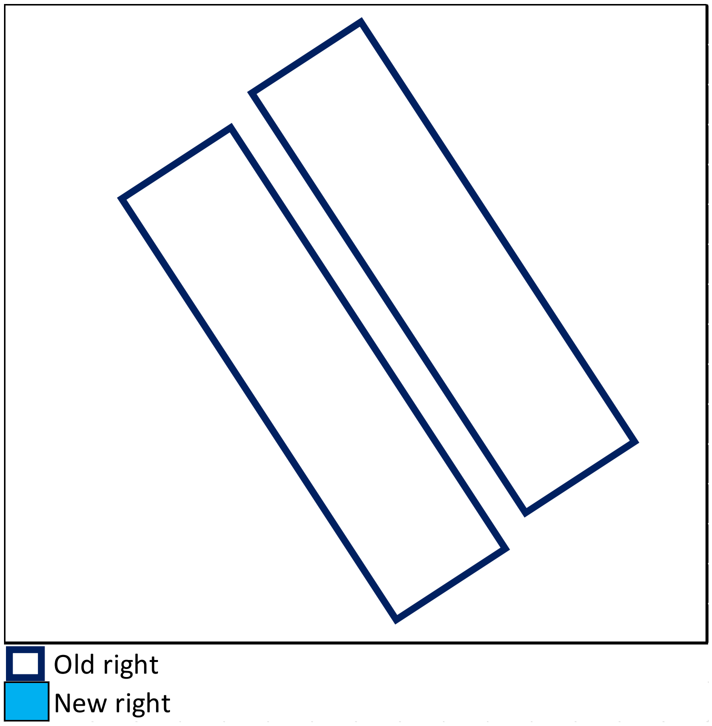

Figure 17 Original rights

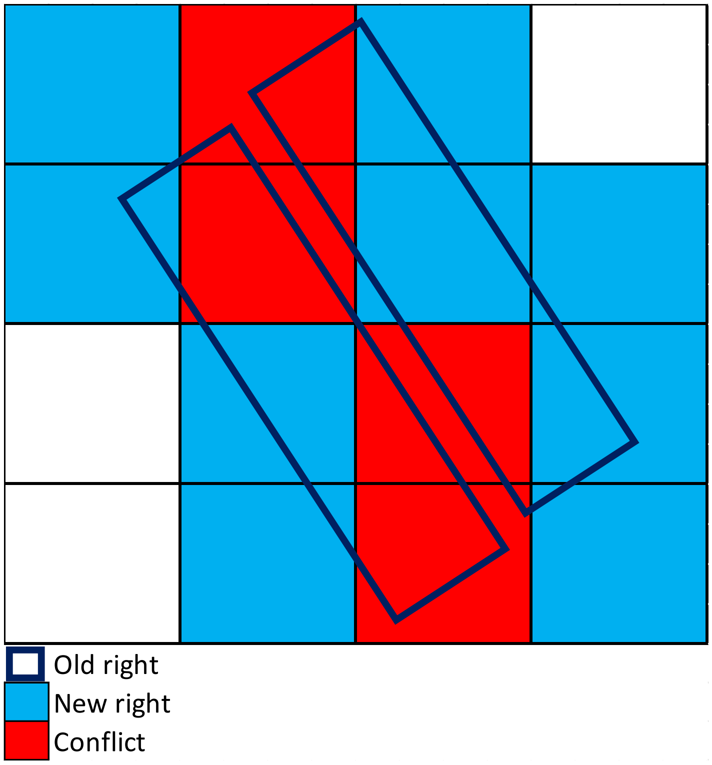

Figure 18 New rights migrated to a cadastral grid with large sized blocks

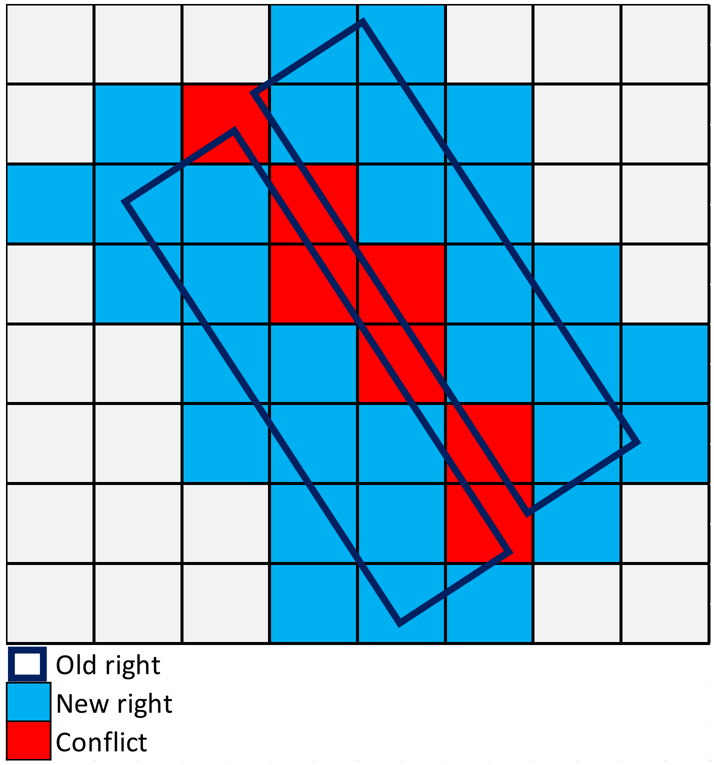

Figure 19 New rights migrated to a cadastral grid with medium sized blocks

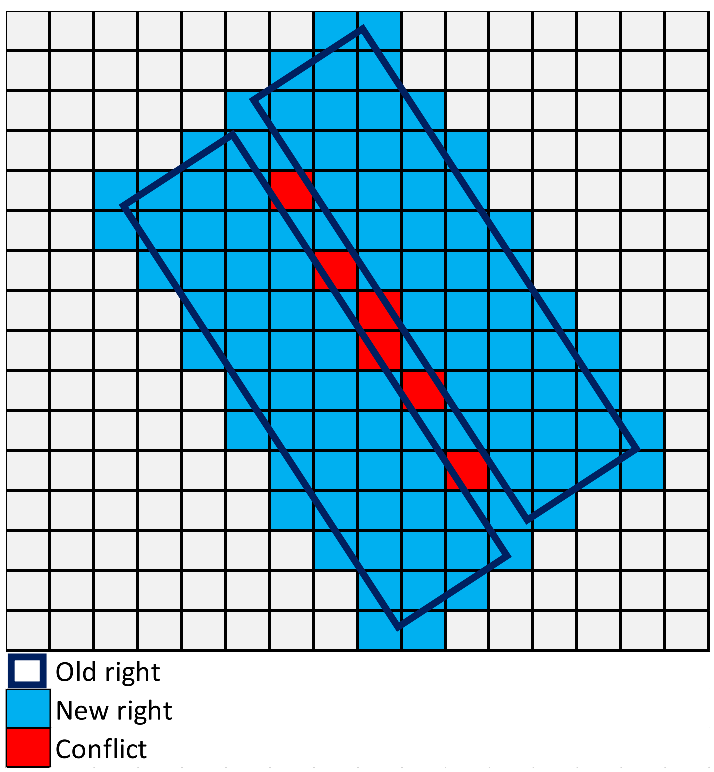

Figure 20 New rights migrated to a cadastral grid with small sized blocks resulting in very complex polygons but a lower total area of conflicted blocks

Spatial Dimension

In the figures below, the complexity of trying to implement a single block size to accommodate different types of rights is shown.

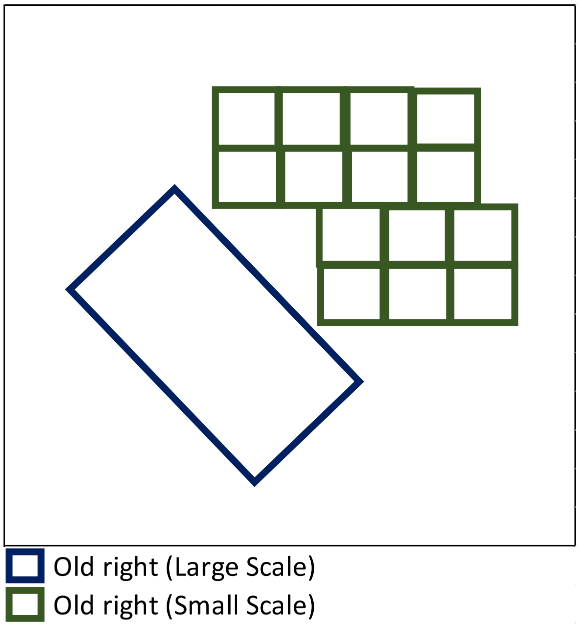

Figure 21 Original Large Scale and Small-Scale Rights

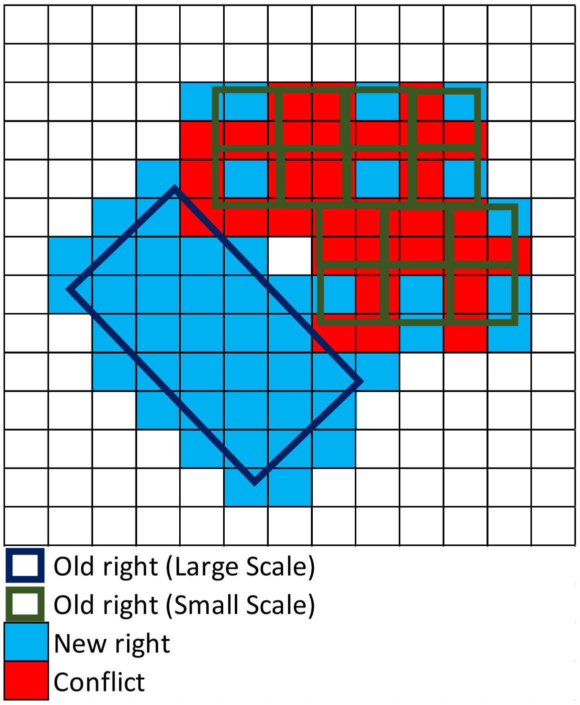

Figure 22 Implementation of a cadastral grid that is too small for Large Scale rights but too large for Small Scale Rights leading to significant conflicts

Spatial Dimension

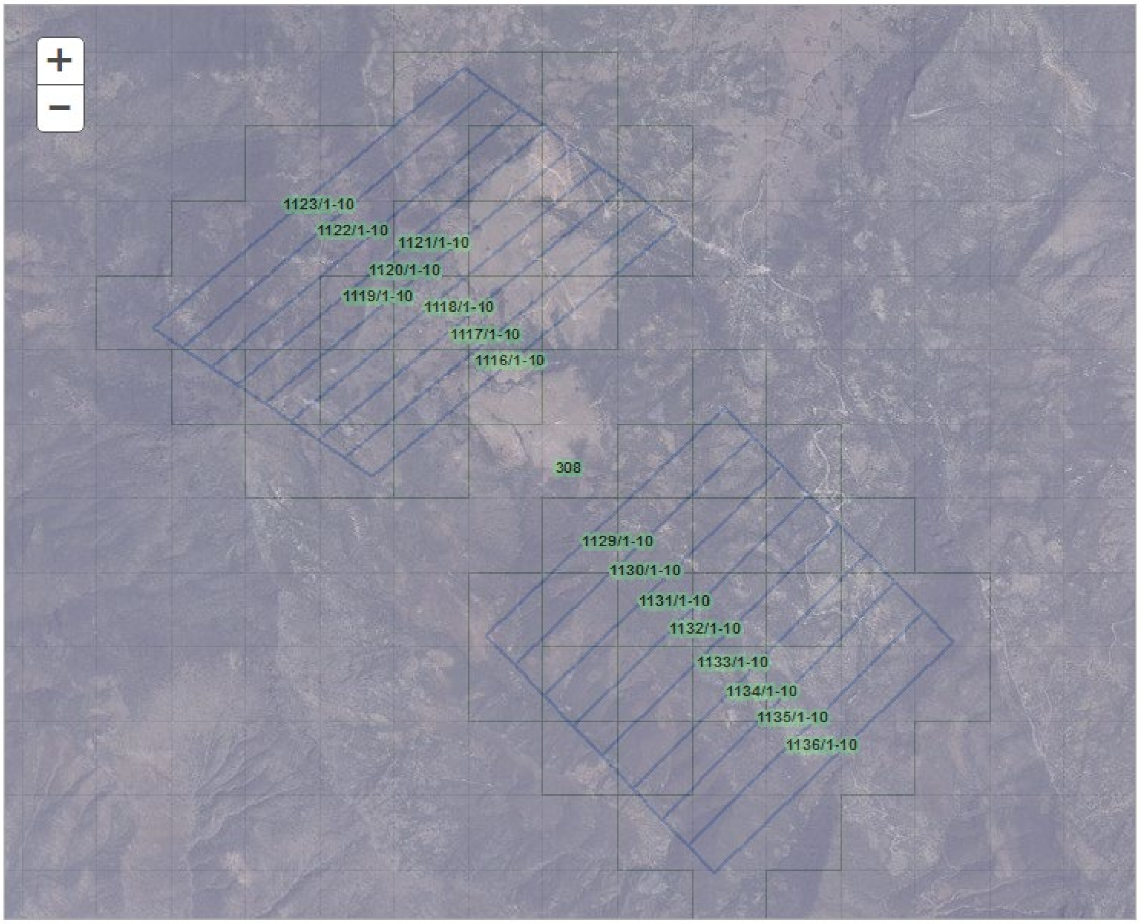

Figure 23 Screen capture from Kenya's online mining cadastre system. The oblique small scale rights were supposed to be migrated to the superimposed cadastral blocks.

4.2. Large number of vertices

As detailed Section 4.1, the size of the cadastral grid, together with the orientation of the existing rights can result in a simple four vertex polygon being converted into a complex shape with numerous vertices.

This can introduce various challenges, including:

- Where Regulatory Authorities still require a hard copy application form to be submitted, this application will often require hundreds, if not thousands of coordinate pairs to be transcribed, first by the applicant onto the form, and then by the Regulatory Authority into the mining cadastre system. This creates an opportunity for the introduction of significant errors.
- Any legal documentation for these rights will need to include a full list of coordinate pairs. A license document that used be printed on a few pages, would now require reams of paper.
- Field identification of rights with large numbers of vertices becomes very challenging.

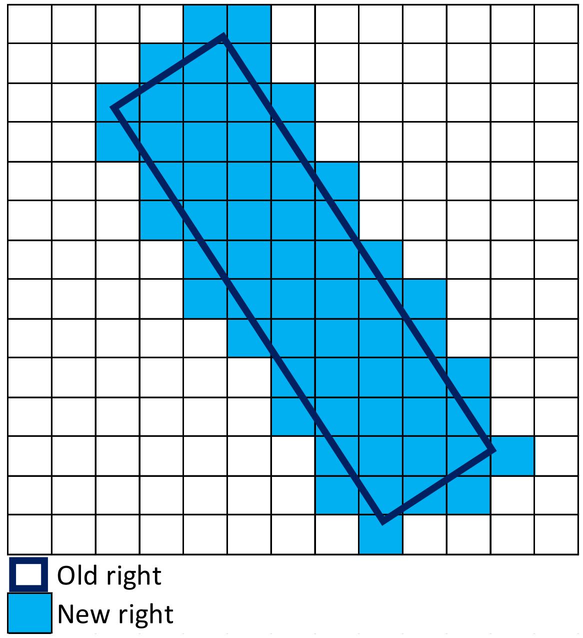

Figure 24 How would new right be identified in the field? With 37 beacons?

The following figures show the real-life impact of the implementation of a cadastral grid on the number of vertices required to describe a mineral right.

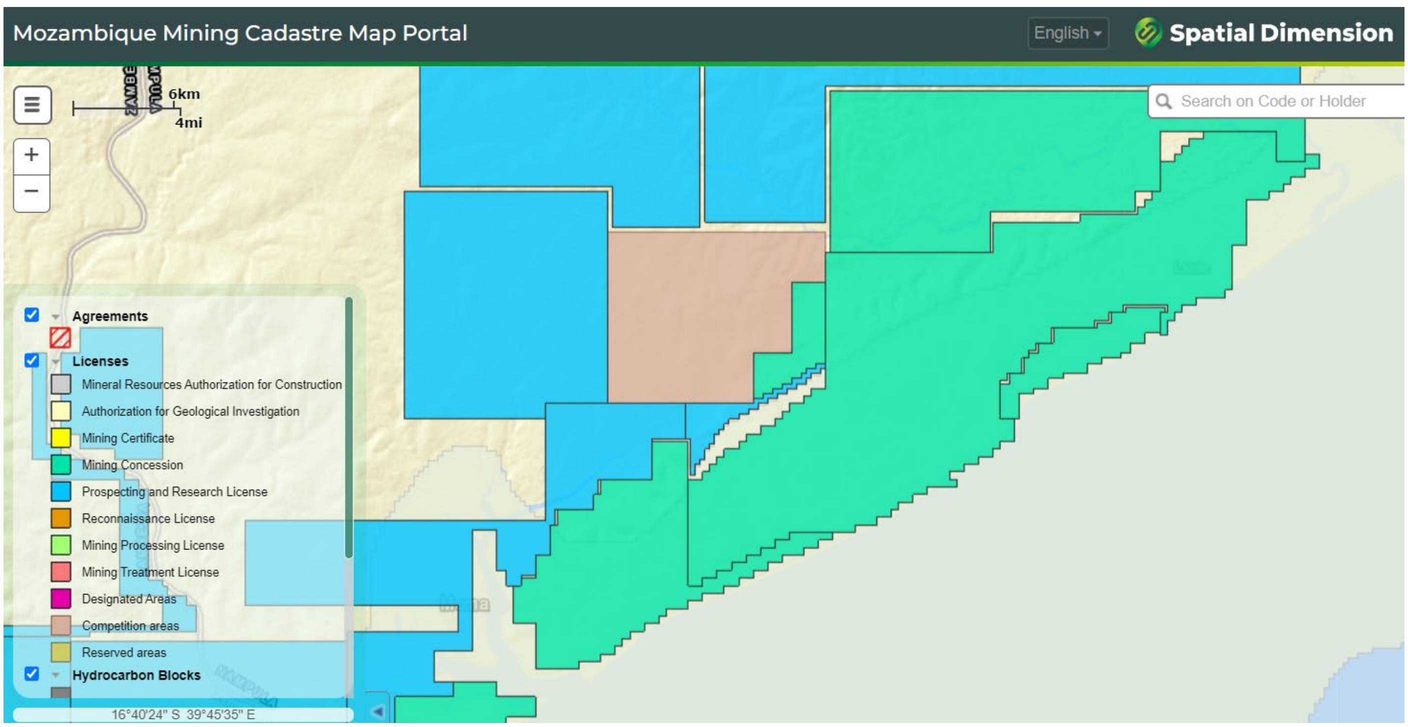

Figure 25 Mozambique: A simple oblique right for mineral sands along a beach converted into a complex polygon with hundreds of vertices

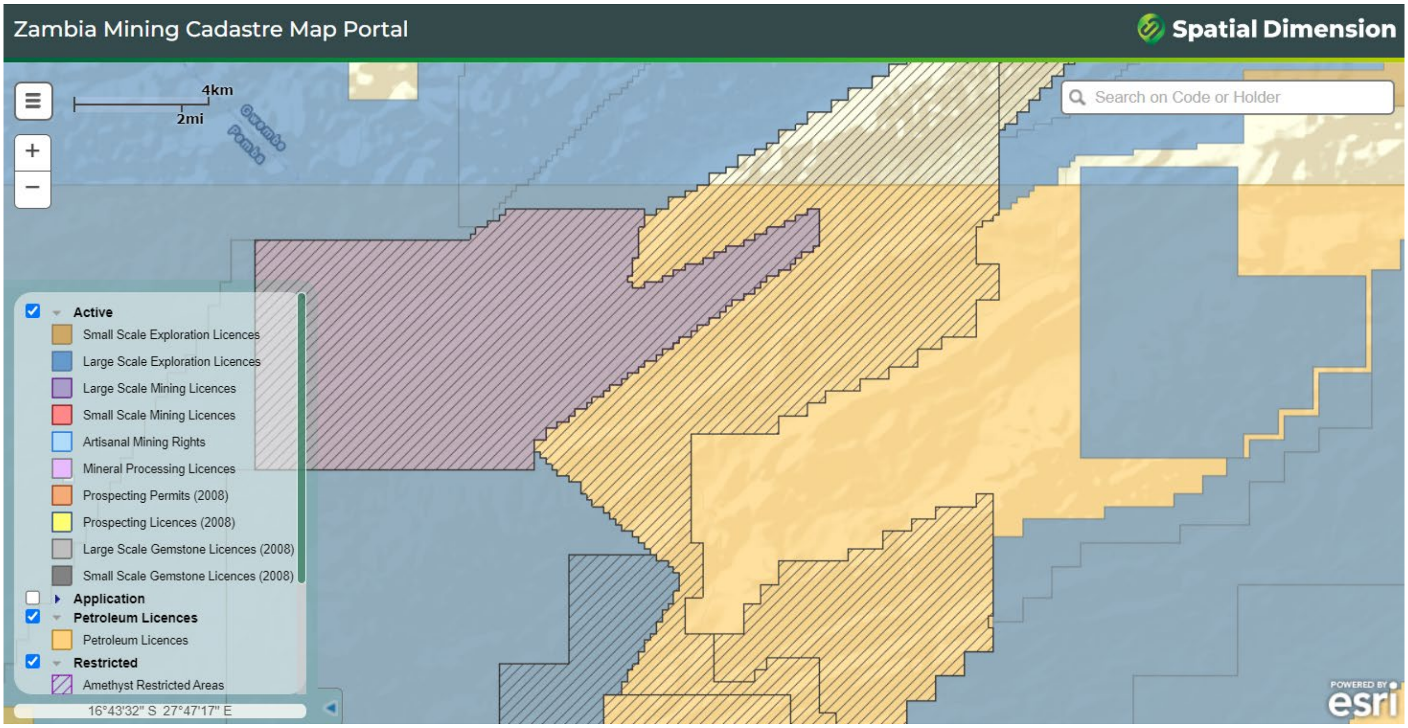

Figure 26 Zambia: Relatively simple polygons converted into complex polygons with thousands of vertices

4.3. Allocation of rights outside country border

In free-form mining cadastre regimes, rights are typically extended (snapped) to the country border.

When implementing cadastral grids a decision needs to be made whether rights will extend beyond the country border (see Figure 27) or be fully contained within the country border which leads to block sterilization (see Figure 28).

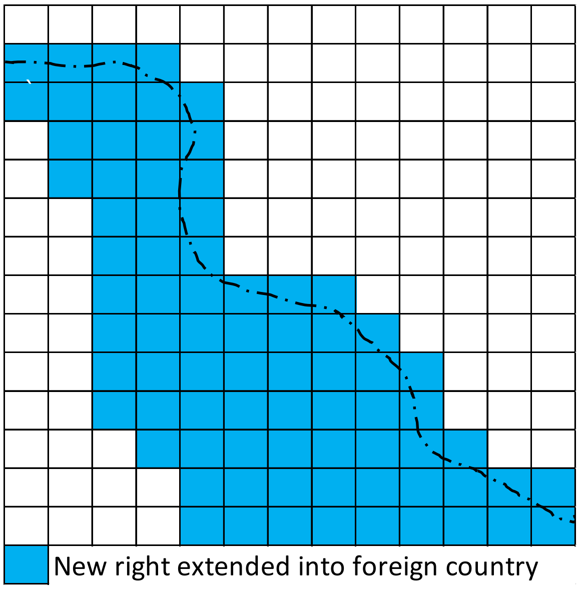

Figure 27 New rights extending into neighbouring country

Spatial Dimension

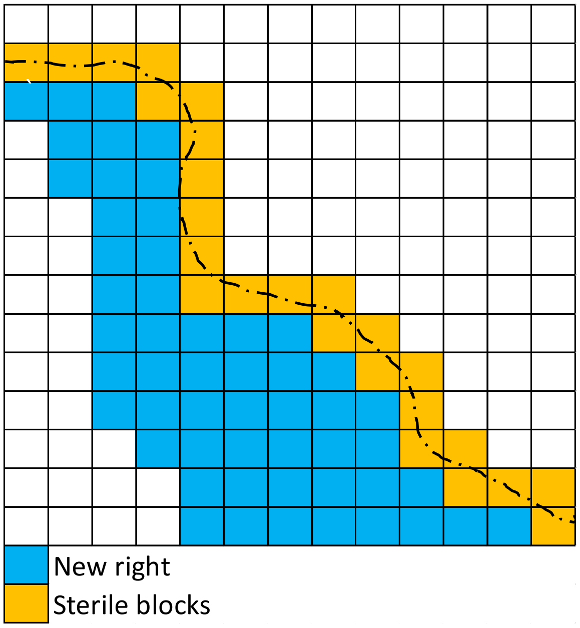

Figure 28 New rights fully contained within country resulting in sterile blocks

The following figures show the real-life impact of the implementation of a cadastral grid on rights adjacent to a country border.

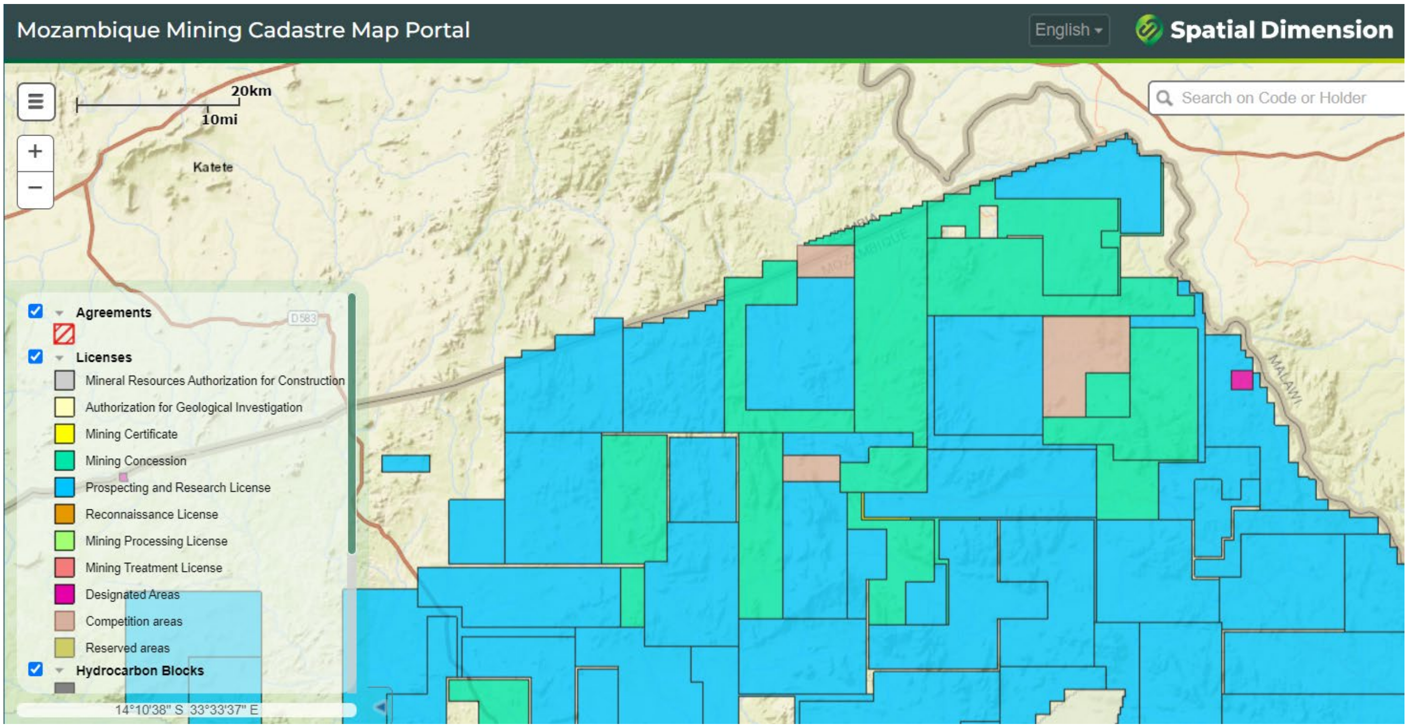

Figure 29 Mozambique: New rights extending into Zambia

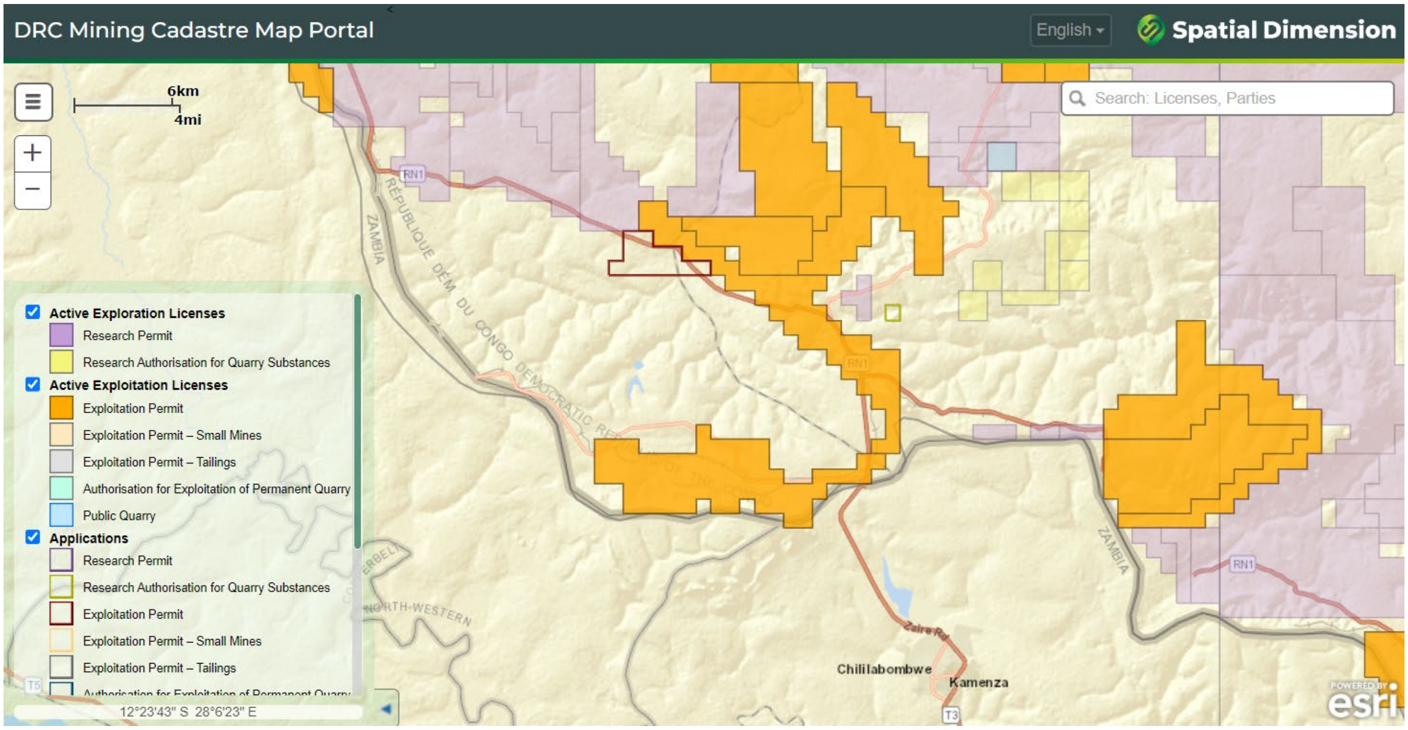

Figure 30 DRC: New rights extending into Zambia

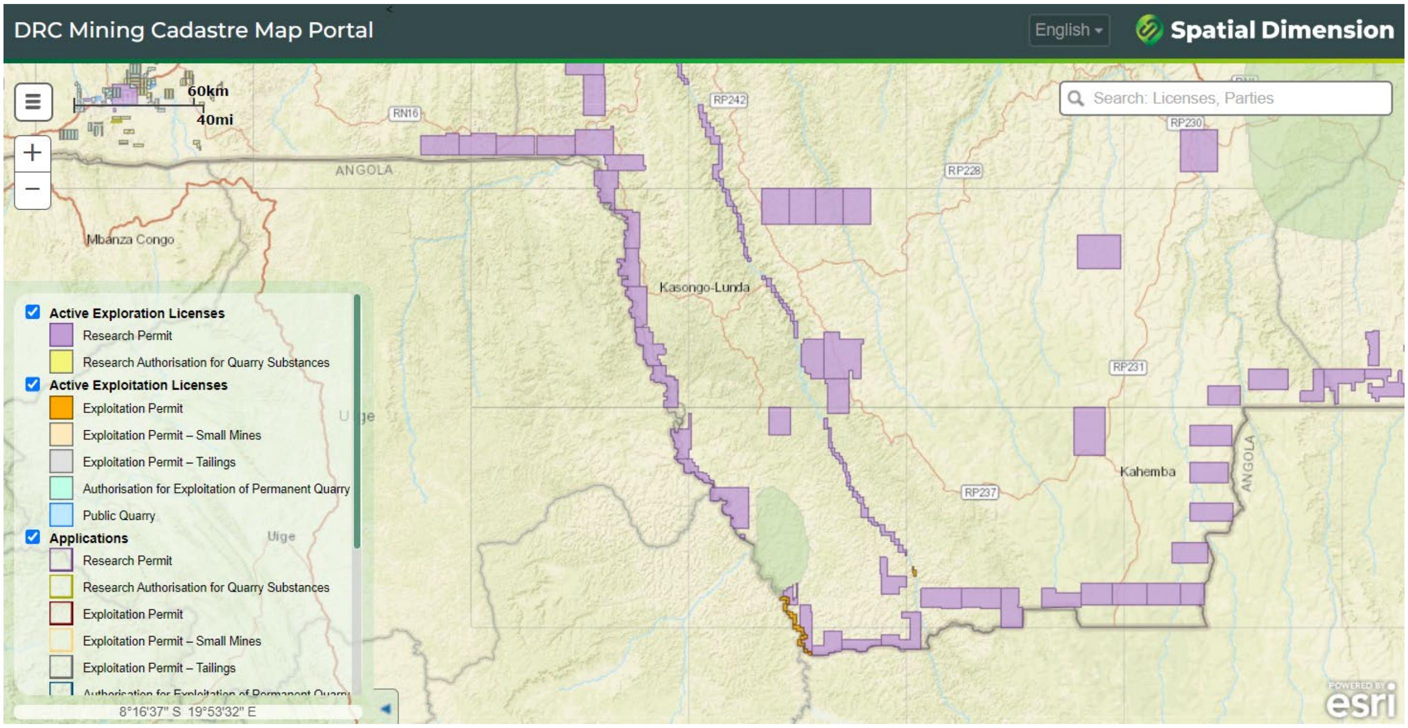

Figure 31 DRC: New rights extending into Angola

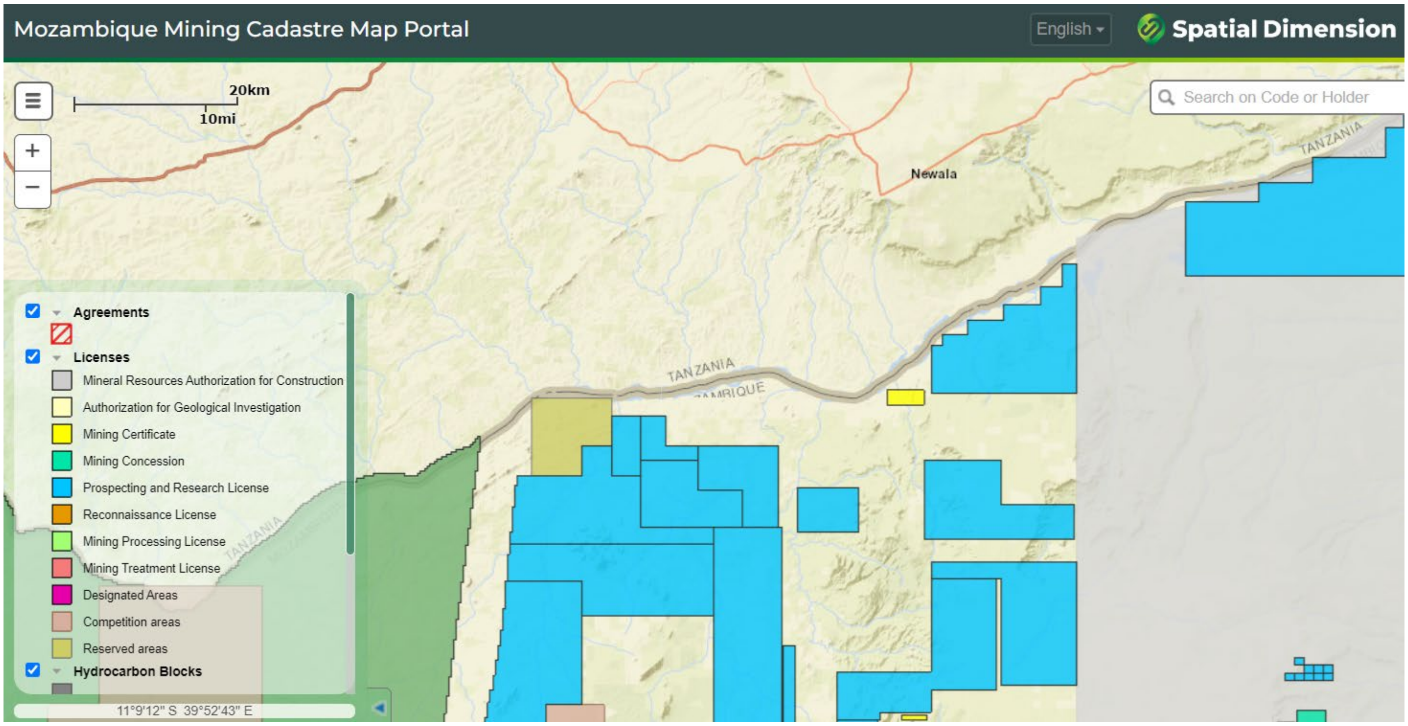

Figure 32 Mozambique: Sterile blocks along border

5. Conclusion

It is our experience from working in numerous countries that the process of implementing a cadastral grid has typically distracted the Regulatory Authority from conducting their mission critical and mandated responsibilities.

As with any proposal to change the legal regime in a country, the onus should very much be placed on those advocating for the implementation of a cadastral grid to provide a detailed implementation methodology together with a comprehensive cost benefit analysis for such an implementation. This exercise should be completed before any legal amendments are considered.

Simply stating that cadastral grids are 'international best practice' should not be considered sufficient to justify the very real risks involved in such an implementation in some countries.

As a penultimate example, see below a screen shot from Tanzania's mining cadastre system. Tanzania has tens of thousands of large scale and small scale licenses. They encourage a north/south, east/west alignment of rights, but have not implemented a cadastral grid.

The Regulatory Authority has correctly prioritized their efforts and resources towards compliance monitoring and revenue collection. They see no benefit in converting existing rights to align to a hypothetical grid.

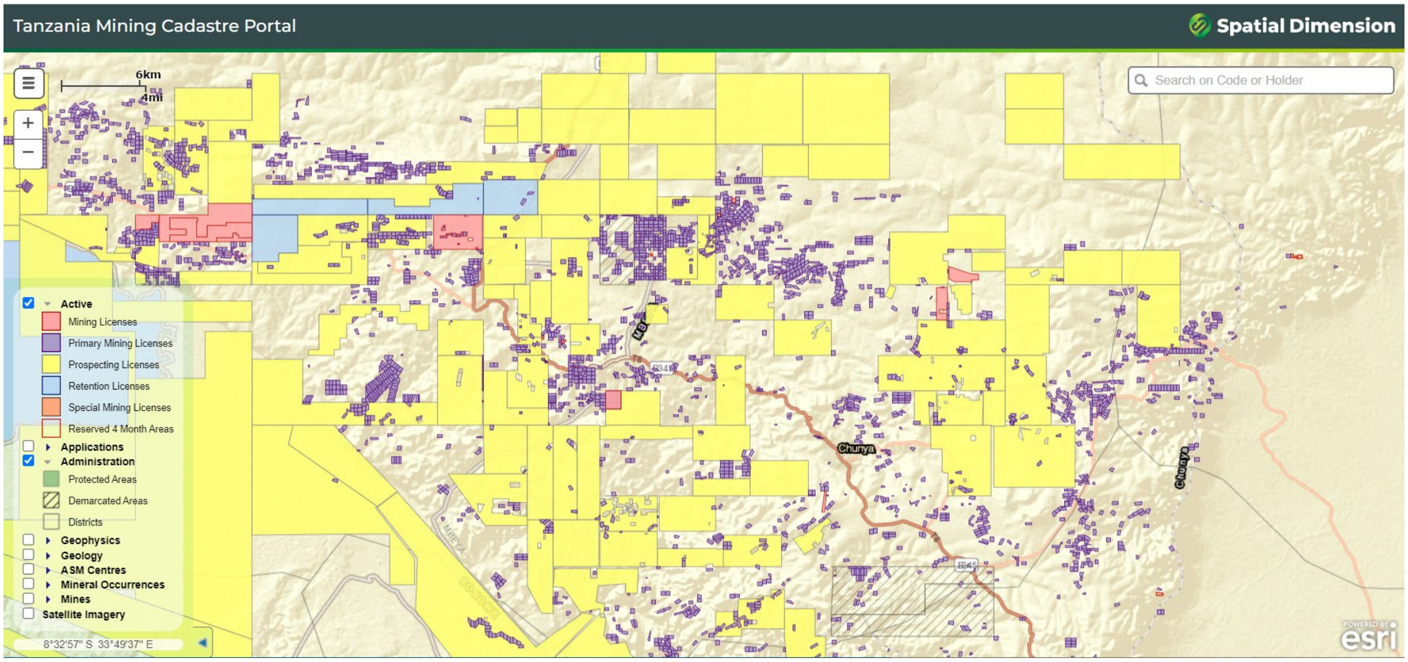

Figure 33 Tanzania: Africa's largest mining cadastre caters for large scale and small scale rights without resorting to a hypothetical grid

As the final example, see below a screen shot from South Sudan's mining cadastre system. As the world's youngest country, it was well suited to the introduction of a cadastral grid. At the time of the introduction of the mining cadastre system, only three licenses existed in the country, and a cadastral grid could be implemented without creating any conflicts. The Regulatory Authority could therefore remain focused on its mandated responsibilities rather than on managing a conflict resolution process of its own making.

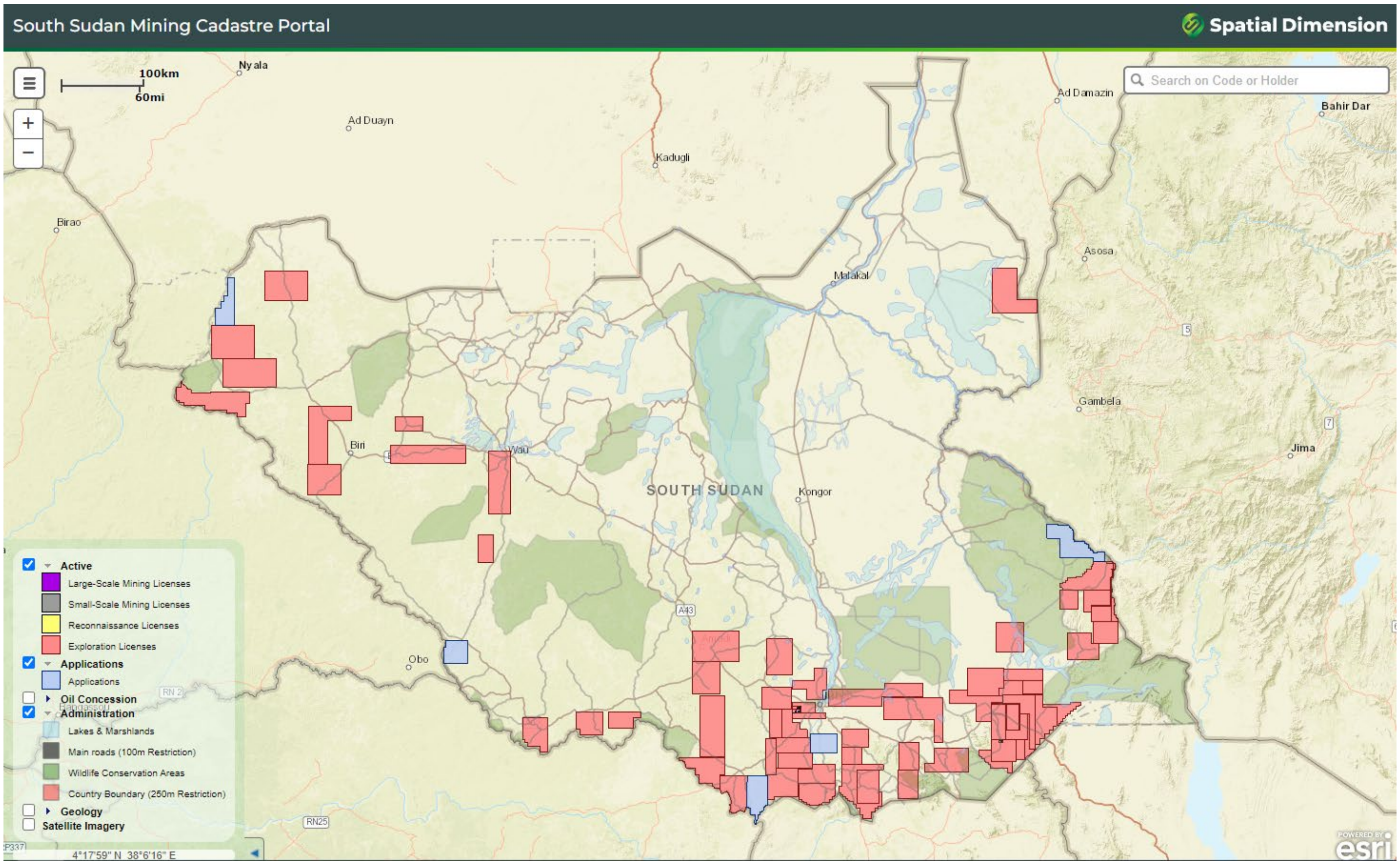

Figure 34 South Sudan: A cadastral grid could easily be implemented as only three licenses existed and no conflicts where created

6. Spatial Dimension Project History

Spatial Dimension has implemented modern mining cadastre systems in the following countries:

Country	Client	Operational Since	Backoffice	Public Portal	e-Gov Portal	Small Scale (ASM)	Cadastral Blocks	Licenses Managed	Connected Offices	Users of the System	Stakeholders Managed	Graticular Block Size
Botswana	Botswana Geoscience Institute (BGI)	2022	✓	✓	✓	✓		2400	1	10	1400	
Cameroon	Ministry of Industry, Mines & Technological Development	2016	✓	✓		✓	✓	1000	1	10	500	15"x15"
Democratic Republic of Congo	Cadastre Minier	2007	✓	✓		✓	✓	15000	1	120	3000	30"x30"
Ethiopia	Ministry of Mines	2008	✓	✓	✓	✓		3000	12	70	4500	
Greenland	Bureau of Minerals and Petroleum	2006	✓	✓				300	1	30	500	
Guinea	Ministry of Mines and Geology	2016	✓	✓		✓		700	3	30	700	
Guinea-Bissau	Ministry of Energy, Industry and Natural Resources	2015	✓	✓				50	1	10	100	
Ivory Coast	Ministry of Mines, Oil and Energy	2012	✓	✓				150	1	25	175	
Kenya	Ministry of Environment and Mineral Resources	2011	✓	✓	✓	✓	✓	1500	5	30	1000	15"x15"
Lao PDR	Ministry of Energy and Mines	2013	✓	✓				1000	3	80	750	
Liberia	National Bureau of Concessions	2013	✓	✓				500	5	75	150	
Malawi	Ministry of Natural	2017	✓	✓		✓		600	3	20	1300	

Country	Client	Operational Since	Backoffice	Public Portal	e-Gov Portal	Small Scale (ASM)	Cadastral Blocks	Licenses Managed	Connected Offices	Users of the System	Stakeholders Managed	Graticular Block Size
	Resources, Energy and Mining											
Mauritania	Ministry of Petroleum, Energy and Mines	2018	✓	✓			✓	3000	1	30	1600	1 Km2 (UTM)
Mozambique	Ministry of Mineral Resources	2003	✓	✓	✓	✓	✓	7000	12	110	4000	15"x15"
Myanmar	Ministry of Natural Resources and Environmental Conservation	2020	✓	✓	✓			18000	1	25	3000	
Namibia	Namibia Ministry of Mines and Energy	2013	✓	✓		✓		20000	5	30	10000	
Pakistan	Khyber Pakhtunkhwa Minerals Development Department	2020	✓	✓	✓			10500	5	320	12000	
Papua New Guinea	Mineral Resource Authority	2013	✓	✓	✓		✓	3500	1	50	1000	5”x5”
Rwanda	Ministry of Natural Resources	2013	✓	✓				400	1	20	600	
Senegal	Ministry of Energy and Mines	2009	✓	✓		✓		600	15	15	500	
South Sudan	Ministry of Petroleum & Mining	2014	✓	✓			✓	100	1	10	100	15"x15"
Tanzania	Ministry of Energy and Mines	2005	✓	✓	✓	✓		115000	24	220	65000	
Uganda	Department of Geology and Mines	2011	✓	✓	✓	✓		1500	2	50	1000	

Country	Client	Operational Since	Backoffice	Public Portal	e-Gov Portal	Small Scale (ASM)	Cadastral Blocks	Licenses Managed	Connected Offices	Users of the System	Stakeholders Managed	Graticular Block Size
United States	Idaho Department of Lands	2017	✓	✓								
Zambia	Ministry of Mines, Energy and Water Development	2006	✓	✓	✓	✓	✓	11000	6	70	6500	6”x6”
Zimbabwe	Ministry of Mines & Mining Development	2016	✓	✓	✓	✓	✓	100000	9	100	20000	