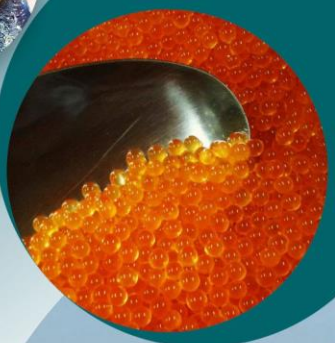
2019
Strategic Environmental Assessment for Marine and Freshwater Aquaculture Development in South Africa

APPENDIX A-5

Socio-Economic Specialist Assessment








Socio-Economic Specialist Assessment

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ABBREVIATIONS & ACRONYMS

ADEP	Aquaculture Development and Enhancement Programme
ADZ	Aquaculture Development Zone
CLD	Causal Loop Diagram
CPPP	Community Public Private Partnerships
CPR	Common-pool Resource
DAFF	Department of Agriculture, Forestry and Fisheries
DWS	Department of Water and Sanitation
DDT	dichlorodiphenyltrichloroethane
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GDPR	Gross Domestic Product Per Region
GVA	Gross Value Added
ICMZ	Integrated Coastal Management Zone
LIFDs	Low-income food-deficit countries
MRL	Maximum residue levels
MT	Megatonne
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NGOs	Non-Governmental Organisations
POPs	Persistent organic pollutants
RMP	Resource Management Plan
SEA	Strategic Environmental Assessment
SOP	Standard Operating Procedure
USA	United States of America
WHO	World Health Organisation

1 SUMMARY

In 1974 aquaculture provided 7 % to global fish supply, by 2014 this percentage had increased to 39 %. This increase in aquaculture production means that aquaculture has become the fastest growing animal food production system in the world, with the Food and Agriculture Organisation of the United Nations estimating that 73.8 million tonnes of fish were harvested from aquaculture in 2014. Aquaculture development is shown to be able to contribute on an economic and social front to the countries and communities. Within the South African context, Operation Phakisa also acknowledges the potential of aquaculture to contribute to social and economic upliftment through its Ocean's Economy Aquaculture focus area and aims to increase the revenue from the aquaculture sector from R 0.67 billion to R 3 billion and to create 2 500 - 15 000 direct and full time jobs over a five year period (2014 -2019).

To fully understand the potential socio-economic opportunities and risks associated with aquaculture development the **first key consideration should be the socio-economic setting within each study area**. Secondly, **the form of aquaculture (freshwater or marine) and the type of aquaculture development (subsistence or commercial) proposed within a study area must be considered,** since each option comes with its distinct environmental, social and economic impacts. The importance of understanding the socio-economic environment and the proposed type of aquaculture development to be introduced is discussed in Section 2 of this assessment.

The limitations of this assessment are outlined within Section 3 of this report. Given the scale, scope, and uncertainties inherent within this assessment, a level of complexity emerges. To address the complexity issue effectively and realistically, a **Social Vulnerability Index** and the **Gross Value Added of local municipalities included in a Socio-Economic Intensity Index** were used to determine the consequence levels and associated risks and opportunities associated with proposing aquaculture development in the various study areas (Section 4).

One of the key opportunities associated with commercial aquaculture development is the **potential to contribute to the macro-economy** of South Africa (Section 5.1 and Section 6). It should be noted, however, that macro-economic opportunities, measured in this case by the potential to contribute to Gross Domestic Product and Gross Domestic Product per Region, may not be fully acknowledged and/or accounted for in National or Provincial accounting systems. **The economic opportunities within local municipalities that have a declining Gross Value Added compared with national growth have been identified to have a high opportunity rating**, if suitable management measures are adopted.

The contribution of aquaculture **to rural and livelihood development** potentially comes with various social opportunities. The **social opportunities within high vulnerability areas, as per the Social Vulnerability Index, have been identified to have a high opportunity rating** (Section 5.2 and Section 6), following the implementation of the recommended mitigation measures.

In dams where no resource management plans exist, **conflict in the form of user displacement within freshwater systems** has been identified as having **a moderate risk** (Section 5.3 and 6).

The **health impact resulting from aquaculture may be caused by microbial and chemical contamination or nutrient enrichment** of the water environment. The consequence level of 'extreme' was allocated to any scenario where there would be an adverse human health impact resulting from aquaculture practices. Should the suitable South African monitoring and permitting guidelines be followed, the likelihood of the impact occurring is considered to be unlikely and the overall risk reduced **to very low** (Section 5.4 and Section 6). It is recommended that the economic and social environment of each area is understood prior to an individual aquaculture project or a number of projects being introduced. This will provide a suitable baseline for identifying suitable management and mitigation measures to enhance the economic and social opportunities and reduce the risks. Although the contaminants that may affect human health are known, the human health risks associated with fish produced through aquaculture are not fully understood. Further research is needed to assess associated human health risks and to develop appropriate interventions that could reduce or prevent these risks.

2 INTRODUCTION

2.1 International and national context

In 1974 aquaculture provided 7 % to global fish supply, by 2014 this number had increased to 39 %. This increase in supply means that aquaculture has become the fastest growing animal food production in the world (FAO, 2016). The Food and Agriculture Organisation of the United Nations (FAO) estimates that 73.8 million tonnes of fish were harvested from aquaculture in 2014 compared to 93.4 million tonnes harvested through captured fisheries (FAO, 2016). The highest percentage of fish produced is for human consumption and a small percentage of by-products are used for non-food purposes (FAO, 2016). World per capita fish consumption has increased from 14,4 kg in the 1990s to 19.7 kg and was expected to increase to over 20 kg by 2015 (FAO, 2016). Whilst the global demand for fish has been increasing on a per capita basis over the past couple of years, overfishing is steadily depleting the fish stocks within the world's oceans (Allsopp *et al*., 2008). Increased fish supply from aquaculture therefore continues to contribute to fulfilling global fish demand (Asche *et al*., 2009).

On a global scale, developed countries such as Japan, countries within the European Union and the United States of America (USA) are the top aquaculture producers, while China, India, Philippines and Indonesia are the dominant producers in developing countries (FAO, 2000a). The production in developing countries and in low-income food-deficit countries (LIFDs) has been increasing by 10 % per year for the past 30 years, while developed countries have only seen a 3,7 % increase within the same period (FAO, 2002).

On the African continent inland fisheries contribute to the food security and economies of many countries. For example, 75 % of Malawi's protein comes from locally sourced fish (Ribbink, 1994). It was estimated that in 2007, 5 % of the African population depended on the fisheries sector (including aquaculture but to a limited extent) (FAO, 1996). According to Brummett and Williams (2000) freshwater fish production dominates in Africa, with Egypt leading in terms of output, and Nile Tilapia (*Oreochromis niloticus*) being the dominant produced species. Aquaculture currently plays a role in African economies through commercial and subsistence aquaculture. Commercial aquaculture refers to the production of high value species, while the role of aquaculture in subsistence development comprises its contribution to job creation and food security. Aquaculture can play a larger economic role but several constraints are present in African countries which inhibit aquaculture development. These include poor infrastructure, small government budgets, lack of local expertise and consumer poverty. Key initiatives highlighted to address these constraints include a call for broader integrated rural development initiatives and support from national policies and programmes (Brummett & Williams, 2000).

In 2014, there were 233 operational farms in South Africa; of which 39 were in the mariculture sector (including abalone, finfish, oysters, mussels); and 194 in the freshwater aquaculture sector (including tilapia, trout, catfish, marron crayfish, carp, koi carp or ornamental fish) (DAFF, 2015). In the 2012 Department of Agriculture, Forestry and Fisheries (DAFF) Aquaculture Yearbook, it was estimated that the total production from aquaculture in South Africa was approximately 1883 tonnes (DAFF, 2012), while in 2015 it was estimated that 5209 tonnes of fish were produced (DAFF, 2015). The aquaculture products produced are traded both locally and internationally and the product and quantities traded are influenced by factors such as demand, supply, rates of exchange, and competing prices of a similar product from other countries (DAFF, 2015).

The mariculture sector exports abalone and mussels mainly to Hong Kong (DAFF, 2015). The abalone subsector export capacity is deterred by the increasing pressure from competition with international sales and lower cost with higher production yields by other exporting countries (DAFF, 2011). Other constraints experienced by the mariculture sector are the cost of energy and health services (DAFF, 2012) and, specifically for the oyster and mussel subsectors, the health certification programme, which creates a trade barrier (DAFF, 2011).

South Africa does not have large natural bodies of inland waters for aquaculture development, but through the process of dam construction, extensive human-made inland waters have been established (Andrew *et al*., 2000). The trout subsector is the largest production component of freshwater aquaculture in South Africa, contributing nearly 86 % of the total production (DAFF, 2015). The contribution by the freshwater aquaculture to the national economy is currently insignificant. This can be attributed to the lack of skills development and constraints in the awareness of the aquaculture sector (DAFF, 2015) and the unwillingness of the Department of Water and Sanitation (DWS) to accommodate aquaculture in water supply dams.

In support of Operation Phakisa, the Oceans Economy Labs took place in July and August 2014 to identify the new coordinated ocean governance approach over the next five years. The main aim of the Lab is to "Implement an overarching, integrated ocean governance framework for sustainable growth of the ocean economy that will maximise socio-economic benefits while ensuring adequate ocean environmental protection within the next five years" (DAFF, 2016). Key targets that have been set for the Ocean's Economy Aquaculture focus area over five years (2014-2019) are to increase the annual revenue from the sector from R 0.67 billion to R 3 billion, produce 20 000 tonnes of fish per annum and to the create of 2 500 - 15 000 jobs (DAFF, 2016).

For social wellbeing, aquaculture undoubtedly offers potential in terms of livelihood development. Commercial aquaculture opens employment and business development opportunities within a sector and aquaculture's beneficial impact on food security further serves to highlight its potential for improving social conditions (FAO, 2016). Realising the social and economic benefits of aquaculture is highly dependent on the relevant socio-economic context of the receiving environment. Many South African communities face high unemployment, low income, low educational attainment, social vulnerability, and a lack of opportunity for social upliftment; and could therefore benefit from aquaculture development.

2.2 Key links to other topics

2.2.1 User displacement

The Socio-economic Impact Assessment for the Algoa Bay Aquaculture Development Zone (ADZ) identified the following sources of user conflict via user displacement (Bloom, 2013):

- Specialist tourism and recreational activities.
- Marine Protected Areas in Algoa Bay.
- Vessel navigation routes (port traffic zones).
- Pollution of the marine environment.
- Existing mariculture activities in the area.
- Impact on the local fishing industry.

User displacement in the marine environment was considered within the following chapters included in this Strategic Environmental Assessment (SEA):

The Visual Impact Assessment included in Chapter 5 the SEA identifies the sensitive receptors within the study areas (Section 4.2). These include tourism destinations, national parks, private reserves and human settlements. A sensitivity scoring was allocated to each feature and was based on the size of the aquaculture facility and its proximity to the sensitive receptor. Measures have been included in the assessment to address the concerns.

Socio-economic sensitivity and user displacement from a marine perspective were included and considered within the Marine Biodiversity and Ecology assessment (Chapter 3 of the SEA Report). The assessment mapped the following socio-economic features present within the marine environment:

important recreational areas (Blue flag beaches and popular diving sites), high density urbanised areas, cultivated lands, commercial ports and small ports and fishing harbours.

The risk of user displacement considered within this assessment (Section 5.3) therefore does not consider the user conflict in the marine environment and focuses on user displacement within the freshwater environment.

2.2.2 Water quality and associated human health impact

Human health impacts from aquaculture have two pathways: recreation and consumption. Recreation refers to the use of a Common-pool Resource (CPR) for swimming, water skiing etc. that has a reduced water quality due to aquaculture practises and consumption relates to the eating of fish that is contaminated by, for instance, harmful algal blooms or by drinking or using water with a reduced quality.

The Freshwater Biodiversity and Ecology (Chapter 2) and Marine Biodiversity and Ecology (Chapter 3) assessments consider the impact of altered water quality on the aquatic environment and the associated ecosystem goods and services. The environmental and human health impacts associated with a reduction in water quality are therefore not considered within this assessment.

3 SCOPE OF THIS STRATEGIC ISSUE

As noted in Ronnback *et al*. (2003), aquaculture is a diverse activity with a large number of species cultivated using various production systems and technologies. Each of these options comes with its distinct environmental, social and economic impacts. For instance, there is a clear difference between an aquaculture project aimed towards exports and a subsistence aquaculture project that satisfies a household's food security needs. In support of this, the types of aquaculture development (subsistence versus commercial) have significantly different characteristics associated with them, as highlighted in Ridler and Hishamunda (2001) and summarised in Table 1. As shown in the table, the key characteristics of a subsistence aquaculture development would be to provide a household with food security, have a low yield and be a small-scale system. A commercial aquaculture development would aim to maximise profits. The system would typically be large scale and have a high output.

Table 1. Principal characteristics of subsistence and commercial farms (Ridler & Hishamunda, 2001)

Main characteristic	Subsistence Aquaculture	Commercial Aquaculture
Main goal	Maximise family utility	Maximise profits
Main market	Domestic (family/rural)	Exports/Urban/Rural
System size	Small	Large
Input	Unpaid family labour	Paid labour
Main beneficiaries	Family	Owner/stakeholders
Average Capital-Labour Ratio	Low	Average to High
Average Yield per unit of land/water	Low	Average to High

In terms of marine aquaculture, because of the large financial investment required and the high value products being produced, such as abalone, mussels and oysters, it is expected that mariculture developments proposed in South Africa will mostly have the characteristics of a commercial aquaculture development. For freshwater aquaculture developments, these can either be subsistence or commercial, depending on what the goal of the farm is i.e. if it is for a household's food security, it would be a subsistence aquaculture development and if it is to maximise profits, then the development will be commercially orientated.

The distinction between the type of aquaculture development and the relative production output of the system, where subsistence aquaculture normally has a low output and commercial aquaculture a high output, is particularly important given the aims of this SEA. The National Environmental Management Act (Act No. 107 of 1998) (NEMA) and promulgated Environmental Impact Assessment (EIA) Regulations of 2014 (as amended) outline the listed activities that, if triggered, would require Environmental Authorisation (EA) from the relevant Competent Authority prior to commencing with the listed activity. The production output per annum of the listed activities associated with aquaculture range between 20 000 kg (land-based aquaculture) to 50 000 kg (sea-based aquaculture). Based on Table 1, the high production outputs would most likely be associated with commercial aquaculture. Given the low outputs associated with subsistence aquaculture, it will most likely fall below the production outputs requiring EA.

One of the aims of the SEA is the "development of a Decision Support Framework which proposes recommendations for *streamlined and integrated management and regulatory frameworks (emphasis added)* that aim to reduce compliance complexities and improve decision-making processes towards sustainable and responsible development in the study areas". Given that subsistence aquaculture will most likely not require compliance to any regulatory frameworks (due to its scale and low production outputs), the focus of this assessment is on commercial aquaculture development proposed within the marine or freshwater environment. It should however be noted that the exclusion of subsistence aquaculture from this assessment does not mean that risks and opportunities do not exist for this type of development but rather that this falls outside the mandate of this assessment.

3.1 Assumptions and limitations

- Assessment of socio-economic impacts is inherently challenging due to the variation on the capacity human beings to adapt to change and unexpected shocks and is linked to diverse factors such a culture, value systems, relative income levels, and physiological resilience. This level of uncertainty is compounded by strategic-level assessments in which concrete project variables (location, size, layout, employment numbers, etc.) are excluded in favour of understanding a relative geographic location's capacity to accommodate a given development. Unsurprisingly, uncertainty is further exacerbated when the scope of the assessment encompasses vast geographic regions of a country as socio-economically diverse as South Africa.
- This assessment was undertaken at a national scale (using national data to compile indices to enable comparison between different regions) and considers high-level impacts associated with freshwater and marine aquaculture development. By necessary implication, high-level impact evaluation cannot provide accurate information on economic and social impacts which are strongly related to unique local contextual variables. Conversely, unique contextual variables cannot be effectively scaled, standardised or otherwise codified for use in strategic-level assessments. It therefore follows that poorly-documented and poorly-understood economic and social impacts, which are disproportionately determined by local context, cannot be accurately accounted for in a strategic assessment.
- This assessment distinguishes, where necessary, between marine and freshwater aquaculture, but does not distinguish between the various production systems or species produced.
- Because of the complexity of the socio-economic environment and the heterogeneous setting of the system, depending on a proposed area, the relationships between the various impacts and associated factors will differ. It is therefore impossible to pinpoint localised socio-economic impacts for such a high level assessment.
- The scale of the assessment compels the researcher to depend, almost exclusively, on published secondary data. Since primary research (i.e. fieldwork) is simply not feasible when considering the vast tracts of land, numerous municipalities, and varying socio-economic contexts which forms the geographic baseline for the study areas under investigation. As such, the findings of this assessment need to differentiate between well and poorly documented impacts.
- The primary focus or end-point is the identification of management and mitigation measures including measures for the enhancement of opportunities. Assessment of impacts is therefore

limited to that which is required to understand impacts at a strategic level and identify such measures which may be developed further in an overall SEA.

- It is assumed that aquaculture will occur within the study areas for this assessment. Therefore, this socio-economic assessment does not assess the economic viability or technical feasibility of undertaking aquaculture within the study areas.

4 KEY SOCIAL AND ECONOMIC ATTRIBUTES OF THE STUDY AREAS

4.1 Social Vulnerability Index

Le Roux and Naudé (2014) created a Social Vulnerability Index to support national decision-makers in South Africa. The indicators that form part of the Social Vulnerability Index are detailed in Table 2. Since the Social Vulnerability Index comprises 14 indicators, it is the composite of these indicators that allocate a vulnerability value to an area and not one single factor. The profiling of vulnerable communities is seen as the first step to plan for resilient communities, i.e. determining how vulnerable is a community or group of people within a generic framework of multiple stressors. Social vulnerability can therefore be considered as the "*inability of people, settlements and societies to withstand or adapt to the impact of multiple stressors such as disruptive natural or manmade events*" (Le Roux and Naudé, 2014).

Table 2. Indicators that informed the Social Vulnerability Index (Le Roux and Naudé, 2014)

Nr.	Indicator	Nr.	Indicator
1	Average household size	8	Percentage of the population aged 25 with no education
2	Percentage of the population that is age dependent	9	Percentage of the population that is disabled
3	Percentage of the population that is unemployed	10	Percentage of households that are female headed
4	Percentage of the population living below the poverty line	11	Percentage of households using non-electric sources of energy for cooking
5	Percentage of the population living in rural areas	12	Percentage households without telephone lines
6	Percentage of dwellings that are shacks	13	Percentage of households without a car
7	Percentage of households without public water	14	Percentage of the population without South African citizenship

Figure 1 shows the social vulnerability map of South Africa overlain with the freshwater and marine aquaculture study areas considered as part of this chapter. In the case of aquaculture, especially if multiple large scale aquaculture projects are introduced into an area, there is a need to understand the social resilience of the community to adapt to this change and to identify suitable measures to manage the social and economic vulnerabilities present. This index also provides a mechanism to compare the vulnerability of the various study areas and associated risks or opportunities to each other (at the given scale of assessment). From this figure it can be seen that potentially, introducing a project into the Limpopo study area (more areas with high social vulnerability) will need more consideration in terms of the social vulnerability of the community but will also stand to benefit more from the opportunities offered by aquaculture, compared with the Western Cape study area, which predominately includes lower social vulnerability classes. In addition, each study area may have various social vulnerability classes within them, which makes each locality within a study area an unique unit. It is therefore not only the study area's location (inland or coastal) that will influence the risk or opportunities arising from aquaculture development but also the specific location of an aquaculture project within a study area.

Figure 1 includes an overview of the Social Vulnerablity Index for all the study areas. The Social Vulnerability Index per study area is included in **Appendix A** of this report.

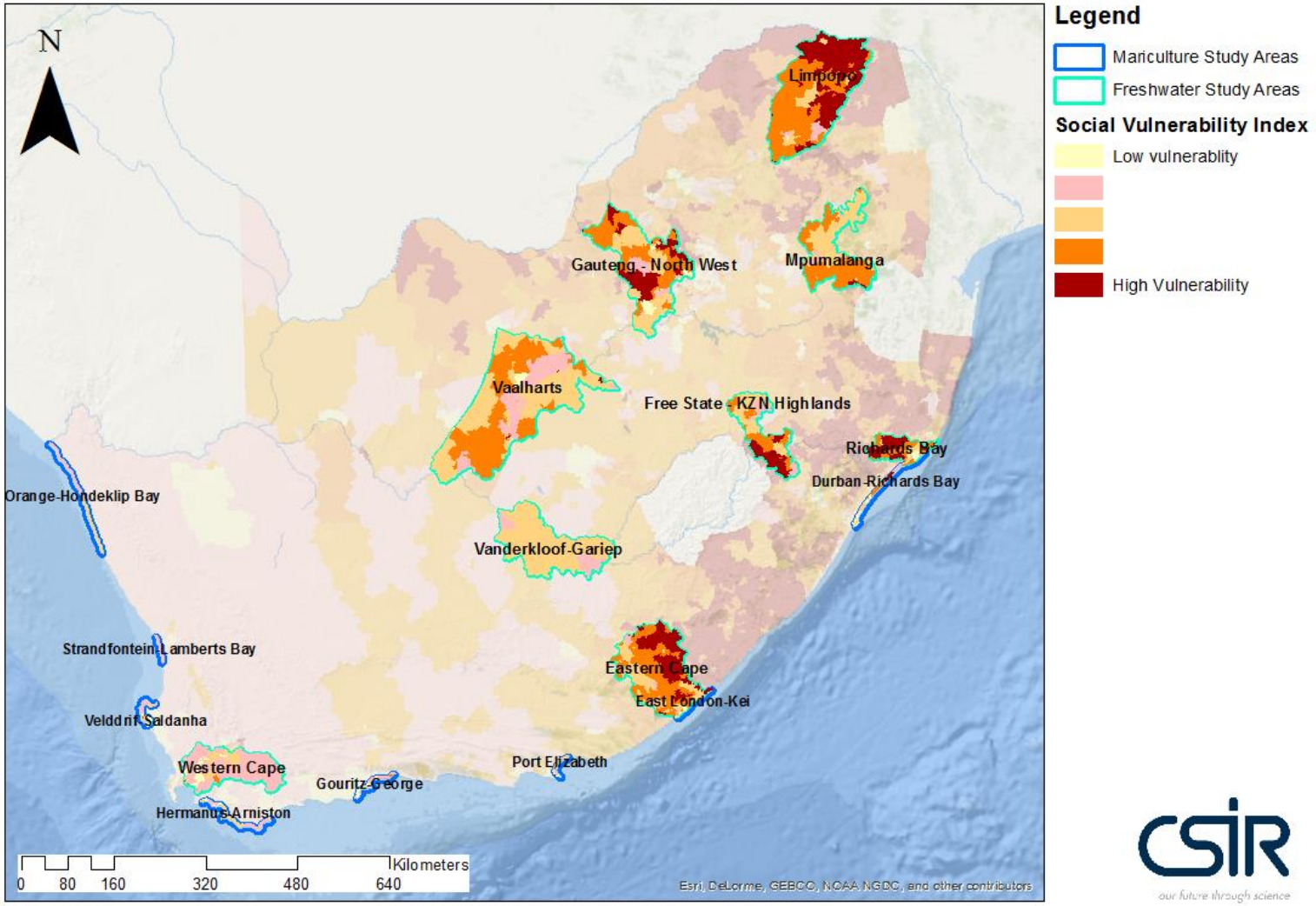

Figure 1. Social Vulnerability Index of South Africa, overlain with the freshwater and mariculture study areas (Le Roux and Naudé, 2014)

4.2 Socio-economic Intensity Index

Aquaculture will potentially provide economic incentives to the local, regional and national economy through market interactions, value chains and employment opportunities which will lead to increased spending in an area. To identify the economic opportunities associated with aquaculture, there needs to be an understanding of the *status quo* of the affected local municipalities' economic output (bearing in mind the scale at which this assessment is being undertaken).

Ngidi and van Huyssteen (2017) compiled a Socio-economic Intensity Index for municipalities in South Africa. A parameter that informed the index was the Gross Value Added (GVA) to determine the economic output of each municipality. The GVA used within the index was calculated based on the Real GVA at basic prices (in Rand millions) at 2010 prices to ensure temporal comparability and the weighted GVA growth between 2011 and 2016 of each municipality, compared with the national absolute growth of 7.8%. The latter was used to compare the growth of one municipality in relation to other municipalities as shown in Figure 2.

Most local municipalities within the study areas have a GVA growth that is on par with national growth. A limited number of local municipalities within the Vanderkloof-Gariep, Vaalharts and East London-Kei areas have a GVA growth that is either below the national growth or a GVA that is declining.

The GVA weighted growth of the local municipalities is included in **Appendix A** of this chapter. Figure 2 provides a general overview of the GVA growth associated with the study areas.

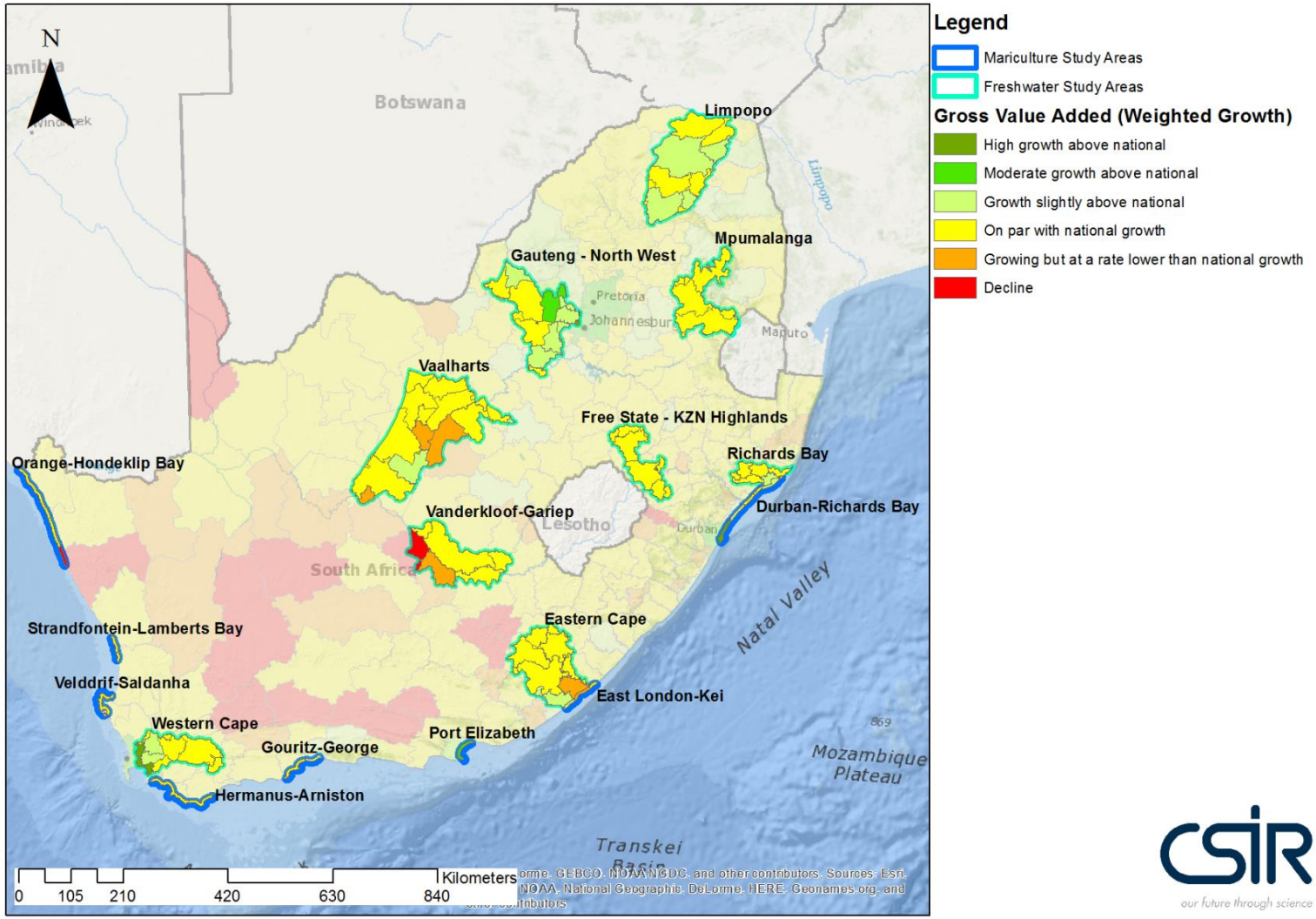

Figure 2. GVA weighted growth for the local municipalities located within the freshwater and mariculture study areas (Ngidi and van Huyssteen, 2017)

5 KEY POTENTIAL RISKS, OPPORTUNITIES AND MEASURES FOR RISK MITIGATION AND BENEFIT ENHANCEMENT

5.1 Impact 1 - Macro-economic opportunities

5.1.1 Contribution to the macro-economy by commercial aquaculture developments

5.1.1.1 Marine and freshwater aquaculture developments

The contribution of a sector to the macro-economy is captured within the Gross Domestic Product (GDP) and Gross Domestic Product per Region (GDPR). As highlighted in Cai *et al*. (2009), to understand the contribution by aquaculture to the GDP or GDPR, the various sectoral linkages must first be identified and understood. This includes the input-output, backward, forward, income and non-output linkages (Cai *et al*., 2009). The main reason for not fully accounting for, or acknowledging, the aquaculture sector's contribution to the GDP and GDPR is that all the linkages and contribution to the macro-economy are not captured within single sector (de Graaf & Garibaldi, 2014). The economic contribution of aquaculture, for instance, from fish processing and marketing are included in many GDP and GDPR estimates under "manufacturing" or "other sectors", while the primary production activity (i.e. fish processing) is captured under "agriculture, forestry and fisheries" sector (de Graaf & Garibaldi, 2014). In addition, aquaculture trading within the informal market is not captured within the GDP or GDPR. This, in turn, deters investment by funding and government agencies, since these agencies base their support on the a sector's contribution to the national economy (Cai *et al*., 2009).

Within the South African context, mariculture's contribution to the GDP was approximately 0,02 % in 2012 (DAFF, 2012) or, R 0.67 billion, while the Ocean's Economy Aquaculture focus area aims for a contribution over a five year period (2014-2019) of R 3 billion per annum to the GDP. In 2016, according to the Aquaculture Year Two Review (October 2014-October 2016), the Ocean's Economy aquaculture focus area has contributed 450 direct jobs, 2000 tonnes of fish and a projected increase of R 500 million per annum to the aquaculture sector through its 35 prioritised projects (DAFF, 2016).

On a regional level, the potential to contribute to the GDPR will most likely be more significant, compared with the overall percentage contribution of aquaculture to the GDP. The overall contribution of each province to aquaculture production is shown in Table 3. The Western Cape Province leads in aquaculture production in both the marine and freshwater sectors and accounted for 61 % of the tonnage produced and 83 % of the total value of the South African output in 2008 (Britz *et al*., 2009). In 2008, domestic sales of aquaculture products was 2711 tonnes with a total value of R 58.7 million and export sales were 940 tonnes with a total value of R 268.4 million (Britz *et al*., 2009). The high value of aquaculture product exported is attributed to the sale of abalone.

Table 3. Provincial profiles of the value (in ZAR million) of South Africa aquaculture production in 2008 (Britz *et al*., 2009)

Sub-sector	Eastern Cape	KwaZulu Natal	Gauteng	Limpopo	Mpumalanga	North West	Northern Cape	Western Cape
Marine Species	24.5	0.1	0.2	0.0	0.0	0.0	4.4	256.8
Freshwater Species	1.7	5.6	6.4	0.2	11.2	4.6	0.0	16.7
Total	**24.2**	**5.7**	**7.6**	**0.2**	**11.2**	**4.6**	**4.4**	**272.5**

Compared to commercial aquaculture, subsistence aquaculture may also include the selling of fish but this exchange is considered to be to diversify crop production and provide an alternative source of income. Rouhani and Britz (2004) noted that aquaculture projects aimed towards a food security objective were unsuccessful or were not functioning properly due to various reasons including lack of education, little personal capital and low value of fish produced, while commercially orientated aquaculture projects, albeit small-scale, operated at 80% of their production capacity (Rouhani & Britz, 2004). This is supported by Cai *et al*. (2009), where it is noted that a possible solution for the short lived performance and success of aquaculture development could be that aquaculture is not promoted as a business that could lead to measurable and substantial benefits to the aquaculture sector.

5.1.1.2 Management measures to stimulate commercial aquaculture growth and enhance benefits

According to Cai *et al*. (2009), qualitative assessments are not always suitable for funding and government agencies as an acceptable way to measure the potential of aquaculture to contribute to the national economy. Therefore estimates based on a quantitative appraisal must be undertaken to provide support to aquaculture and the potential economic incentives.

Kassam and Dorward (2017) highlight that the extent to which aquaculture growth will stimulate growth in other sectors will be guided by a broader value chain perspective. This value chain perspective is important to ensure that complementary investments are made along the value chain to stimulate and support growth within the aquaculture sector. In addition to these complementary investments, policies should be developed to enable economic growth which includes openness to trade, attracting foreign investment and domestic private sector investment (Ridler and Hishamunda, 2001). It should however be noted that certain parameters in the success of a commercial aquaculture development is outside the government's control. These "no-policy variables" include cultural factors, the market and the appetite of developers to undertake risks (Hishamunda and Ridler, 2012).

Rouhani and Britz (2004) noted that when considering funding for aquaculture projects, it would be prudent to first establish the viability of the aquaculture project by undertaking a feasibility study. This would determine the viability of the project prior to initiating the development process.

Britz *et al*. (1999) found that for the realisation of the socio-economic benefits local level interventions in the form of strategic investment, technology transfer and appropriate education and training are required. In addition, where production occurs, further processing and associated activities should occur within the town or area where the aquaculture development occurs. Social responsibility programmes run by aquaculture industries can also promote skills development and improve livelihoods in the local communities.

5.2 Impact 2 - Rural Development and Livelihoods

Poverty greatly increases vulnerability and any loss of assets held by the poor would serve to reduce their coping capacity. Statistics in South Africa show that in 2015, half of the population is poor (living below the poverty line of R 992 per person per month) (StatsSA, 2017). Poverty levels are disproportionally high in rural areas, among black African females, and among people living in the Eastern Cape and Limpopo (StatsSA, 2017). As shown in Figure 3, there is a significant difference in poverty levels between rural and urban settlements, with 81,3 % of the rural population living in poverty compared to 40,6 % of the urban population.

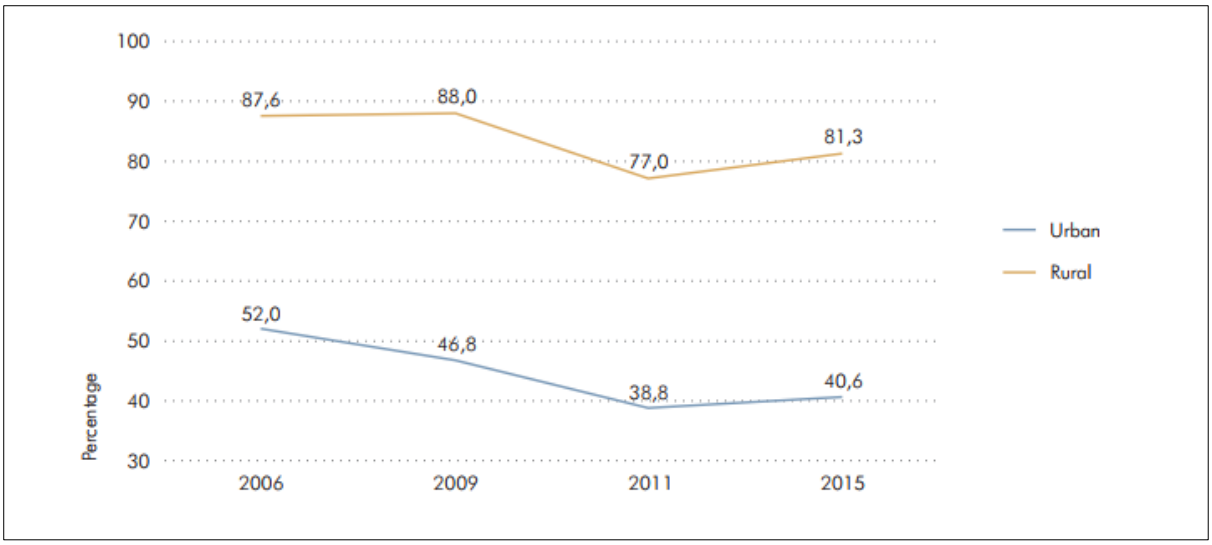

Figure 3. Poverty headcount by settlement type (2006, 2009, 2011 and 2015) (StatsSA, 2017)

Rural development can stimulate poverty alleviation, which in turn can contribute to food security. Although several attempts have been made internationally to support rural development through aquaculture development, limited evidence is available to show that this is truly achievable. One of the main factors that can be attributed to this is the lack of understanding of the socio-economic context in which the aquaculture development is proposed (Stonich *et al*., 1997; Harrison, 1996; Philcox *et al*., 2010).

Livelihoods can be defined as the assets held by rural people (e.g. knowledge, stock, land, food, savings and social networks) and how such assets influence the ability of families to cope with shock and surprise (Allison & Ellis, 2001). Predictably, the relative vulnerability of families is a vital precondition in the evaluation their respective ability to deal with adversity.

Several opportunities exist in introducing commercial aquaculture into rural areas. These opportunities include employment opportunities, food security and supporting vulnerable fishing communities and subsistence aquaculture developments. Conversely, the introduction of commercial aquaculture into rural areas also come with a degree of risk of unrealistic expectations regarding employment opportunities. This risk is discussed and management measures included within the section 5.2.1 below but is not explicitly assessed in the assessment included in Section 6.

5.2.1 Employment opportunities

5.2.1.1 Creation of employment opportunities

On an international level, the contribution to employment opportunities by the aquaculture sector has been considered within the European Union (EU) Commission Fisheries report on Regional Socio-economic studies on Employment and the Level of Dependency on Fishing. According to this report published in 2000, it is estimated that various direct (producing the fish) and indirect (fish processing) employment opportunities are created through aquaculture. While direct jobs are mostly male dominated, women play are role in fish processing (Goulding *et al*., 2000). In addition, the report showed that in areas where there are limited employment opportunities, aquaculture can play a role in reversing rural depopulation and improvement in the rural residents' lives. Through the creation of employment opportunities in rural areas, it may contribute to intra-society equity (Cai *et al*., 2009). Burbridge *et al*. (2001) pointed out that where there are policies in place that promote sustainable development by using local and indigenous resources, it can contribute to the economic and social development in rural communities through employment opportunities, reducing emigration and facilitating infrastructure development.

As part of the project information received from the marine and freshwater aquaculture industry, the average production capacity of the system, the approximate employment numbers during the construction and operation of a production system, the technical capability of the staff (skilled versus unskilled) and the gender (male versus female) that make up the workforce of a typical commercial marine or freshwater aquaculture development for specific species were provided. These numbers do not take into account the multiplier effect of indirect jobs that may be created. A summary of the information received is provided in Table 4. Based on the table, the average ratio of skilled versus unskilled workforce is 1: 2.8, which does show the opportunity for unskilled workers to be employed for aquaculture projects. On average, the male versus female ratio of nearly 3:1, shows that more men are used for the operation of an aquaculture project, compared to women. The anticipated market for the produced fish is national, with exports anticipated of abalone and dusky kob.

A high variation in less labour per tonne of output can be expected since the amount of employment opportunities to be created are dependent on various factors including the type of production system, species farmed, skills required and the anticipated output of the operation. It is generally assumed that the more technologically advanced a system is, the less labour per tonne of output would be required.

Table 4. Summary of the socio-economic information of commercial freshwater and marine aquaculture (technical capability, gender ratio and expected market potential)

Production System	Category	Aquaculture environment	Species	Technical capability of staff (numbers)		Gender (numbers)		Expected market potential (local, national, export)
				skilled	unskilled	male	female	
Cage Culture	Marine	Offshore	Atlantic Salmon	4	10	11	3	Local and National
			Dusky Kob	3	5	8	1	National and Export
		Near-shore	Atlantic Salmon	3	9	9	2	Local and National
			Dusky Kob	1	3	3	1	National and Export
Pond	Marine and Freshwater	Land-based	Dusky Kob	6	9	11	4	National and Export
			Tilapia	5	9	11	2	National
			Trout	1	7	5	3	National
			Catfish	1	5	5	2	National
			Marron	2	7	4	4	National
Longlines	Marine and Freshwater	Near-shore	Oysters and Mussels	4	16	16	4	National
Rafts	Marine and Freshwater	Near-shore	Oysters and Mussels	4	16	16	4	National
Racks	Marine	Near-shore	Oysters	3	16	16	2	National
Flow through	Marine and Freshwater	Land-based	Abalone	6	11	8	2	Export
			Tilapia	1	7	5	3	Local and National
Recirculation	Marine and Freshwater	Land-based	Tilapia	2	4	4	2	Local and National
			Catfish	6	8	10	4	Local and National
			Trout	2	4	3	3	National
			Oysters	2	4	3	3	National
			Mussels	1	6	4	3	Local
			Dusky Kob	2	4	4	2	National and Export
Cage culture	Freshwater	Instream (dams and ponds)	Tilapia	2	5	6	2	National
			Trout	2	6	7	1	National
Flow through	Freshwater	Land-based	Trout	3	8	7	3	National
			Catfish	1	5	5	1	National
			Tilapia	1	6	4	3	National

5.2.1.2 Unrealistic expectation of employment opportunities

Kassam and Dorward (2017) highlighted that while theory supports the potential for aquaculture to provide income through employment opportunities and food security, limited empirical evidence is available in a sub-Saharan Africa context to support this. It is therefore likely that there would potentially be an unrealistic expectation of commercial aquaculture's ability to create a significant amount of direct employment opportunities. As noted above, direct employment uptake by commercial aquaculture development is dependant on several factors including the type of production system, species farmed, skills required and the anticipated output of the operation. To ensure that these expectations do not lead to further conflict, it is prudent to manage the risks that would also come with employment expectations.

5.2.1.3 Opportunities to increase employment opportunities from aquaculture development

For aquaculture to support rural employment opportunities, the local socio-economic context should be understood (understand factors such as ability and availability of the labour market) as well as determining the willingness and capability of individuals within the study areas to consider a livelihood through aquaculture. Understanding the constraints placed on aquaculture development within a specific area can improve the acceptance of aquaculture development and distribution of indirect benefits from the development (Slater *et al*., 2013).

A skills database within the region of the aquaculture project can be compiled. This will ensure that the transferability of human skills and training needs are taken into account when employing residents from the region (Britz *et al*., 1999).

With any new development that may be introduced into an area, a community's expectation regarding employment opportunities should be managed through social risk communication especially where there is an expectation of high employment opportunities. The aim of the social risk communication method is to ensure that the communicator, in this case the aquaculture developer or government, are open about risks, in this case, specifically regarding employment opportunities. This will manage expectations and reduce social conflict (Bueno, 2008).

5.2.2 Provision of food security

5.2.2.1 Provision of food security via aquaculture developments

On an international level, aquaculture is providing food security by contributing to fulfilling the global demand for fish. As noted previously in the report, the global demand for fish has steadily increased in recent years while overfishing is steadily depleting the wild fish stocks within the world's oceans (Allsopp *et al*., 2008). Within the South African context, 11 % of the commercial line fish is overexploited, while populations of 68 % of some fish species have collapsed[1]. Therefore, aquaculture contributes to addressing the supply of fish and by doing so, reduces the pressure on wild fish stocks.

Currently in South Africa, no form of aquaculture (subsistence or commercial) plays a major role in the provision of food security since South Africa is not a predominantly fish-eating country. In addition, due to the low aquaculture production output in South Africa, the contribution to national food security is negligible.

The FAO defines food security as "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2003). Based on this definition, for a person to be food secure he must have access to money to be able to purchase food. As highlighted previously, since more than half of the South African population lives below the poverty line, the ability to purchase food is a major obstacle in achieving food security in South Africa. Commercial aquaculture developments can provide food security through employment opportunities which contributes to a household's purchasing power. The contribution to food security via commercial aquaculture may therefore be in the form of direct

[1] Available at: http://awsassets.wwf.org.za/downloads/wwf_a4_fish_facts_report_lr.pdf

contributions, such as employment opportunities, by filling the supply gap or via the other sectors that contribute to the aquaculture sector. There are therefore potentially upstream and downstream links, where upstream links can be the supply of inputs to the aquaculture sector and downstream links can be the harvesting of species produced (Béné, 2006).

5.2.2.2 Opportunities to increase food security via commercial aquaculture developments

Poverty, linked to food insecurity, is not only connected to weak political structures but also to poor economic performance. Therefore, appropriate policies to promote food security through aquaculture are vital (Halwart *et al*., 2003). Two such policy frameworks that has been developed in South Africa are the National Aquaculture Strategic Framework which aims to create "*a pragmatic and supportive pro-aquaculture enabling regulatory and operational environment to ensure food security and promote food sovereignty*"; and the National Aquaculture Policy Framework which provides the government with a guide to promoting, inter alia, food security (Urban-Econ Development Economists, 2017).

As noted in Primavera (2006), in order for aquaculture to function at the optimal level in terms of poverty alleviation and food security, there must be a shift away from a sectoral approach to a holistic approach whereby local communities and other relevant stakeholders are enabled to participate in the aquaculture development (Primavera, 2006).

5.2.3 Contribution to the livelihoods of fishing communities

5.2.3.1 Opportunity to contribute to the livelihoods of fishing communities

According to Béné (2003), poverty is rife within small-scale fishery communities in Africa and Asia. Extreme poverty in this sector is attributed to, amongst other factors, the role of fishing as a "last resort" for the poor, the open access nature of fishing, and the lack of attractive alternative sources of income (Béné, 2003; FAO, 2000b; Cunningham, 1993). The lack of viable alternatives to the small-scale fishing industry, especially in rural areas, serves to lock families into a cycle of poverty. As a result, the composition of small scale fishing communities is often made-up of a disproportionate number of poor families. In addition, the open access nature of this resource also results in greater competition and overexploitation of CPR (Bailey & Jentoft, 1990; FAO, 2000b). The associated resource degradation can therefore either be a consequence or the cause of poverty (Béné & Friend, 2011; Allison, Horemans, & Béné, 2006).

5.2.3.1.1 Freshwater aquaculture developments

Historically, South Africa possessed an inland fishery policy with environmental, social and economic objectives that supported inland fishery development but over time a policy gap has emerged which had led to a missed opportunity for livelihood development through inland fisheries (Britz, 2015). According to Tapela *et al*. (2015), rural small-scale fishing supporting livelihoods is widespread within South Africa, with 77 % of the 64 dams surveyed supporting a form of small-scale fishing. However, due to a lack of governance and allocated rights, their access to the resource is diminished by other users (Tapela, 2015). Due to the lack of policies and support for inland fisheries, introducing commercial freshwater aquaculture developments in these areas can further increase the vulnerability of these communities (discussed within Section 5.3 of this assessment). However, a key objective of freshwater aquaculture and inland fishery development is to provide a safety net for the vulnerable households and provide a buffer to the unemployed (Tapela *et al*., 2015), which commercial freshwater aquaculture development can support, if suitably introduced into the area.

5.2.3.1.2 Marine aquaculture developments

South African coastal fishing communities are vulnerable to external shocks. Accordingly, any negative impact on the asset-base of such communities is anticipated to have socio-economic consequences; with vulnerable groups (i.e. women and children) being disproportionately impacted.

As outlined by Little *et al*. (2012), commercial aquaculture has had transformational effects on communities in supporting the escape from poverty, which shows that a commercial aquaculture

development does not necessarily threaten efforts to reduce poverty and may contribute in supporting these upliftment efforts. In the Socio-economic Impact Assessment undertaken for the proposed Algoa Bay ADZ, it was highlighted that one of the impacts could be to the local fishing industry through competition in the local market (Bloom, 2013). The feedback from local fishing companies and fishermen was that the supply from aquaculture will contribute to addressing the demand for fish. In all likelihood, the additional supply of fish can create opportunities to in the form of new and/or improved markets which can also benefit the local fishing industry (Bloom, 2013).

Commercial aquaculture may be able to contribute to upliftment within fishing communities but it is prudent to note, as highlighted in Heck *et al*. (2007) and Allison *et al*. (2013), that fishing communities tend to be poor for reasons that go beyond the fisheries sector and addressing the vulnerability of these communities will require a collective effort from various stakeholders. Therefore, an aquaculture development cannot influence, either positively or negatively, the vulnerability of these communities on an individual basis and a collective effort from various stakeholders must be made to address the vulnerability issue. There needs to be an understanding of the relationship between the communities, the guiding legislation or policies and whether it is 'fit for purpose', the type of aquaculture development and other key characteristics of the aquaculture value chain to address this issue.

5.2.3.2 Options for enhancing the contribution of commercial aquaculture to contribute to the livelihoods of fishing communities

On a policy and planning level, the socio-economic drivers that influence human behaviour and vulnerability must be considered in a context-specific setting. To achieve this, all affected stakeholders must be part of the decision-making and policy development process (Krause *et al*., 2015).

Small-scale fishing rights and practices must be recognised in governance arrangements (Hara, 2015). The development of a proposed aquaculture facility must be communicated to affected communities at the earliest possible opportunity. This process would normally be required when undertaking an EIA. In addition to the coordination and cohesion of the community itself, empowerment of the local community is closely linked to a meaningful stakeholder engagement process. In this regard, stakeholder engagement should enable the community to contribute to the decision-making process and to understand the ultimate decisions reached. Naturally, such involvement of communities in the decision-making process should not be construed as limiting, alienating or suspending a developer's statutory and common law rights in any way.

A socio-economic analysis of each area must be undertaken in order to understand the context in which the proposed aquaculture projects will be undertaken. If it is anticipated that an aquaculture project can contribute to livelihoods (either through income diversification or other interventions such as the provision of food security), it first must be understood why the area has a high level of poverty or vulnerability. There are likely to be several causes of poverty in communities, including the high dependence of the poor on the a specific sector, such as fisheries, or alternatively, the lack of viable employment opportunities, limited skills set, or adaptive capacity to changing circumstances such as reduced fish stocks or other external shocks. It might also be that these two factors (i.e. dependence on a specific sector and lack of alternative employment) function in tandem to cause poverty.

5.2.4 Opportunity for stimulating and diversifying income of subsistence aquaculture through the support of commercial aquaculture

In society, income diversification is the norm since very few people within society obtain all their income from a single source. The key reason for income diversification would be to reduce the risk of only depending on a single income source (Barrett *et al*., 2001).

Commercial aquaculture may contribute to diversifying rural income options provided that the limitations for participation in commercial aquaculture are overcome (FAO Inland Water Resources and Aquaculture Service, 2003). Furthermore, it also provides an opportunity for the extension of services and training to local communities by the private sector (Hishamunda & Ridler, 2012). As noted in Mandima (2005), rural

fish farmers in Zimbabwe indicated that their knowledge of aquaculture was obtained while working on commercial aquaculture developments, this shows the potential for commercial aquaculture to support subsistence aquaculture through gaining experience on how to manage such a development.

The South African government has created structures to support and incentivise private sector partnerships with communities through the National Empowerment Fund and the Comprehensive Agricultural Support Programme (Hara, 2017) and the Aquaculture Development and Enhancement Programme (ADEP) managed by the Department of Trade and Industry. According to Wesgro's Fish and Aquaculture Fact Sheet[2], ADEP offers a cost sharing grant up to a maximum of R 40 million for operational equipment and leasehold improvements. An example of how commercial aquaculture and government funding can support small-scale aquaculture to be commercially viable is the Imbaza Mussels operation in Saldanha Bay, Western Cape. Imbaza Mussels was established in 2012 and supplies roughly 50 % of its produce to local markets. The company was established after Blue Bay Mussels bought Sea Harvest's mussel farming operation. Each employee then operated and farmed individually. Following this, six individuals formed Imbaza Mussels. Imbaza Mussels has a 67 % black ownership shareholding, 17 staff members and created 100 jobs at a local processing facility (Ferreira, 2016). Imbaza Mussels is supported and mentored by Blue Bay Mussels (a larger commercial aquaculture development) through the transfer of skills and knowledge and marketing partnerships (Hara, 2017).

Both marine and freshwater aquaculture developments have the potential to support income diversification and reduce the vulnerability of communities by contributing to their resilience to changing conditions, such as loss of an income source and depletion of natural fish stocks. Government intervention will be required to provide investment opportunities to aquaculture developments since the communities may not have suitable funds to establish these aquaculture developments.

5.2.4.1 Options for enhancing the benefit of income diversification from subsistence and commercial aquaculture developments

The role of government (national, provincial and local) is important in establishing the necessary policies, initiatives and plans to support subsistence aquaculture and efforts to integrate existing aquaculture practices into commercial aquaculture developments, potentially via subsidies. In addition, funding initiatives can be spearheaded by government in collaboration with NGOs/research institutions (FAO Inland Water Resources and Aquaculture Service, 2003). However, as highlighted in Hara (2017), a key lesson learnt is that the funding of projects provided by government should be structured in a way that builds independence from the funding. This means that the planning associated with the funding initiative must focused on how to build financial independence and commercial viability instead of social projects that continuously require financial support.

Subsistence aquaculture can also be supported through the involvement of the private sector via Community Public Private Partnerships (CPPPs). The CPPP model combines assets unique to each sector to ensure the viability of a project (Rouhani & Britz, 2004).

5.3 Impact 3 - User conflict

5.3.1 Risk of displacement of existing users by commercial aquaculture development within the inland surface water resources

Dams (reservoirs and natural) will most likely only be utilised for instream cage farming and due to the space (width and depth) requirements associated with this, only large dams will be suitable. Other production systems, such as pond and flow through systems are land based and the potential impacts associated with these systems are considered in the Visual Impact Assessment (as detailed in Section 2.2).

[2] Available at: http://www.wesgro.co.za/pdf_repository/Fish%20&%20Aquaculture%20Fact%20Sheet.pdf

In a study commissioned by the Water Research Commission, 64 dams in South Africa were surveyed to determine the use of the dams, specifically noting the types of fishing activity present (Tapela, 2015). Subsistence fishing took place on 77 %, artisanal activities on 40 % and recreational activities on 69 % of the 64 dams surveyed. User group conflict was reported for 18 % of the dams (Tapela, 2015).

Table 5 details the dams that fall within the SEA study areas that were surveyed, their location, uses and whether user conflict was present. Of the 64 dams surveyed, 11 fall within the study areas and only 2 were noted to have user conflict, namely the Roodekopjes and Driekoppies dams. For the Roodekopjes dam, user conflict was noted between the recreational anglers and the subsistence fishers, whereby the recreational anglers had a perceived right to use of the dam since they own the properties around it (Tapela, 2015). User conflict noted at the Driekoppies Dam was attributed to certain users overharvesting fish and/or utilising illegal harvesting methods (Tapela, 2015).

Table 5. Dams present within the study area with available user information and indication of whether a RMP is available or in development for the dams

Nr	Dam Name	Location	Uses				Resource Management Plan (RMP)
			Subsistence	Artisanal	Recreational	User conflict	
1	Albasini	Limpopo	✓		✓		Completed en routed for approval
2	Chuniespoort	Limpopo	✓		✓		No
3	Fundudzi	Limpopo	✓				No
4	Middle Letaba	Limpopo	✓	✓	✓		Final RMP expected 2nd quarter of 2017
5	Nzhelele	Limpopo	✓				No
6	Turfloop	Limpopo			✓		No
7	Nooitgedacht13	Northern Cape	✓		✓		No
8	Vaalharts	North West	✓	✓	✓		No
9	Roodekopjes	North West	✓	✓	✓	✓	Final RMP expected 2nd quarter of 2017
10	Sandile	Eastern Cape	✓		✓		No
11	Driekoppies	Mpumalanga	✓	✓	✓	✓	Final RMP expected in 3rd quarter of 2017

Many state-owned dams have Resource Management Plans (RMPs). A RMP is a plan implemented by DWS and aims to guide the utilisation, access and development of the dams. Figure 4 shows the Theewaterskloof RMP and the water zones that determine the different allowable activities within each zone. These zones guide what uses or activities are allowable in each zone. This can potentially manage user displacement and provide authorities with an enforcement mechanism, should users not adhere to the zoning restrictions. The availability of RMPs for all the dams falling inside the freshwater study areas are shown in Table 6.

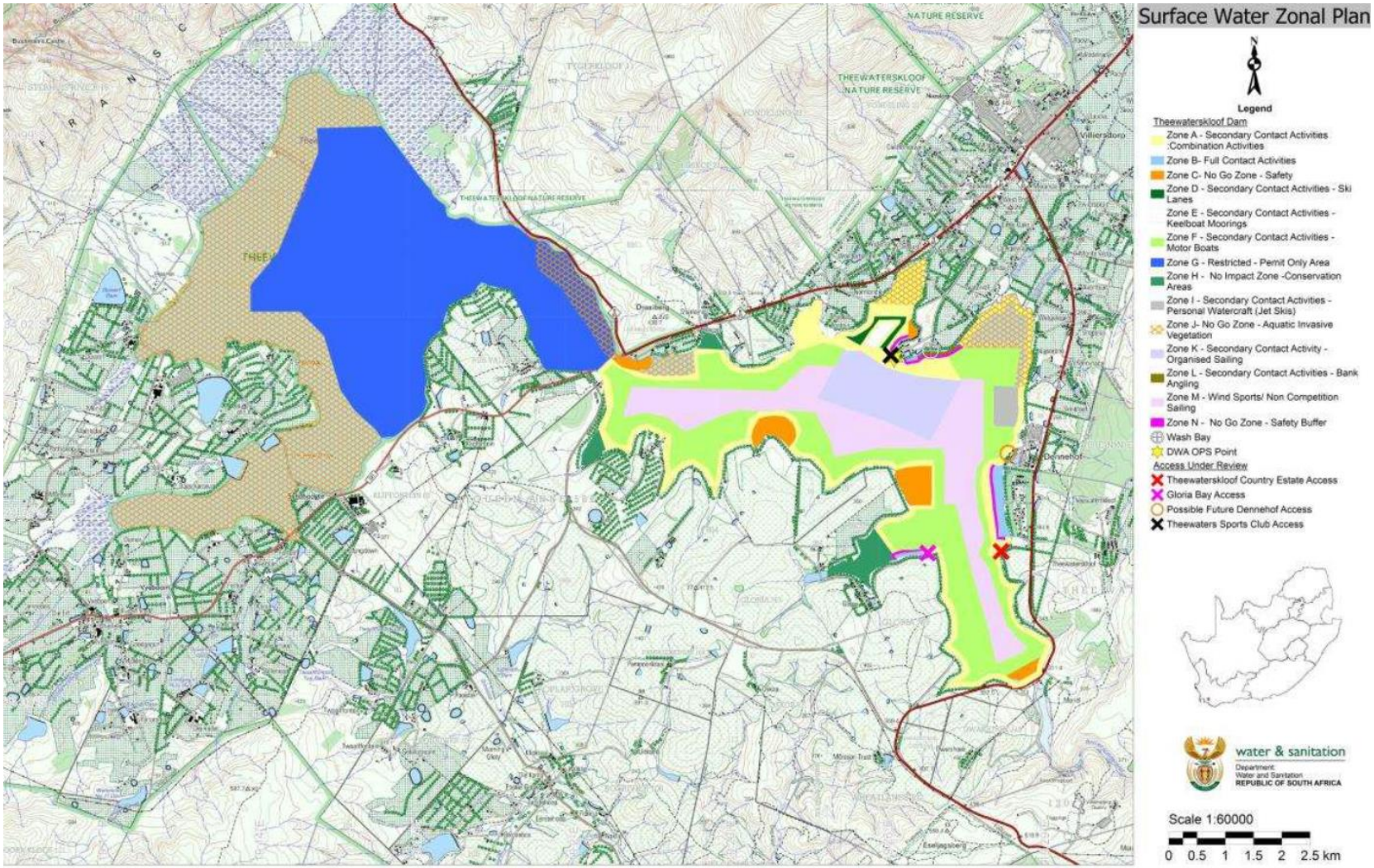

Figure 4. Theewaterskloof RMP (DWS, 2015).

By introducing commercial aquaculture into dams where no RMP is present, user conflict through displacement can occur or be exacerbated and could lead to negative perceptions about aquaculture. For both the Roodekopjes and Driekoppies dams RMPs were to be finalised by the end of 2017. This should assist in managing user conflict.

Table 6. Status of the RMPs of the dams present within the freshwater study areas

Nr	NAME	Province	RMP
1	Bonkolo	Eastern Cape	Not available
2	Bridle Drift	Eastern Cape	Not available
3	Cata	Eastern Cape	Not available
4	Gubu	Eastern Cape	RMP development on hold
5	Laing	Eastern Cape	Not available
6	Lubisi	Eastern Cape	Not available
7	Maden	Eastern Cape	RMP development in progress
8	Nahoon	Eastern Cape	Available
9	Ncora	Eastern Cape	Not available
10	Rooikrantz	Eastern Cape	Not available
11	Sandile	Eastern Cape	Not available
12	Toleni	Eastern Cape	Not available
13	Tsojana	Eastern Cape	Not available
14	Waterdown	Eastern Cape	Not available
15	Wriggleswade	Eastern Cape	Available
16	Xonxa	Eastern Cape	Not available
17	Bellary825	Free State	Not available
18	Bethulie	Free State	Not available
19	Driekloof	Free State	Not available
20	Gariep	Free State	Available
21	Klipfontein010	Free State	RMP development in progress
22	Sterkfontein	Free State	RMP development in progress
23	Klipdrif	Gauteng	Not available
24	Driel Barrage	KwaZulu Natal	Not available
25	Goedertrouw	KwaZulu Natal	RMP development on hold
26	Jagers Rust	KwaZulu Natal	Not available
27	Kilburn	KwaZulu Natal	Not available
28	Lake Cubhu	KwaZulu Natal	Not available
29	Lake Msingazi	KwaZulu Natal	Not available
30	Mhlatuze Lagoon	KwaZulu Natal	Not available
31	Nhlabane	KwaZulu Natal	Not available
32	Nsezi	KwaZulu Natal	Not available
33	Richards Bay	KwaZulu Natal	Not available
34	Spioenkop	KwaZulu Natal	RMP development in progress
35	Wagendrift	KwaZulu Natal	RMP development in progress
36	Woodstock	KwaZulu Natal	RMP development on hold
37	Albasini	Limpopo	Available
38	Chuniespoort	Limpopo	Not available
39	Dr Neethling	Limpopo	Not available
40	Ebenezer	Limpopo	Available
41	Fundudzi	Limpopo	Not available
42	Hans Merensky	Limpopo	Not available
43	Hout River	Limpopo	Not available
44	Lornadawn	Limpopo	Not available
45	Magoebaskloof	Limpopo	Not available
46	Middle Letaba	Limpopo	Not available
47	Mutshedzi	Limpopo	Not available
48	Nkumpi1	Limpopo	Not available
49	Nkumpi2	Limpopo	Not available
50	Nwanedi	Limpopo	Not available
51	Nzhelele	Limpopo	Not available
52	Nzhelele	Limpopo	Not available
53	Tonteldoos	Limpopo	Not available

Nr	NAME	Province	RMP
54	Turfloop	Limpopo	Not available
55	Tzaneen	Limpopo	Available
56	Vlugkraal	Limpopo	Not available
57	Vondo	Limpopo	Not available
58	Buffelskloof	Mpumalanga	Not available
59	Grootrietvley210JS	Mpumalanga	Not available
60	Kwena	Mpumalanga	Available
61	Nooitgedacht	Mpumalanga	Available
62	Ohrigstad	Mpumalanga	RMP development in progress
63	Vygeboom	Mpumalanga	Available
64	Bloemhof	North West	RMP development in progress
65	Boskop	North West	Available
66	Bospoort	North West	RMP development in progress
67	Buffelspoort	North West	Available
68	Klerkskraal	North West	Not available
69	Koster	North West	RMP development in progress
70	Kromellenboog	North West	Not available
71	Kromspruit019JP	North West	Not available
72	Lindleys Poort	North West	Not available
73	Marico-Bosveld	North West	Not available
74	Modder	North West	RMP development in progress
75	Olifantsnek	North West	Not available
76	Potchefstroom	North West	Not available
77	Rietspruit	North West	Not available
78	Roodekopjes	North West	RMP development in progress
79	Schweitzer Reneke	North West	Not available
80	Spitskop	North West	Not available
81	Swartruggens	North West	Not available
82	Taung	North West	Not available
83	Uitkyk22JP	North West	Not available
84	Vaalharts	North West	Not available
85	Douglas	Northern Cape	Not available
86	Nooitgedacht13	Northern Cape	Not available
87	Vanderkloof	Northern Cape	Available
88	Applethwaite	Western Cape	Not available
89	Berg River	Western Cape	Available
90	Brandvlei	Western Cape	Available
91	Eikenhof	Western Cape	Not available
92	Elandskloof	Western Cape	Not available
93	Keerom	Western Cape	Not available
94	Kleinplaas	Western Cape	Not available
95	Klipberg	Western Cape	Not available
96	Kwaggaskloof	Western Cape	Not available
97	Moordkuil	Western Cape	Not available
98	Nuweberg	Western Cape	Not available
99	Paardevlei	Western Cape	Not available
100	Pietersfontein	Western Cape	Not available
101	Poortjieskloof	Western Cape	Not available
102	Steenbras (Lower)	Western Cape	Not available
103	Steenbras (Upper)	Western Cape	Not available
104	Stettynskloof	Western Cape	Not available
105	Theewaterskloof	Western Cape	Available
106	Wemmershoek	Western Cape	Not available
107	Zwiegelaars	Western Cape	Not available

5.3.2 Options for managing the conflict potentially arising due to user displacement

User conflict can be managed through a dam's RMP. All aquaculture development within dams should be guided by whether it is aligned with the dam's RMP. Provisions should be included in the RMPs which allow for the management of user conflict through community forums and proper governance.

Other key management tools available in South Africa and supported by international best practice are EIAs and other spatial tools to reduce the conflict between different CPR users. Within the framework of these tools, stakeholder engagement will also be undertaken which would further support sustainable

development. The potential of aquaculture development should also be incorporated into local planning tools such as the Integrated Development Plan and Spatial Development Plan developed every 5 years. This would ensure the alignment with local planning initiatives and provide the necessary support in terms of budget allocations, infrastructure development and reduce the risk of conflict with other users.

5.4 Impact 4 - Human health

5.4.1 Risks potentially posed to human health by aquaculture

As noted in Section 2.2 human health impacts from aquaculture have two pathways: recreational and consumption. Recreational refers to the use of a Common-pool Resource (CPR) for swimming, water skiing etc. that has a reduced water quality due to aquaculture practises and consumption relates to the eating of fish contaminated by, for instance, by harmful algal blooms or by drinking or using water with a reduced quality. This section focusses on the latter. The type of production system used, species farmed, the intensity of the aquaculture, and where it is placed will affect the likelihood of adverse health effects since the contamination levels will vary. For instance, the risk of pollution to water bodies due to the discharge of organic wastes is more likely to occur in land-based aquaculture facilities.

Human health impacts can occur from microbial and chemical contamination or nutrient enrichment of the water environment as a result of aquaculture practices. Among the microalgal species, about 300 are involved in harmful events and more than 100 produce toxins that can cause adverse health effects or death in humans and animals. These toxins have been classified based on their health effects and symptoms produced, namely paralytic shellfish poisoning, amnesic shellfish poisoning, diarrheic shellfish poisoning, neurotoxic shellfish poisoning, and ciguatera fish poisoning (Poletti *et al*., 2003).

Chemicals used in aquaculture, such as therapeutic chemicals for cultured stock and antifouling treatments for infrastructure, have the potential to pollute both marine and freshwater environments that may in turn have indirect, downstream negative impacts on food chains and human health (Pillay, 2004). Chemical contamination may occur through the overuse and misuse of chemicals in the aquaculture operations. According to the World Health Organisation (WHO) Expert Working Group on Antimicrobial Agents (2006), no case of adverse health effects resulting from the consumption of aquaculture products contaminated with antimicrobial residues has ever been reported and that the control of antibiotic use is vital to manage antimicrobial resistance.

Within South Africa, DAFF is responsible for aquaculture health management. The Directorate: Sustainable Aquaculture Management is responsible for safety and aquatic animal health The Directorate's functions include the development and implementation of food safety programmes for aquacultured fish, monitoring of phytoplankton, the implementation of contingency measures where a cultured product posed a risk to human health and the undertaking of sanitary surveys of new farms (DAFF, 2018).

The South African Molluscan Shellfish Monitoring and Control Programme manages the food safety risks associated with the production of molluscan shellfish and works closely with the Fisheries Compliance Office of DAFF, South African molluscan shellfish farmers, laboratories, the National Regulator for Compulsory Specification, the Department of Health and local municipalities. The Directorate undertakes regular monitoring of the farms. When any concentrations are above the regulatory limits, a farm is closed until further testing can be completed. If the farms tests positive again, then the farm is temporarily closed and only re-opened when the exceeded concentrations are below the applicable limits.

5.4.2 Options for managing the risk of human health impacts due to aquaculture

The DAFF permit conditions and the Shellfish and Fish monitoring control programmes provide manuals for South African operators which provide the necessary guarantees to foreign buyers and governments as well as to local consumers that the risk of disease and poisoning through consuming molluscan shellfish is adequately managed and minimised.

Frameworks, Plans and Monitoring and Control programmes include[3]:

- National Aquatic Animal Health and Welfare Plan for South Africa.
- National Strategic Framework for Aquatic Animal Health.
- Standard Operating Procedure (SOP) Classification of farms.
- SOP Closing and reopening of fish farms.
- SOP Movement document books.
- SOP On-farm phytoplankton monitoring.
- Toxic Phytoplankton Identification Handbook.
- South African Molluscan Shellfish Monitoring and Control Programme Manual 2016.
- South African Aquacultured Marine Fish Monitoring and Control Programme Manual 2016.

It is expected that the adherence to the relevant legislation, policies and guidelines will adequately manage the risk to human health from aquaculture products.

5.5 Cumulative impacts

The assessment of cumulative impacts is generally more difficult to predict as they often require more onerous assumptions regarding the likely actions of other aquaculture developments and their management practices. In essence, at a cumulative level, the identified social risks, human health impacts and economic opportunities would all be amplified if more than one aquaculture development occurs within the same socio-economic system.

The same would apply to the human health impact; if the mitigation measures are not implemented by the aquaculture developments, then the risk to human health would increase. Setting threshold limits for water quality will enable the establishment of the appropriate density of aquaculture development in a given water body or area. Appropriate water quality limits based on relevant legislation and guidelines have been included within the Freshwater and Marine Chapters and have therefore not been included here.

6 RISK ASSESSMENT

6.1 Consequence levels

The risks and opportunities assessment provides a high level indication of the risks and opportunities associated with proposing aquaculture within local municipalities or communities in relation to the other local municipalities or communities present within the study areas. Because of the uncertainty or lack of information regarding the 1) economies of scale of each production system, 2) how many aquaculture projects will realise in each study area, and 3) the local socio-economic context of each town or community within the study areas, this high-level risk assessment will, where applicable, use existing indices to rate the potential risks that the identified impacts may have.

For this assessment, the Social Vulnerability Index (Le Roux and Naudé, 2014) was used to quantify the social opportunities (Table 7) and the GVA calculation included within the Socio-economic Intensity Index (Ngidi and van Huyssteen, 2017) was used to quantify the economic opportunities (Table 8) (as discussed in Section 4). Table 9 and Table 10 outline the determination of the consequence rating for user conflict in the freshwater study areas and human health impacts. This assessment must be read in conjunction with

[3] Available at: http://www.daff.gov.za/daffweb3/Branches/Fisheries-Management/Aquaculture-and-Economic-Development/aaquaculture-sustainable-management/food-safety

the proposed mitigation measures, to ensure that on a project specific level, these impacts are suitably managed or opportunities suitably enhanced.

Table 7. Consequence level determination for social opportunities

Definition / Justification of consequence rating		
Consequence	**Social Vulnerability Index Rating**	**Reason**
Minor	Low vulnerability	The community has been identified as having a low vulnerability. While aquaculture development will still provide opportunities to these communities, compared to the high vulnerability category, these communities are more resilient and will most likely have a support system which will enable them to withstand outside stressors.
Substantial	Intermediate vulnerability	The indicator does not provide information on the vulnerabilities between low and high vulnerability. Therefore, opportunities to potentially realise within these areas would be allocated to have a substantial consequence, based on the precautionary approach.
Outstanding	High vulnerability	The community has been identified as having a high vulnerability. The community will most likely not be resilient to outside stressors and is most likely already experiencing psychological stress. The community can benefit the most from the opportunities offered through aquaculture development, compared to the other vulnerability classes.

Table 8. Consequence level determination for economic opportunities

Definition / Justification of consequence rating		
Consequence	**GVA Rating (Weighted Growth)**	**Reason**
Minor	High growth above national	The contribution to economic growth via economic opportunities from aquaculture within these areas will be tangible but since these areas are already experiencing high growth above national growth, the economic opportunities created would be less prominent, compared to other areas.
Moderate	Moderate growth above national and growth slightly above national	These areas have a moderate or slightly higher growth above national growth. Economic opportunities within these areas will contribute moderately to the economic output, given the growth already experienced within the areas.
Substantial	On par with national growth	These areas have a GVA growth that is on par with national growth. The economic growth that may be experienced due to the realisation of the economic opportunities from aquaculture can therefore support the continuous growth of the economy in these areas.
Major	Growing but at a lower rate than national growth	These areas have a growth in GVA but is lower than the national growth of 7.8 %. Aquaculture's economic contribution may therefore contribute to the GVA to ensure that there is an increase in GVA growth.
Outstanding	Decline	Compared to other areas, these areas require intervention to stimulate economic growth since the GVA of these areas is in decline. Economic growth of these areas, should the economic opportunities from aquaculture be realised, will most likely be the most tangible, in comparison to the other areas.

Table 9. Consequence level determination of user conflict in the freshwater study areas

Definition / Justification of consequence rating		
Consequence	**Status of RMP**	**Reason**
Substantial	Available, RMP completed en route for approval, RMP development in process, Not available	Irrespective of whether a RMP is available, completed, in progress or unavailable for the dams within the freshwater study areas, user conflict due to user displacement will have a negative impact on the current users. The *likelihood* of user conflict will be guided by the status of the dam's RMP (as reflected in Table 11).

Table 10. Consequence level determination for human health impacts

Consequence	Reason
Extreme	Adverse human health impact resulting from aquaculture caused by microbial and chemical contamination or nutrient enrichment of the water environment as a result of aquaculture practices. The *likelihood* of the impact occurring will determine the risk rating of this impact.

6.2 Assessment of risks and opportunities

Table 11. Assessment of risks and opportunities

Impact	Category	Location	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk/ Opportunity	Consequence	Likelihood	Risk / Opportunity
Contribution to the macro-economy by commercial aquaculture developments	GVA Rating (Weighted Growth)	High growth above national	Minor	Not likely	Very low opportunity	Minor	Likely	Very low opportunity
		Moderate growth above national and growth slightly above national	Moderate	Not likely	Low opportunity	Moderate	Likely	Low opportunity
		On par with national growth	Substantial	Not likely	Moderate opportunity	Substantial	Likely	Moderate opportunity
		Growing but at a lower rate than national growth	Major	Not likely	Moderate opportunity	Major	Likely	High opportunity
		Decline	Outstanding	Not likely	Moderate opportunity	Outstanding	Likely	High opportunity
Creation of employment opportunities	Social Vulnerability Index	Low vulnerability	Minor	Not likely	Very low opportunity	Minor	Likely	Very low opportunity
		Intermediate vulnerability	Substantial	Not likely	Moderate opportunity	Substantial	Likely	Moderate opportunity
		High vulnerability	Outstanding	Not likely	Moderate opportunity	Outstanding	Likely	High opportunity

Impact	Category	Location	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk/ Opportunity	Consequence	Likelihood	Risk / Opportunity
Provision of food security via aquaculture developments	Social Vulnerability Index	Low vulnerability	Minor	Likely	Very low opportunity	Minor	Likely	Very low opportunity
		Substantial	Substantial	Likely	Moderate opportunity	Substantial	Likely	Moderate opportunity
		High vulnerability	Outstanding	Likely	Moderate opportunity	Outstanding	Likely	High opportunity
Opportunity to contribute to the livelihoods of fishing communities	Social Vulnerability Index	Low vulnerability	Minor	Likely	Very low opportunity	Minor	Likely	Very low opportunity
		Substantial	Substantial	Likely	Moderate opportunity	Substantial	Likely	Moderate opportunity
		High vulnerability	Outstanding	Likely	Moderate opportunity	Outstanding	Likely	High opportunity
Opportunity for stimulating and diversifying income of subsistence aquaculture through the support of commercial aquaculture	Social Vulnerability Index	Low vulnerability	Minor	Likely	Very low opportunity	Minor	Likely	Very low opportunity
		Substantial	Substantial	Likely	Moderate opportunity	Substantial	Likely	Moderate opportunity
		High vulnerability	Outstanding	Likely	Moderate opportunity	Outstanding	Likely	High opportunity

Impact	Category	Location	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk/ Opportunity	Consequence	Likelihood	Risk / Opportunity
Risk of displacement of existing users by commercial aquaculture development within the inland surface water resources	Resource Management Plan availability	Available	Substantial	Extremely unlikely	Very low risk	Substantial	Extremely unlikely	Very low risk
		RMP completed en route for approval	Substantial	Very unlikely	Low risk	Substantial	Extremely unlikely	Very low risk
		RMP development in process	Substantial	Not unlikely	Moderate risk	Substantial	Extremely unlikely	Very low risk
		Not available	Substantial	Likely	Moderate risk	Substantial	Extremely unlikely	Very low risk
Risks potentially posed to human health by aquaculture	All Areas	All Areas	Extreme	Likely	High risk	Extreme	Very Unlikely	Very low risk

7 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS FOR THE MANAGEMENT SOCIAL AND ECONOMIC RISKS AND OPPORTUNITIES

The full text of the management measures to enhance benefits or reduce risks are outlined in the main body of this assessment (Section 5). This section summarises the key interventions or management measures that can be implemented during the different phases of the project as well as the potential role players who can contribute to managing these measures.

7.1 Planning and construction phase

7.1.1 Contribution to the macro-economy by commercial aquaculture developments

Table 12. Management interventions and respective role players in contributing to the macro-economy by commercial aquaculture developments

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Establish and manage funding initiatives	✓	✓		
Promote and incentivise a broader value chain perspective	✓		✓	✓
Develop policies that enable economic growth within the aquaculture sector	✓			
Undertake feasibility assessments to determine the viability of a commercial aquaculture development	✓	✓	✓	

7.1.2 Employment opportunities

Table 13. Management interventions and respective role players in creating employment opportunities and the management of employment expectations

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
The local socio-economic context should be understood (understand factors such as ability and availability of the labour market) as well as determining the willingness and capability of individuals within the study areas to consider a livelihood through aquaculture.	✓		✓	✓
A skills database within the region of the aquaculture project can be compiled. This will ensure that the transferability of human skills and training needs are taken into account when employing residents form the region.	✓		✓	✓
A community's expectation regarding employment opportunities should be managed through social risk communication. Especially where there is an expectation of high employment opportunities, which may not be the case. The aim of the social risk communication method is to ensure that the communicator, in this case the aquaculture developer or government, are open about risks, in this case, specifically regarding employment opportunities. This will manage expectations and reduce social conflict.	✓		✓	✓

7.1.3 Provision of food security

Table 14. Management interventions and respective role players in the provision of food security via aquaculture developments

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Ensure that policies are developed and updated, when required, to support the objectives to promote food security thorough aquaculture	✓	✓		✓

7.1.4 Altered livelihoods of fishing communities

Table 15. Management interventions and respective role players in enhancing the opportunities to contribute to the livelihoods of fishing communities

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
The socio-economic drivers that influence human behaviour and vulnerability must be considered in a context-specific setting. To achieve this, all affected stakeholders must be part of the decision-making and policy development process.	✓	✓	✓	✓
Small-scale fishing rights and practices must be recognised in governance arrangements.	✓	✓		✓
A socio-economic analysis of each area must be undertaken in order to understand the context in which the proposed aquaculture projects will be undertaken	✓	✓		✓
In the coastal communities where there are small scale fisheries, it is important to understand the mechanisms through which these fisheries participate in poverty alleviation and socio-economic advancement	✓	✓	✓	✓

7.1.5 The role of commercial aquaculture in supporting subsistence aquaculture

Table 16. Management interventions and respective role players in enhancing the opportunities for stimulating and diversifying income of subsistence aquaculture through the support of commercial aquaculture

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Establish the necessary policies, initiatives and plans to support subsistence aquaculture and efforts of integrating existing agriculture practises into commercial aquaculture developments, potentially via subsidies.	✓		✓	✓
Planning associated with the funding initiative must focused on how to build financial independence and commercial viability instead of social projects that continuously require financial support.	✓		✓	✓
Support subsistence aquaculture through the involvement of the private sector via Community Public Private Partnerships (CPPPs). The CPPP model combines assets unique to each sector to ensure the viability of a project.	✓		✓	✓

7.1.6 User conflict

Table 17. Management interventions and respective role players in managing user conflict that may arise due to user displacement

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Ensure all dams to be utilised for aquaculture have a RMP that guides development and uses of the dams. These RMPs must also include mechanisms to manage user conflict through community forums and proper governance.	✓			
Proper consideration of other users utilising the CPR must be undertaken through appropriate planning interventions and policy guidelines to direct aquaculture development into appropriate areas. The includes local-planning tools and the Environmental Impact Assessment process	✓			
Incorporate aquaculture development and associated objectives into local planning tools such as the Integrated Development Plan and Spatial Development Plan developed every 5 years	✓			

7.2 Operations phase

7.2.1 Contribution to the macro-economy by commercial aquaculture developments

Table 18. Management interventions and respective role players in contributing to the macro-economy by commercial aquaculture developments

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Where production occurs, further processing and associated activities should occur within the town or area where the aquaculture development occurs.	✓		✓	
Social responsibility programmes run by aquaculture industries can also promote skills development and improve livelihoods in the local communities.			✓	✓

7.2.2 Provision of food security

Table 19. Management interventions and respective role players in the provision of food security via aquaculture developments

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
Shift away from a sectoral approach to a holistic approach whereby local communities and other relevant stakeholders are enabled to participate in the aquaculture development.	✓	✓	✓	✓

7.2.3 Human health

Table 20. Management interventions and respective role players in managing the risks potentially posed to human health by aquaculture

Interventions or Management Measures	Role players			
	Government (National, Provincial and/or or Local)	NGOs/ Research institutions	Commercial aquaculture developer/ Private Sector	Subsistence aquaculture developer/ community
An aquaculture development's adherence to the relevant legislation, guidelines and frameworks governing human health and food safety is required.	✓		✓	✓
Adhere to the permit conditions and the Shellfish and Fish monitoring control programs provided by DAFF.	✓		✓	✓

8 GAPS IN KNOWLEDGE

The high-level nature of this assessment meant that no finer scale socio-economic information was available for the study areas and associated towns and cities. This implies that potential localised impacts could not be identified, assessed and site-specific mitigation measures included to manage the impacts. The assessment therefore relied on appropriate indices to attempt to address this. If detailed comparative information was available on social structures and economic drivers for towns or cities within the various study areas then, potentially, there may have been more variance in the impacts identified and the associated risk ratings identified. The same holds true for the comparative lack of local and international research on the socio-economic impacts of aquaculture on communities utilising freshwater systems. In addition, since aquaculture development is an emerging sector in South Africa, extensive literature on aquaculture development's potential to contribute to the economy and social upliftment in a South African context was unavailable. The assessment therefore mostly relied on international research contributions.

In terms of the impact to human health, although the contaminants that may affect human health are known, the human health risks associated with fish produced through aquaculture are not fully understood. Research is needed to assess associated health risks and to develop appropriate interventions that could reduce or prevent these risks.

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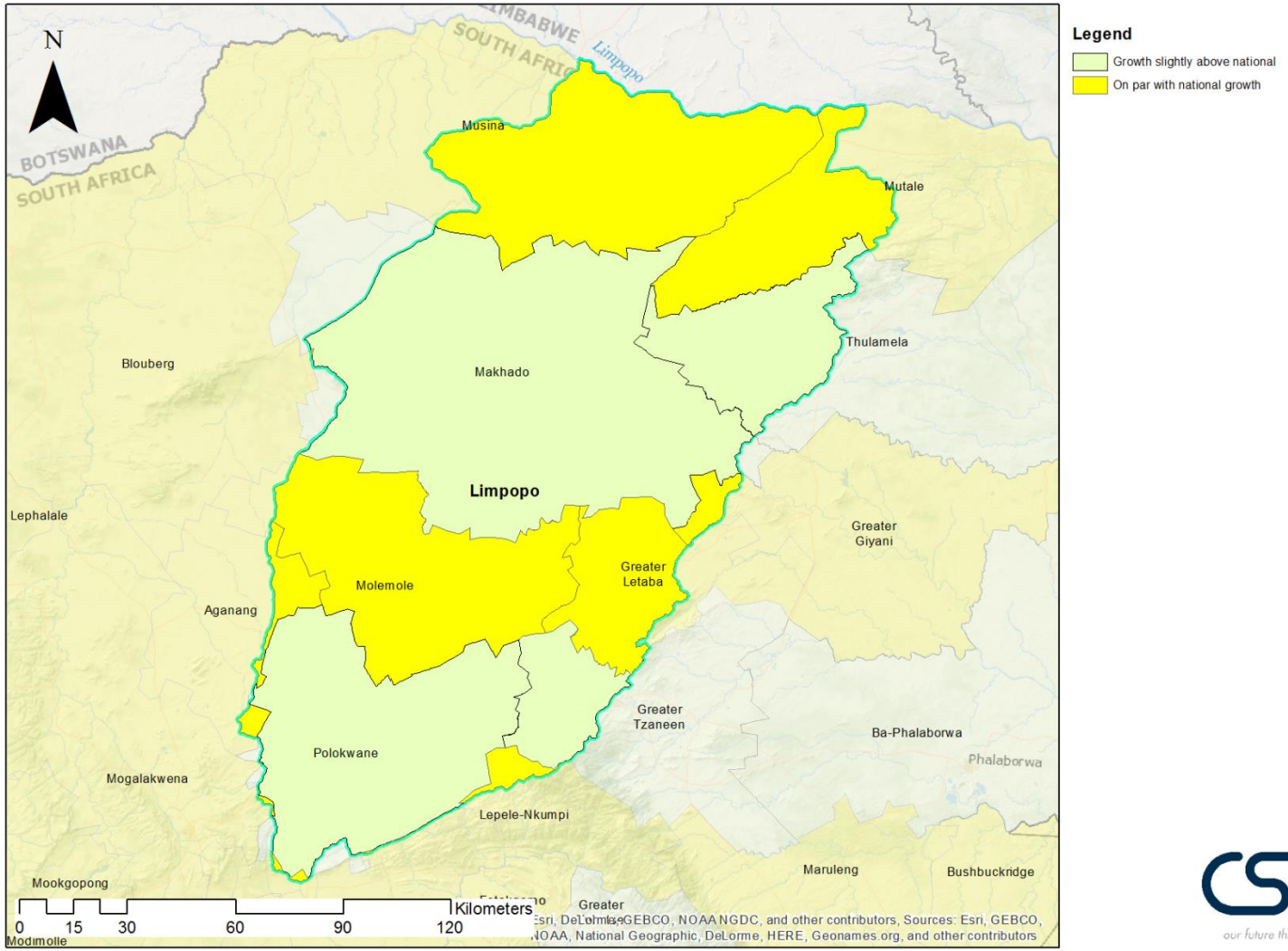
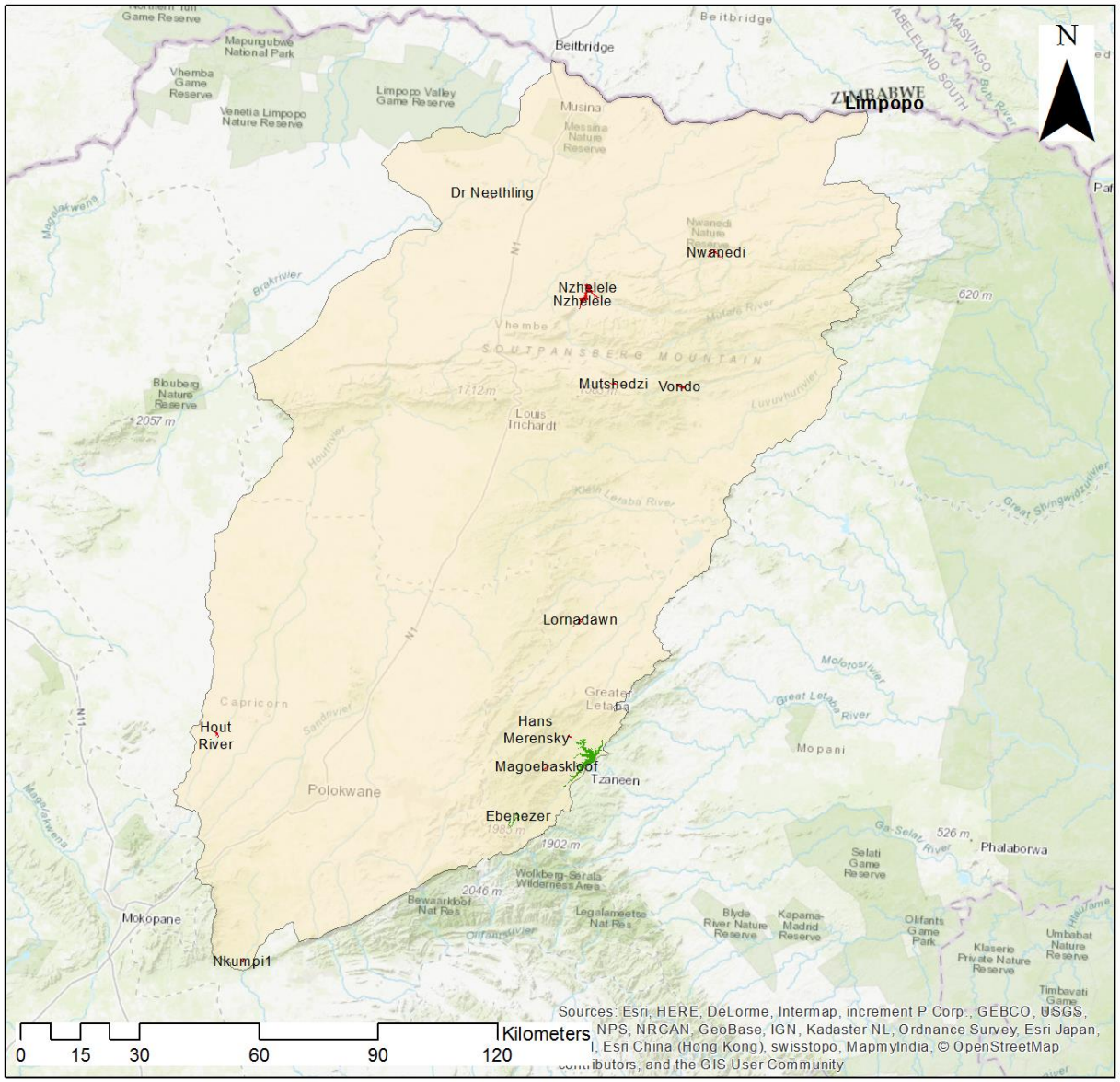
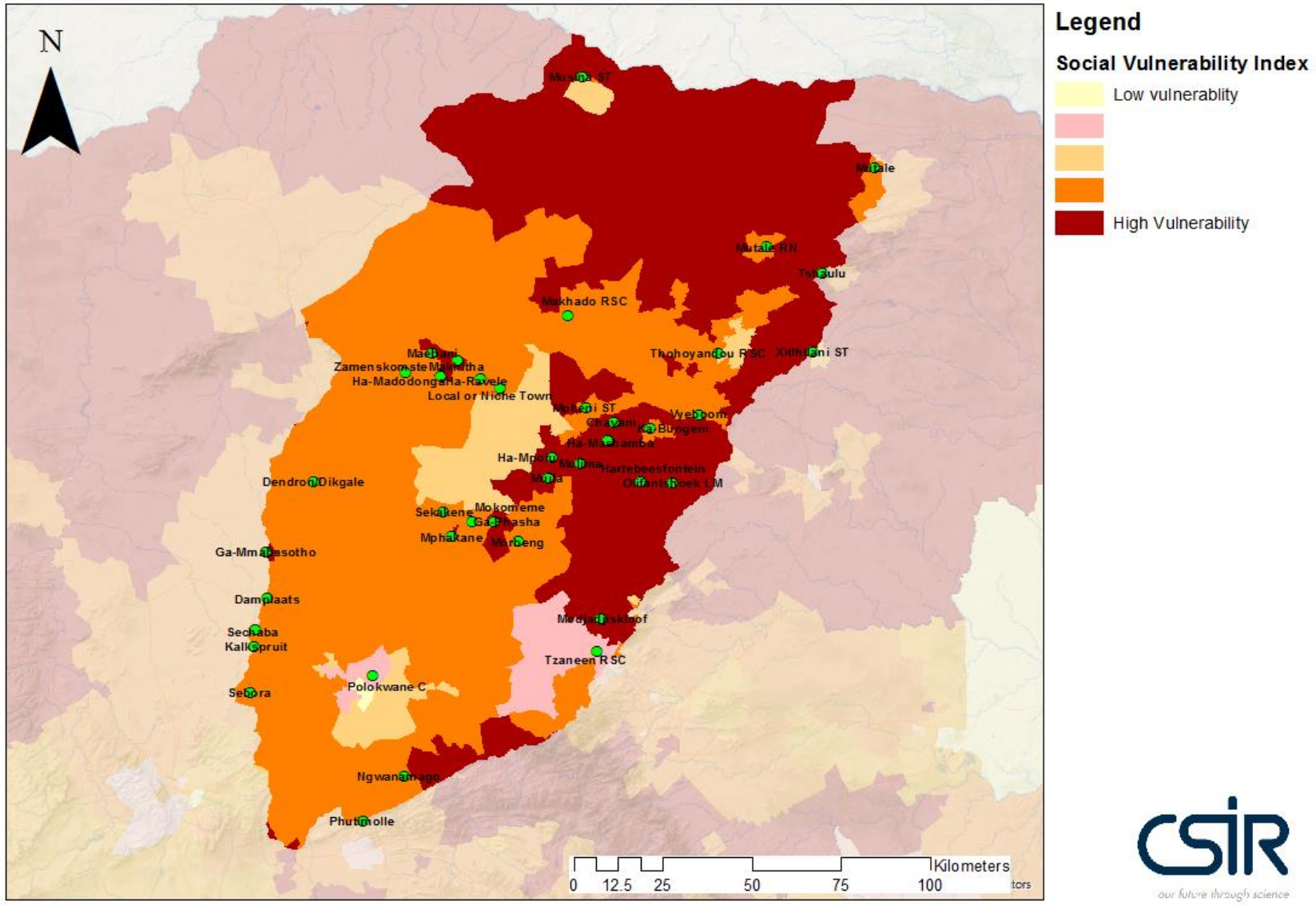
Appendix to Socio-Economic Specialist Assessment

CONTENTS

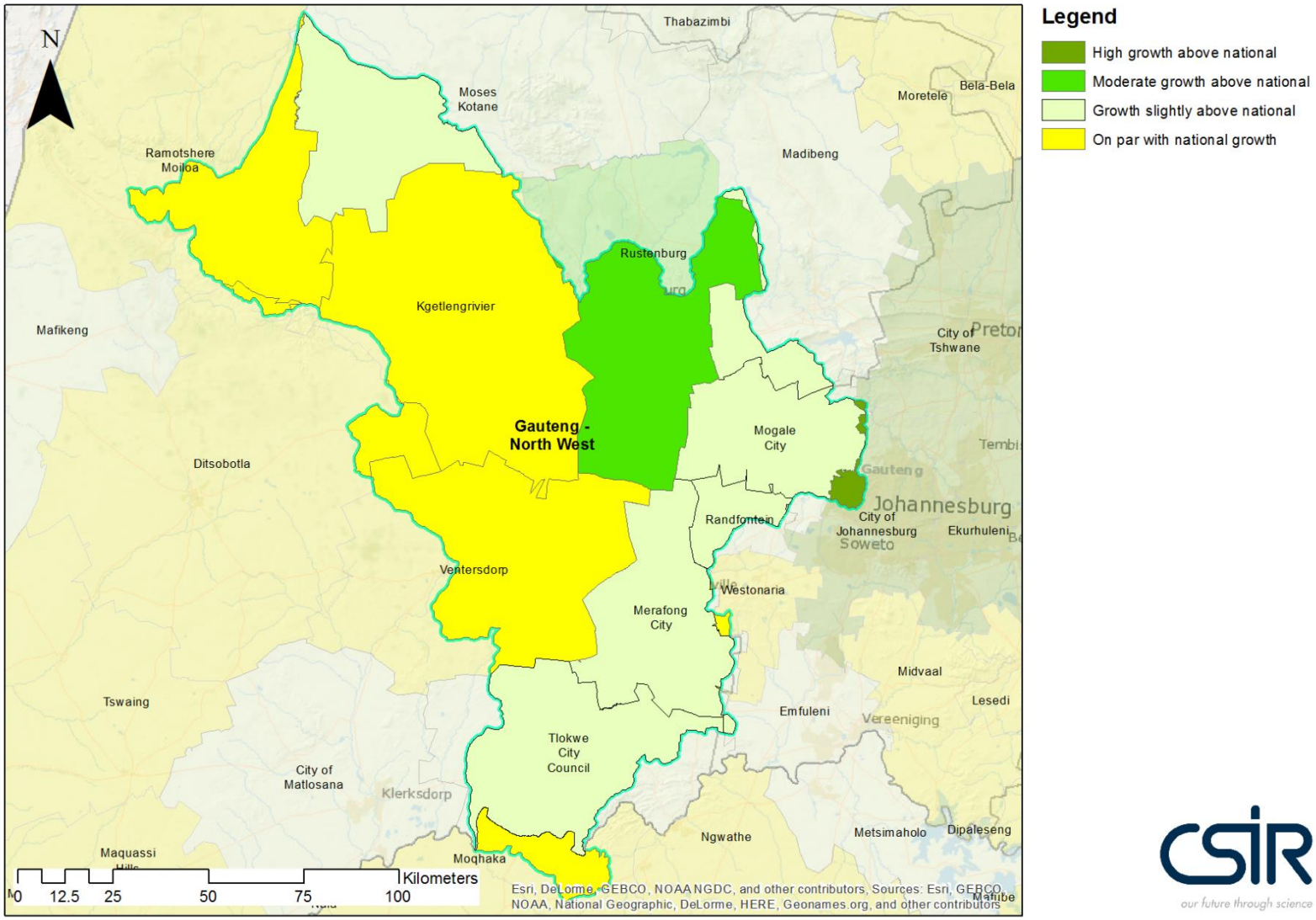
A.1 Limpopo

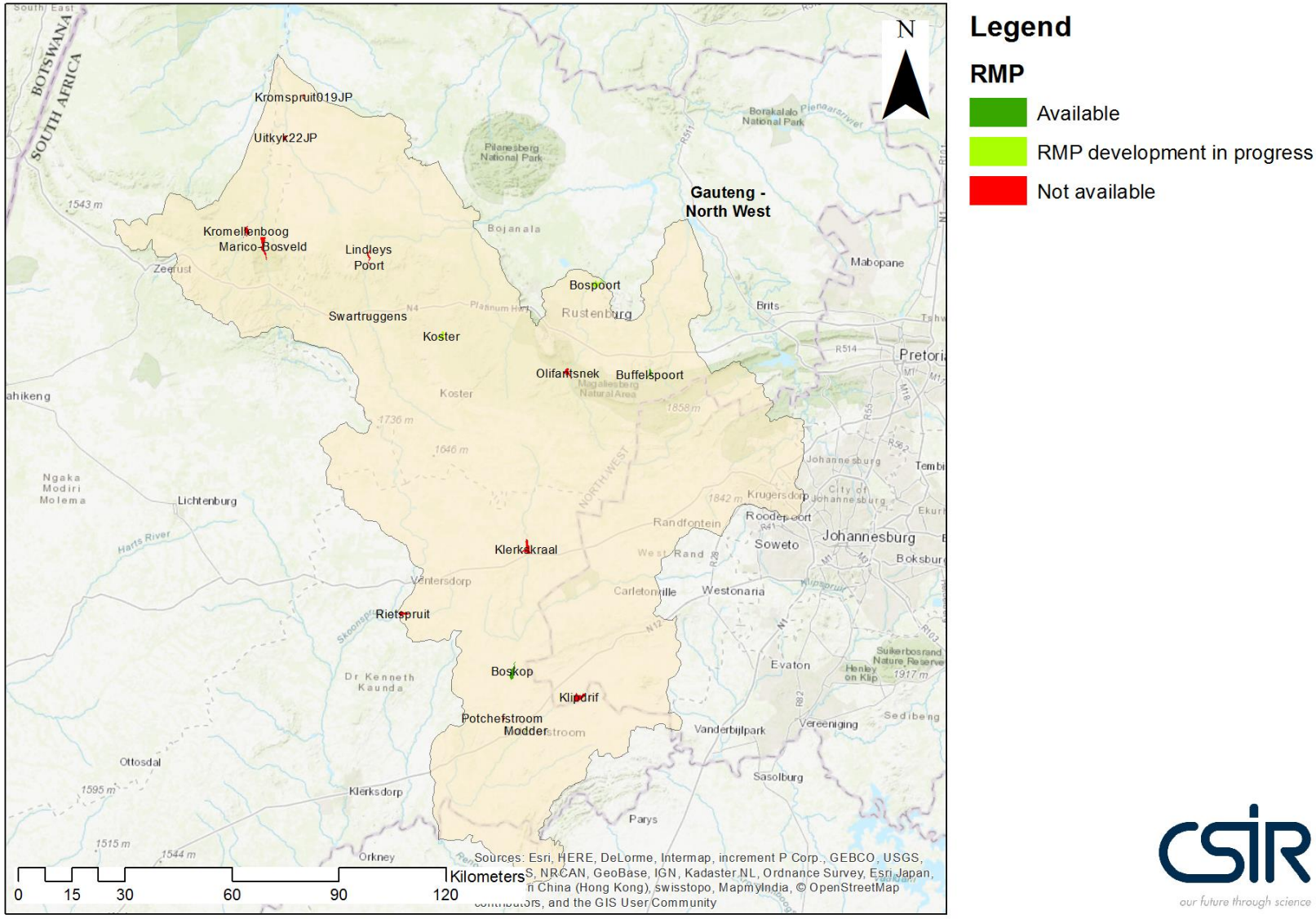

N
Legend
Growth slightly above national
On par with national growth
BOTSWANA
SOUTH AFRICA
Limpopo
Musina
Mutale
Thulamela
Makhado
Blouberg
Limpopo
Lephalale
Greater Giyani
Molemole
Greater Letaba
Aganang
Greater Tzaneen
Ba-Phalaborwa
Phalaborwa
Polokwane
Mogalakwena
Lepele-Nkumpi
Maruleng
Bushbuckridge
Mookgopong
Modimolle
Kilometers
0 15 30 60 90 120
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors, Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

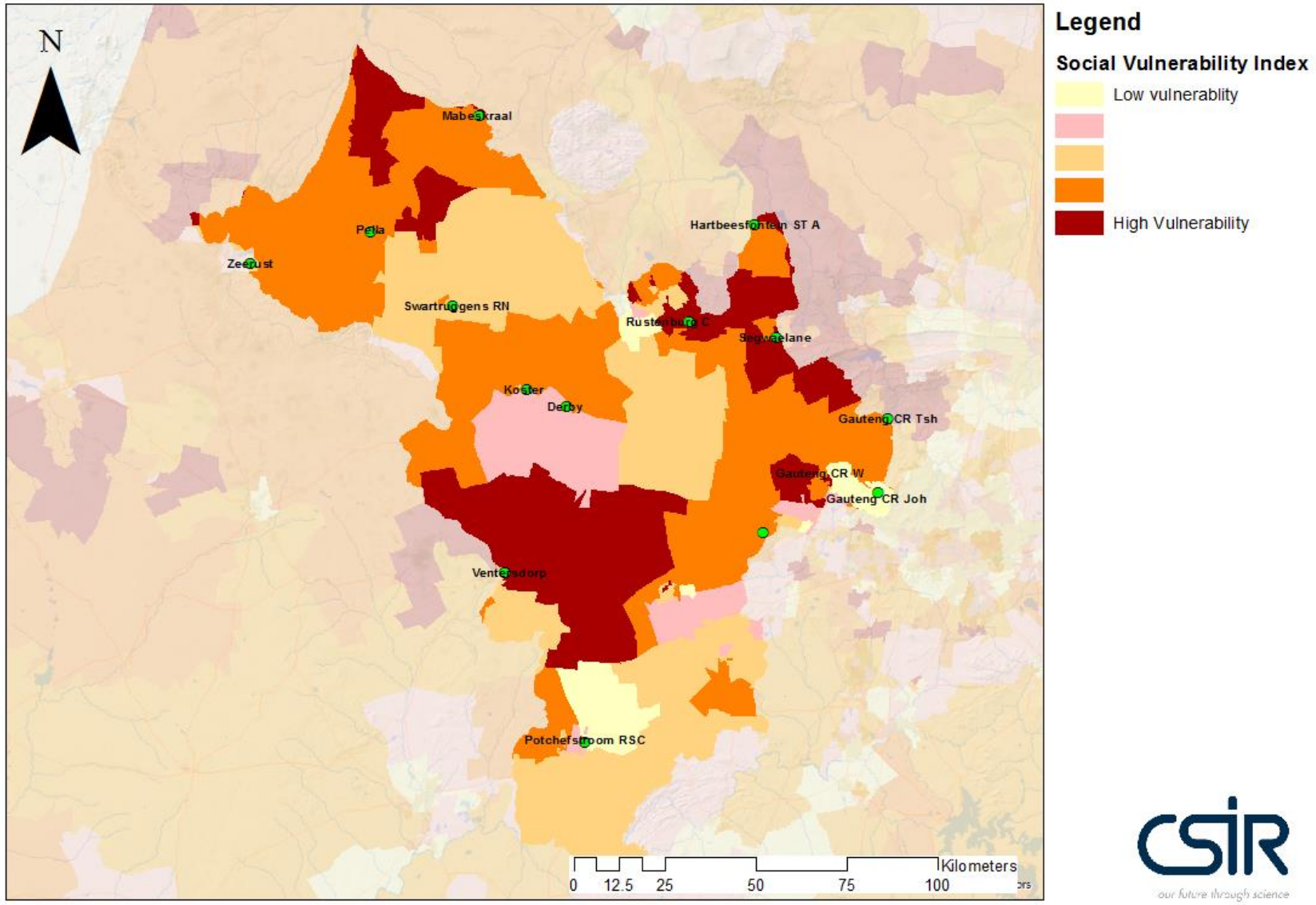

Legend
RMP
Available
Not available
N
Limpopo
Beitbridge
Dr Neethling
Nwanedi
Nzhelele
Mutshedzi
Vondo
Lornadawn
Hans Merensky
Magoebaskloof
Tzaneen
Ebenezer
Hout River
Polokwane
Mokopane
Nkumpi1
Phalaborwa
Kilometers
0 15 30 60 90 120
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, I, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


N
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability
Musina ST
Mutale RN
Tshibulu
Makhado RSC
Thohoyandou RSC
Xitlhelani ST
Zamenskomste
Makhitha
Ha-Madodongsha-Ravele
Local or Niche Town
Mphephi ST
Vyeboom
Ha-Mashamba
Ha-Mphephu
Harrebeesfontein
Dendron
Dikgale
Sekakene
Mokomeme
Ga-Phasha
Mphakane
Ga-Mmabasotho
Damplaats
Sechaba
Kalkspruit
Tzaneen RSC
Sebora
Polokwane C
Ngwanamago
Phuthiolle
Kilometers
0 12.5 25 50 75 100

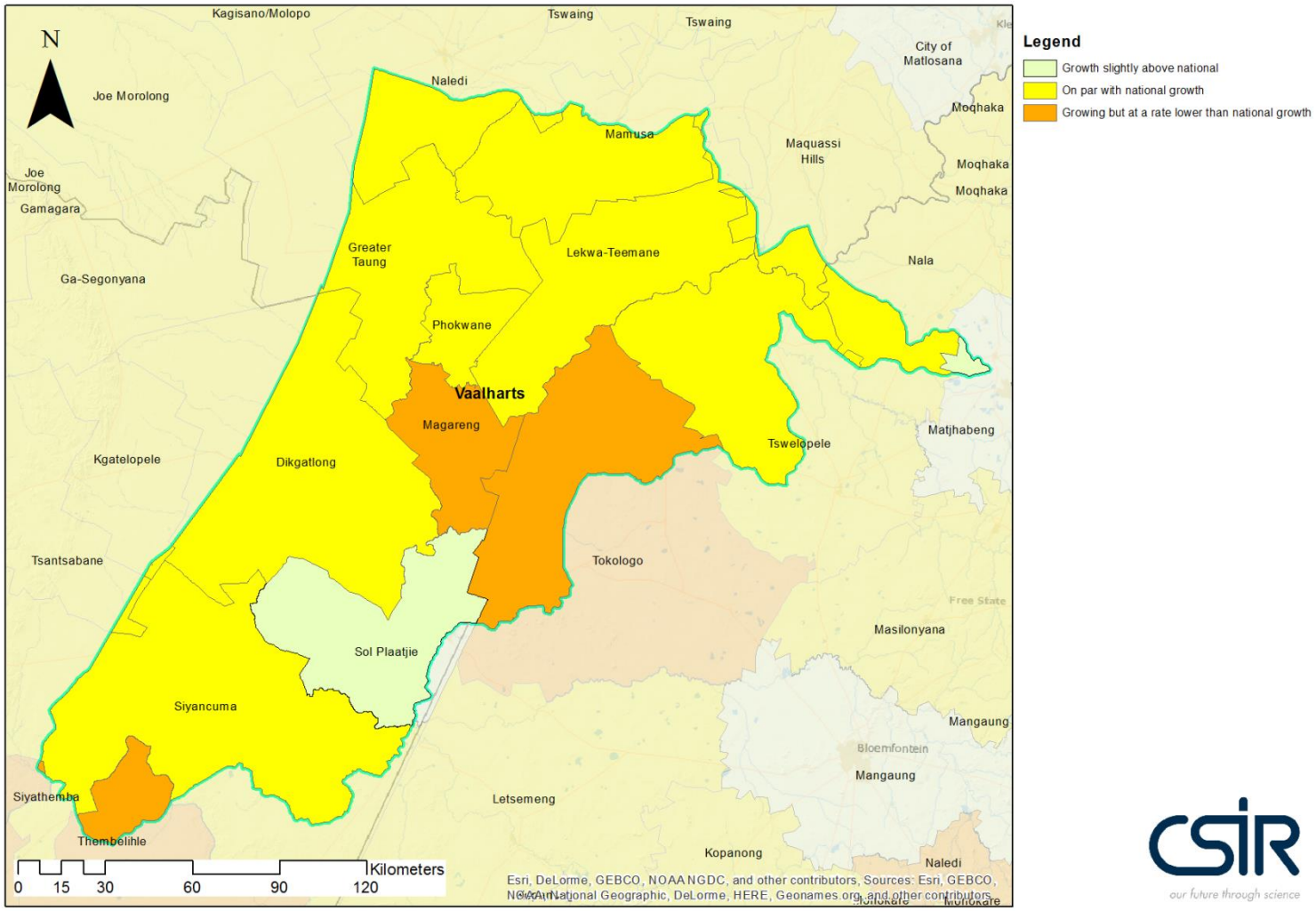
A.2 Gauteng-North West

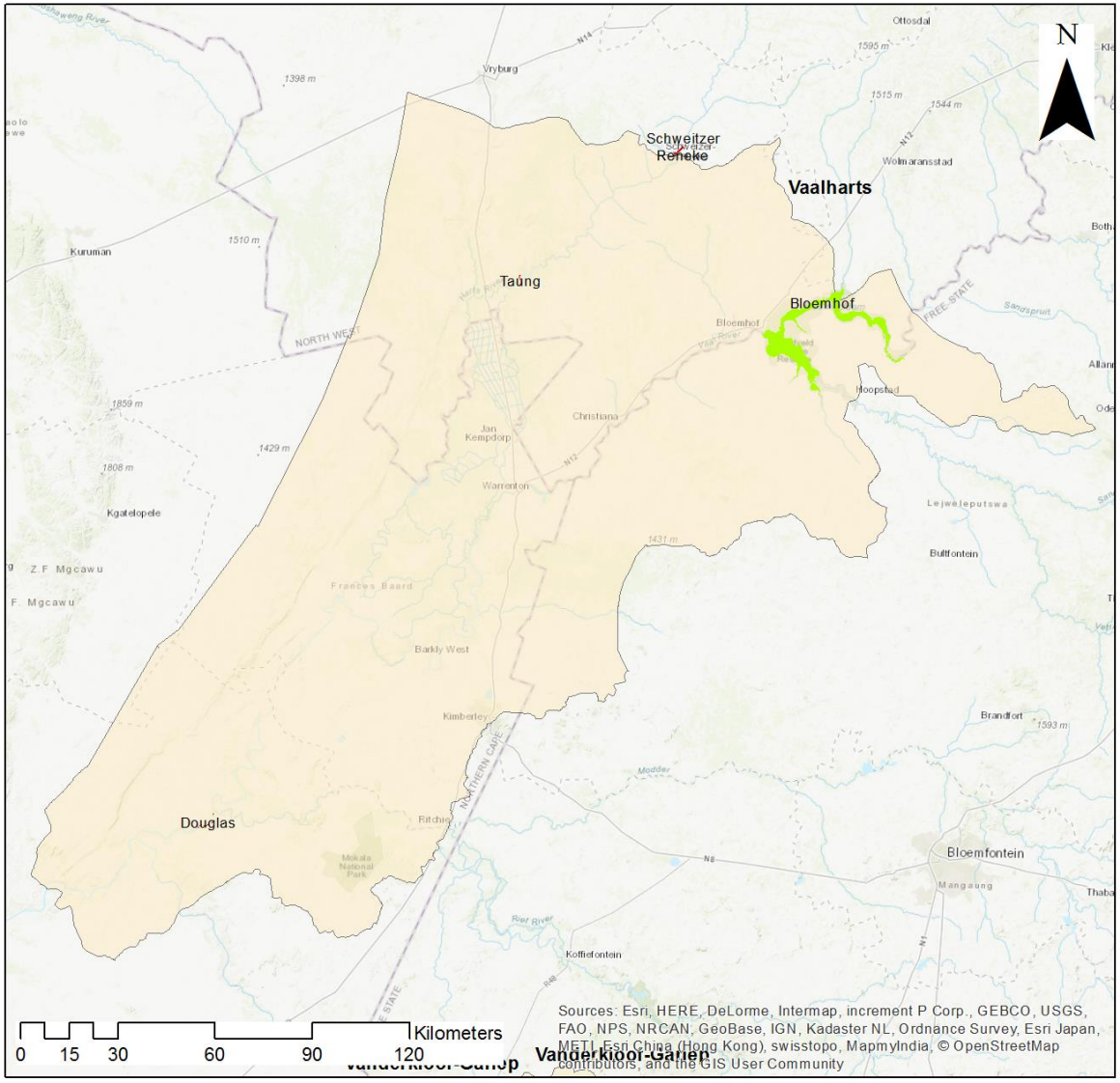


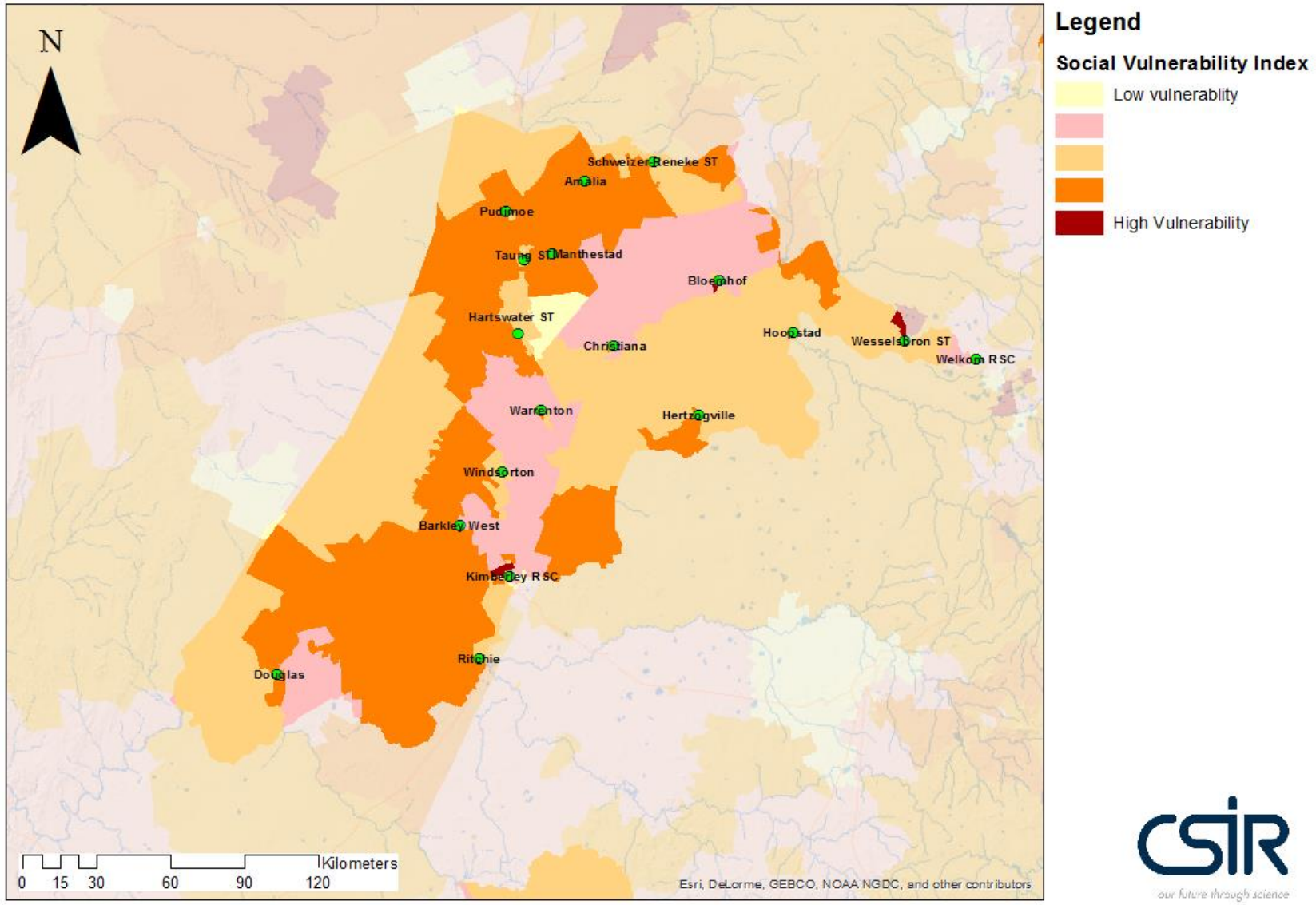

Legend
RMP
Available
RMP development in progress
Not available
N
Kromspruit019JP
Uitkyk22JP
Kromellenboog
Marico-Bosveld
Lindleys
Poort
Zeerust
Swartruggens
Koster
Bospoort
Rustenburg
Olifantsnek
Buffelspoort
Gauteng -
North West
Mabopane
Brits
Pretoria
Johannesburg
Soweto
Krugersdorp
Randfontein
Roodepoort
Lichtenburg
Klerkskraal
Ventersdorp
Carletonville
Westonaria
Rietspruit
Boskop
Klipdrif
Potchefstroom
Modderfontein
Vanderbijlpark
Vereeniging
Evaton
Sasolburg
Parys
Ottosdal
Klerksdorp
Orkney
Ngaka
Modiri
Molema
Harts River
Dr Kenneth
Kaunda
Bojanala
Pilanesberg
National Park
Borakalalo
National Park
Magaliesberg
Natural Area
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS,
S, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan,
n China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap
ntributors, and the GIS User Community
0
15
30
60
90
120
Kilometers


N
Mabeskraal
Pella
Zeerust
Swartruggens RN
Hartbeesfontein ST A
Rustenburg C
Segwaelane
Koster
Derby
Gauteng CR Tsh
Gauteng CR W
Gauteng CR Joh
Ventersdorp
Potchefstroom RSC
Kilometers
0 12.5 25 50 75 100
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability

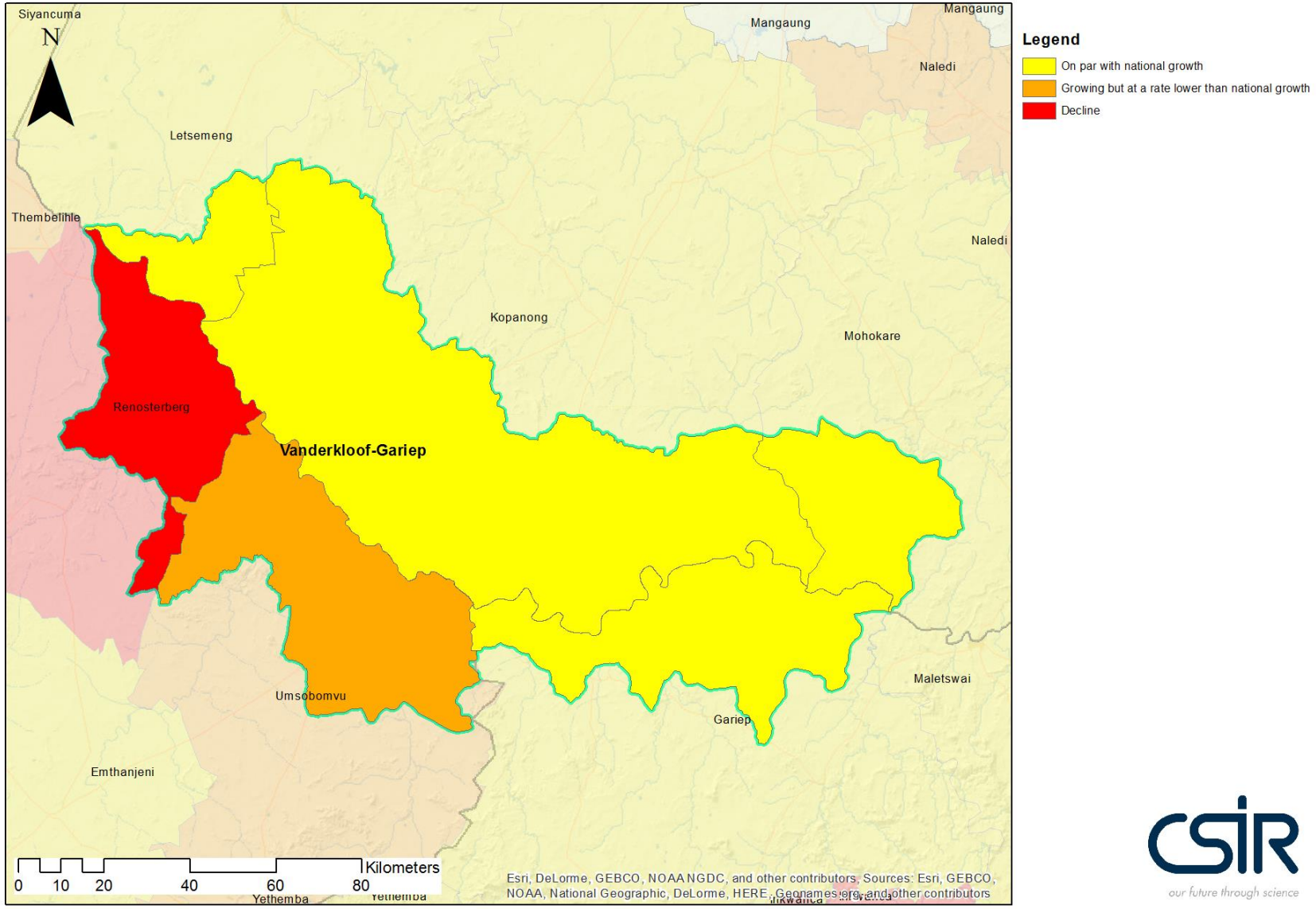
A.3 Vaalharts

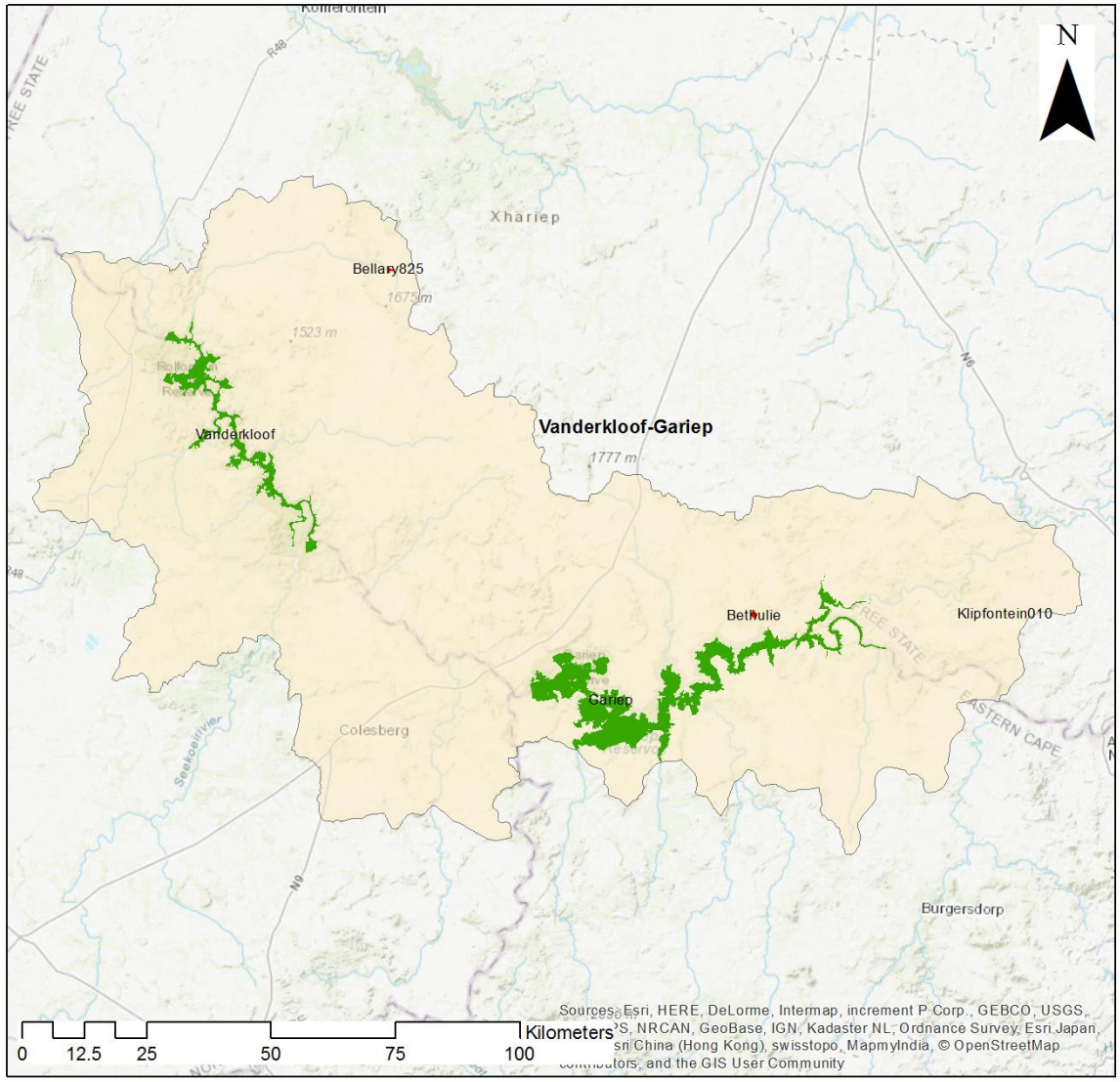



N
Legend
RMP
RMP development in progress
Not available
Vaalharts
Taung
Bloemhof
Douglas
Vanderkloof-Gariep
Schweitzer Reneke
Vryburg
Wolmaransstad
Kuruman
Hoopstad
Christiana
Jan Kempdorp
Warrenton
Kgatelopele
Barkly West
Kimberley
Bultfontein
Brandfort
Bloemfontein
Koffiefontein
Ottosdal
Lejweleputswa
Mangaung
Kilometers
0 15 30 60 90 120
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


N
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability
Schweizer-Reneke ST
Amalia
Pudimoe
Taung ST
Manthestad
Bloemhof
Hartswater ST
Christiana
Hoopstad
Wesselsbron ST
Welkom RSC
Warrenton
Hertzogville
Windsorton
Barkley West
Kimberley RSC
Ritchie
Douglas
0 15 30 60 90 120
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

A.4 Vanderkloof Gariep

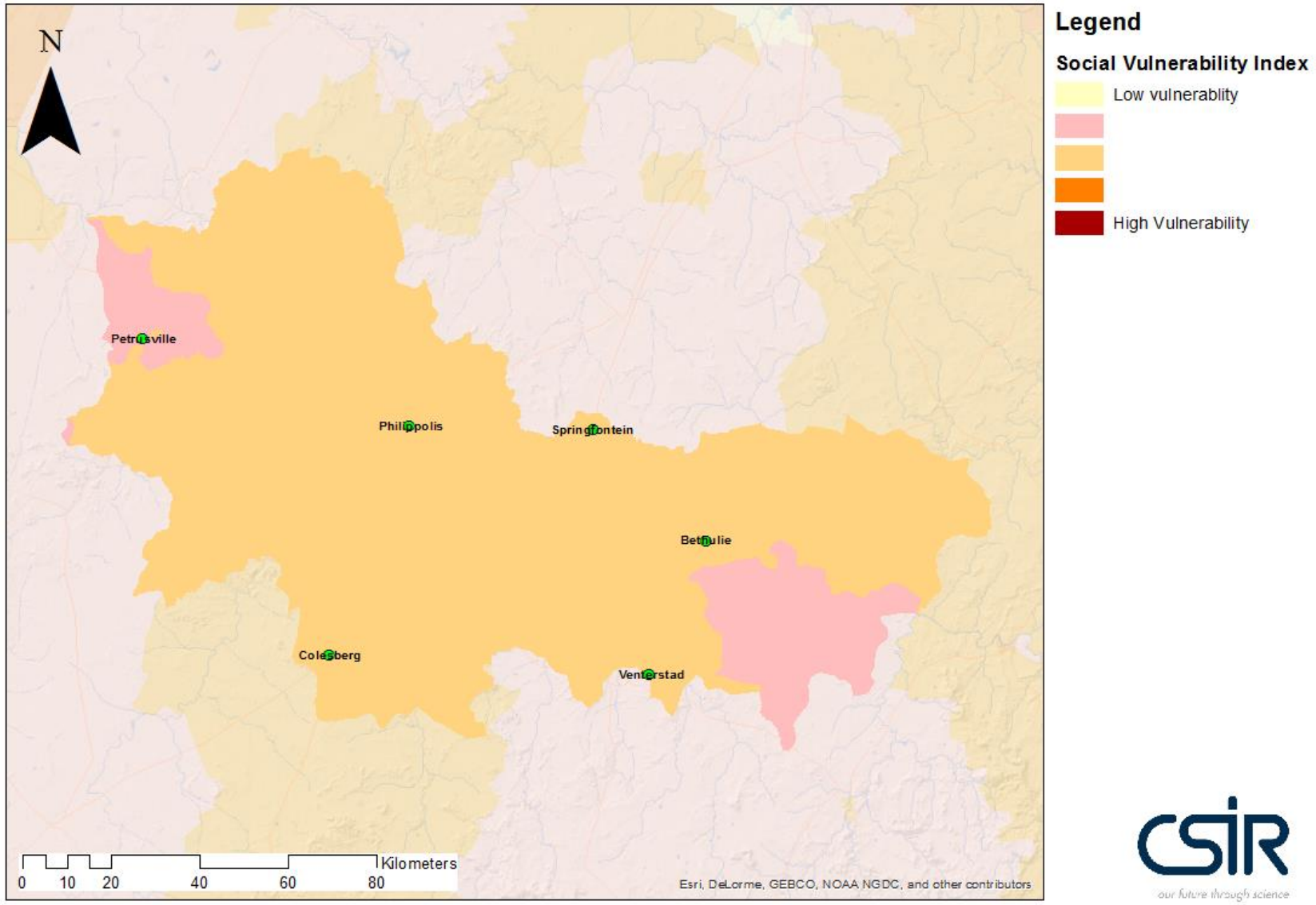




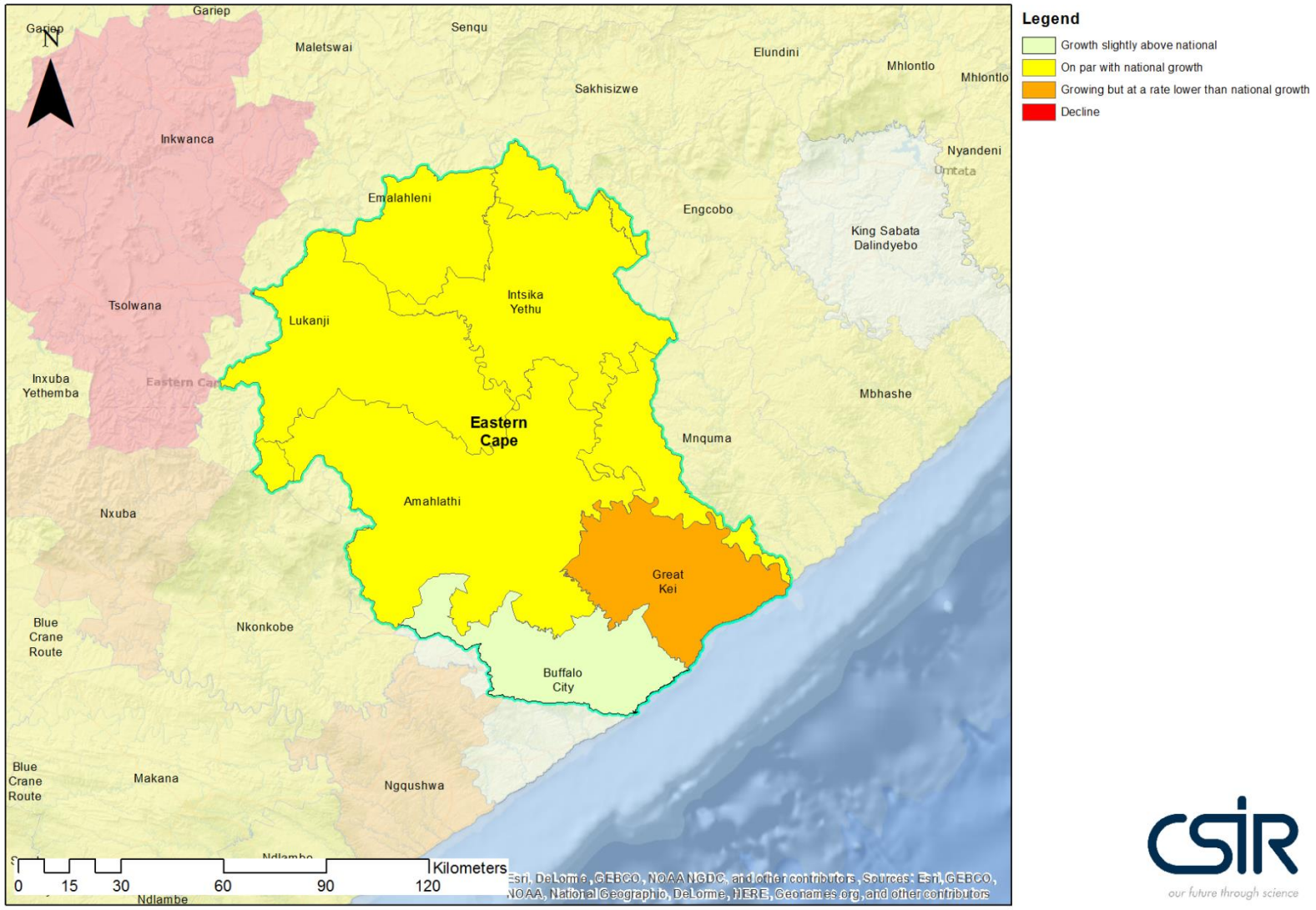
Legend

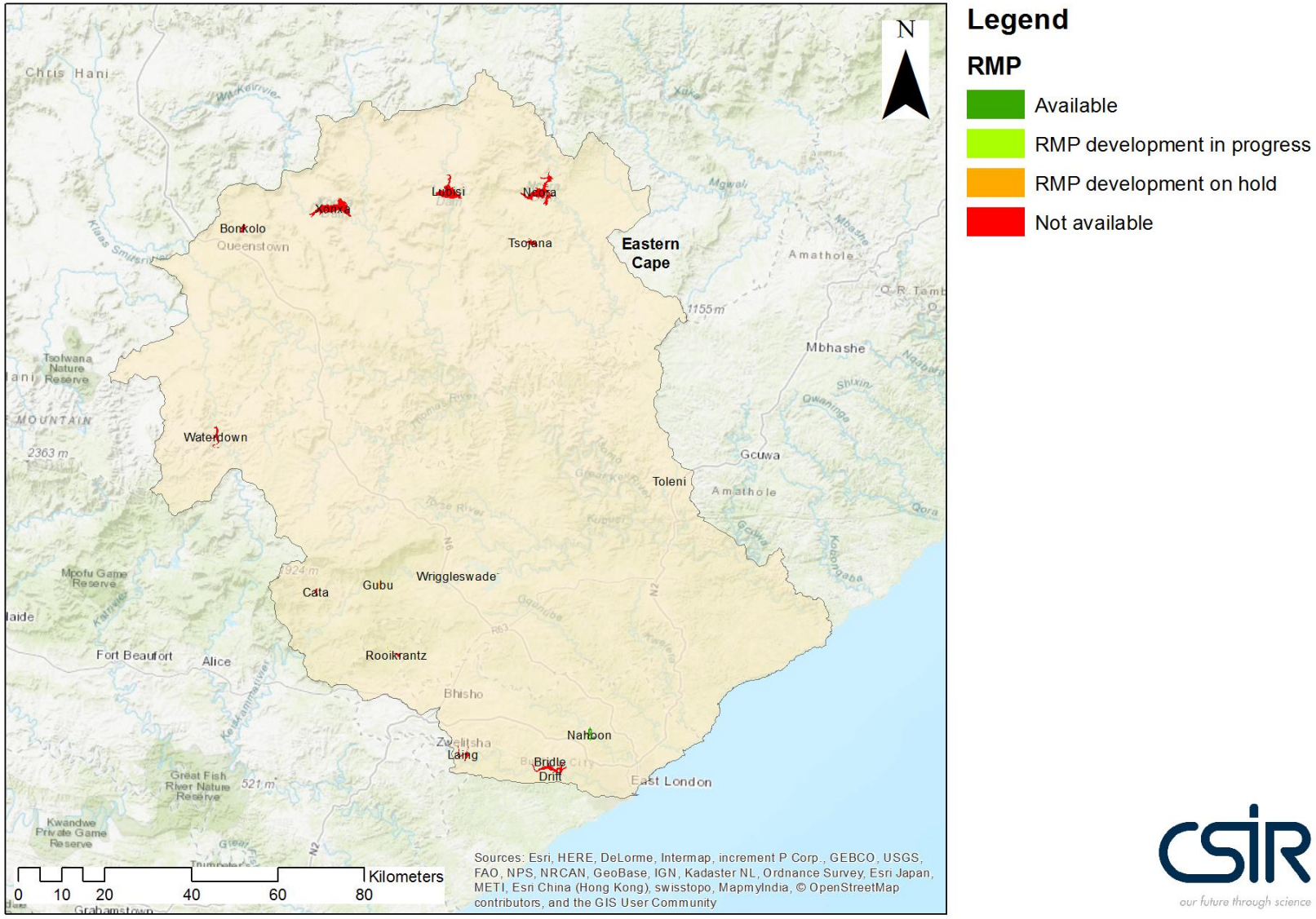
RMP

- Available
- RMP development in progress
- Not available


N
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability
Petrusville
Philippolis
Springfontein
Bethulie
Colesberg
Venterstad
0 10 20 40 60 80
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

A.5 Eastern Cape



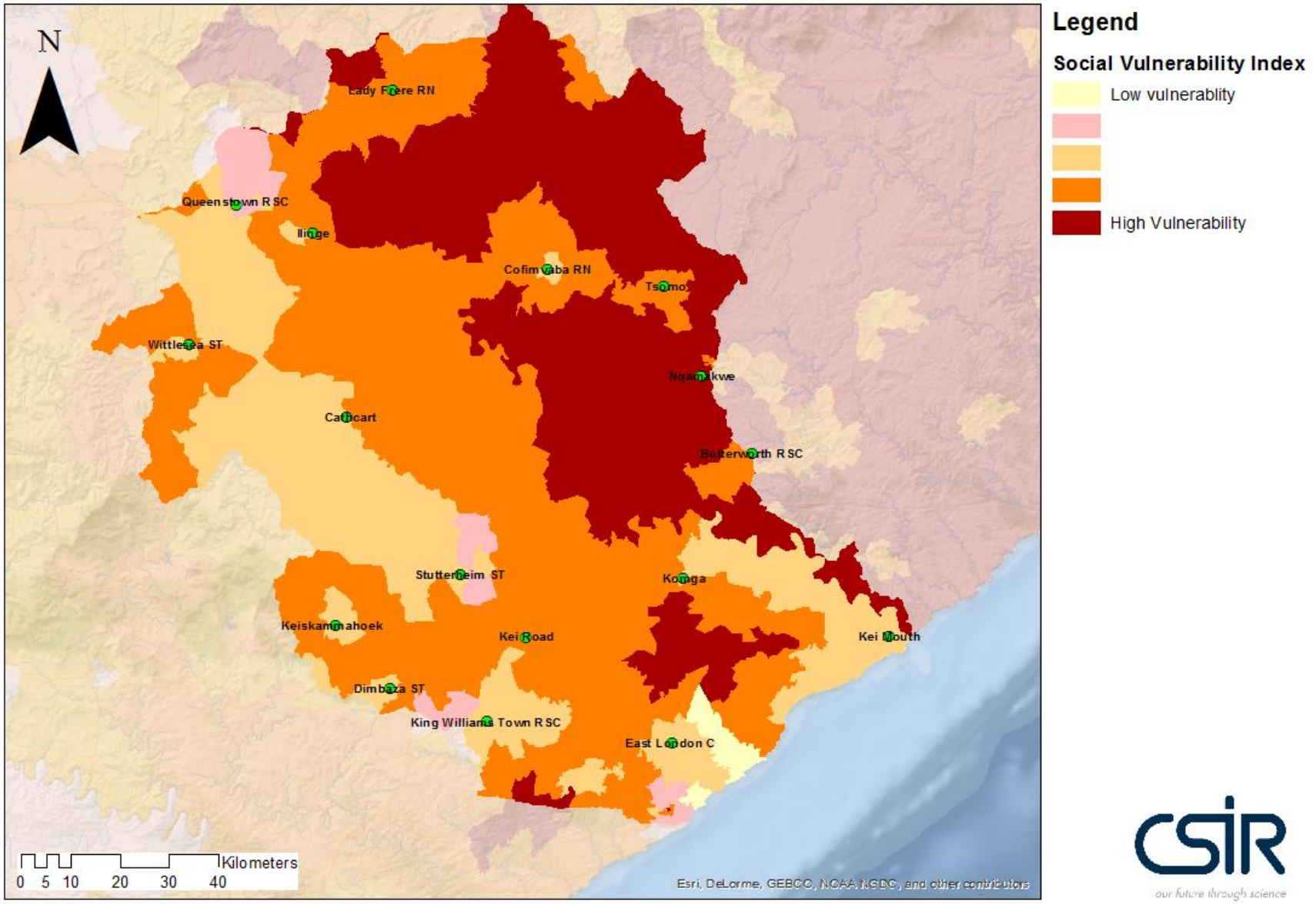


Legend

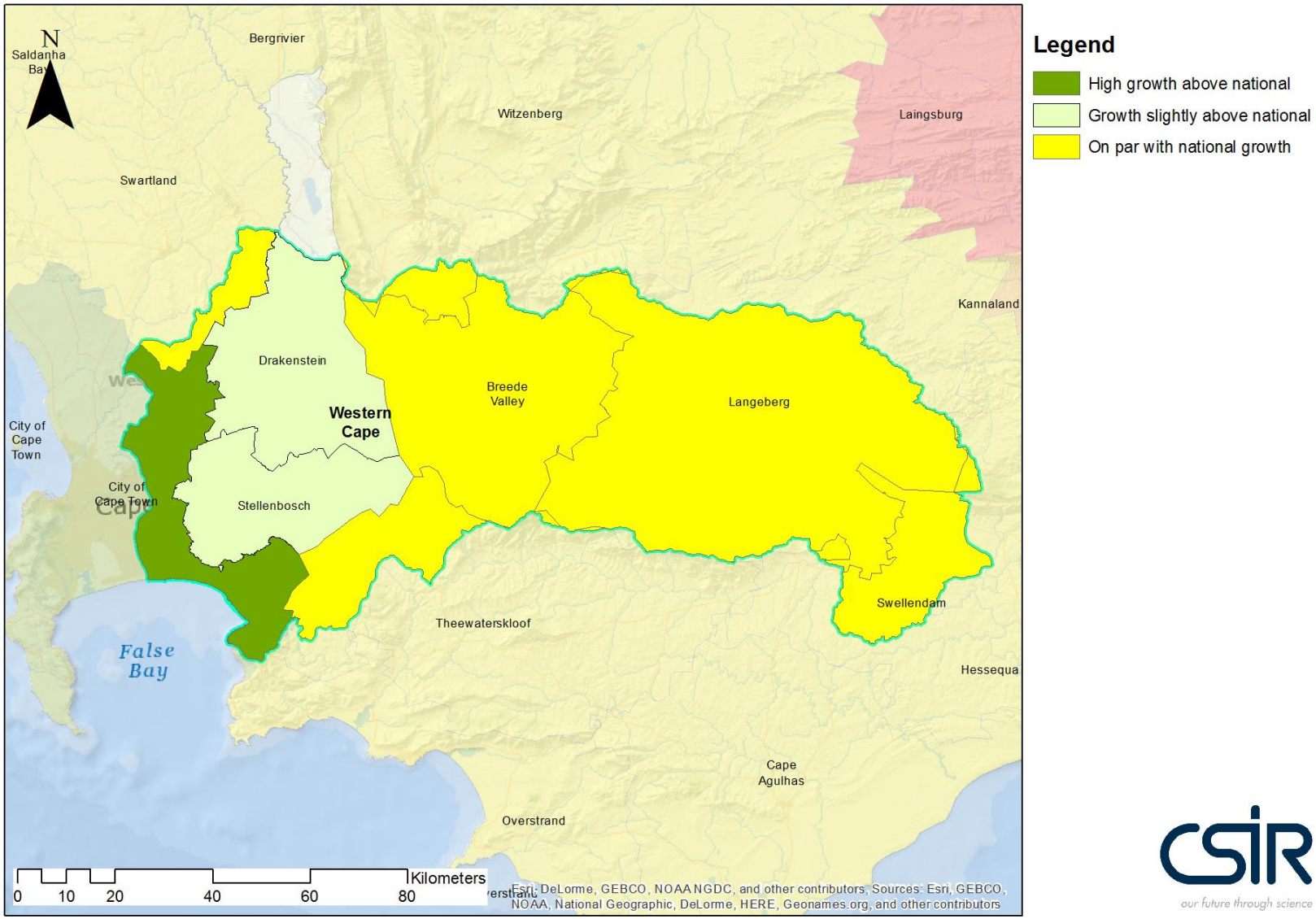
RMP

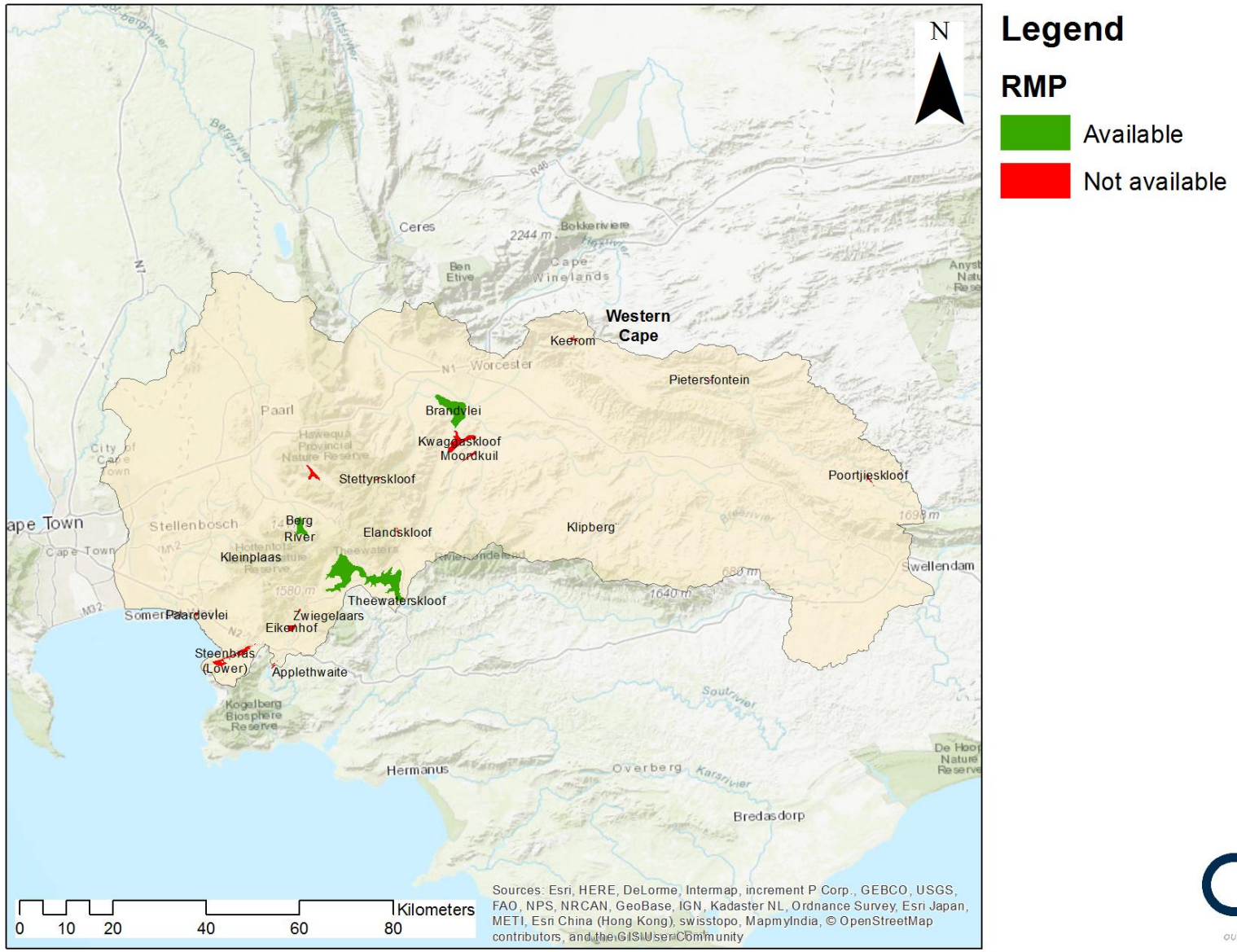
- Available
- RMP development in progress
- RMP development on hold
- Not available

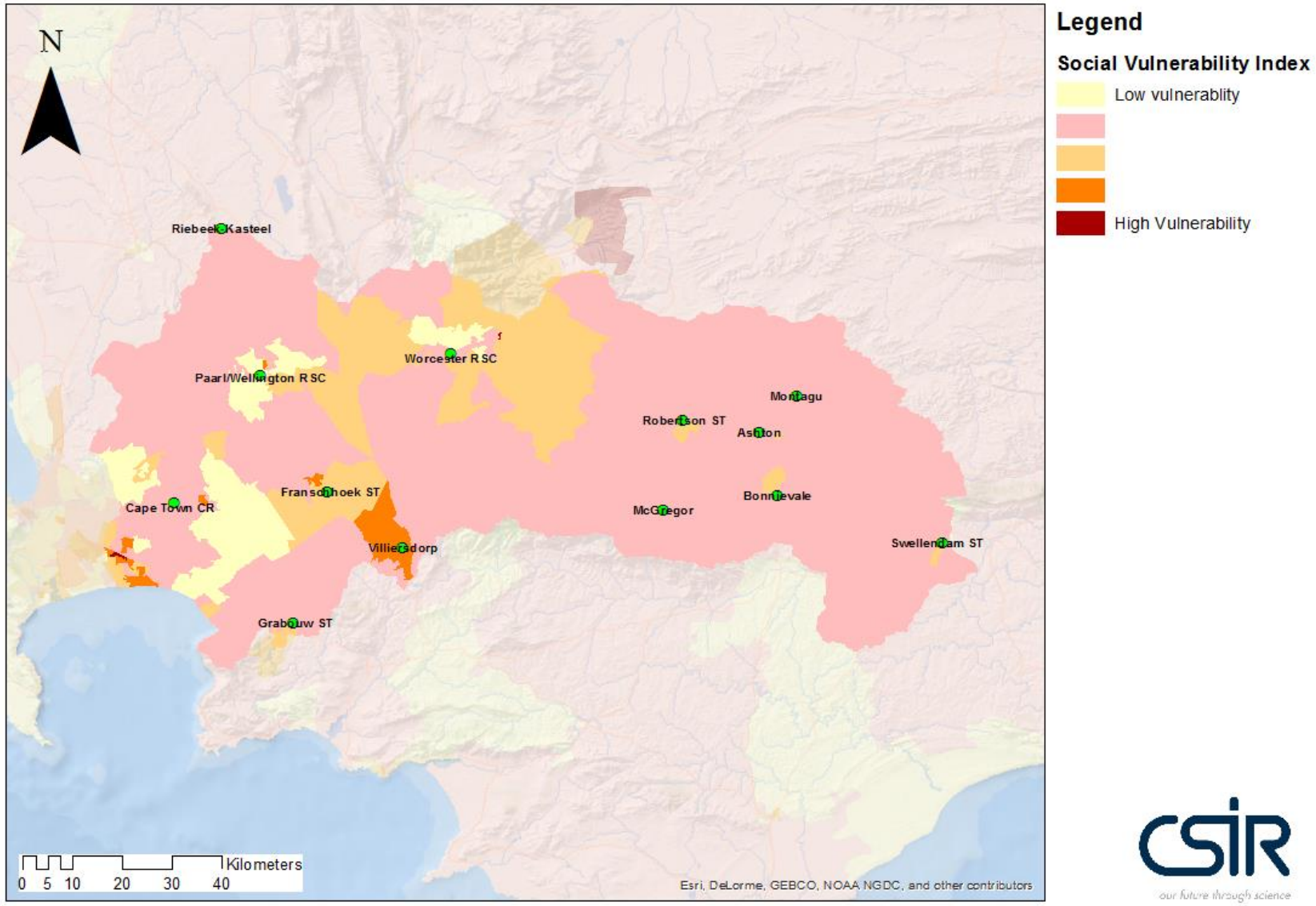
CSIR
our future through science


N
Lady Frere RN
Queenstown RSC
Ilinge
Cofimvaba RN
Tsomo
Whittlesea ST
Ngamakwe
Cadcart
Butterworth RSC
Stutterheim ST
Komga
Keiskammahoek
Kei Road
Kei Mouth
Dimbaza ST
King Williams Town RSC
East London C
Kilometers
0 5 10 20 30 40
Esri, DeLorme, GEBCO, NOAA, NGDC, and other contributors
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability

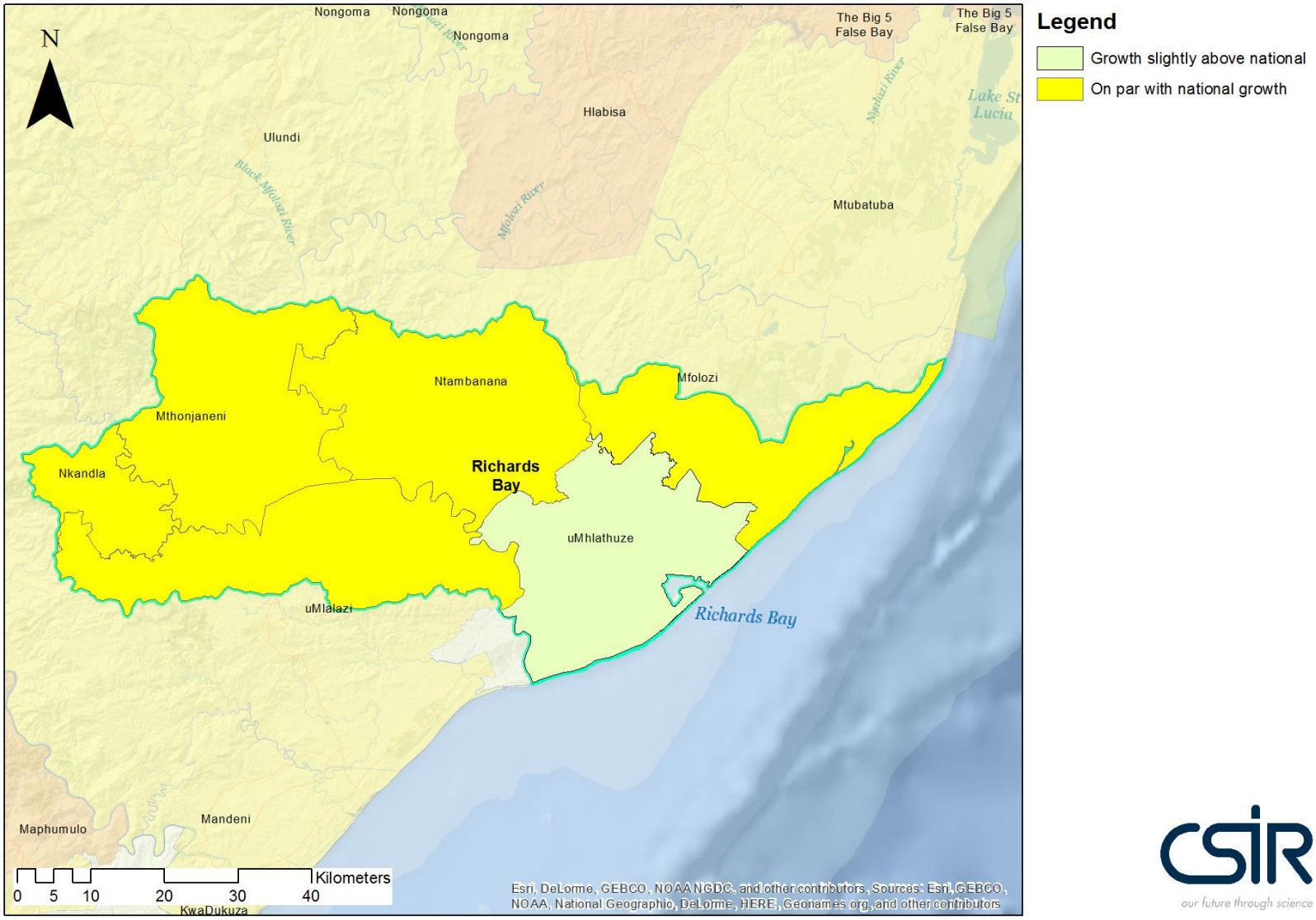
A.6 Western Cape

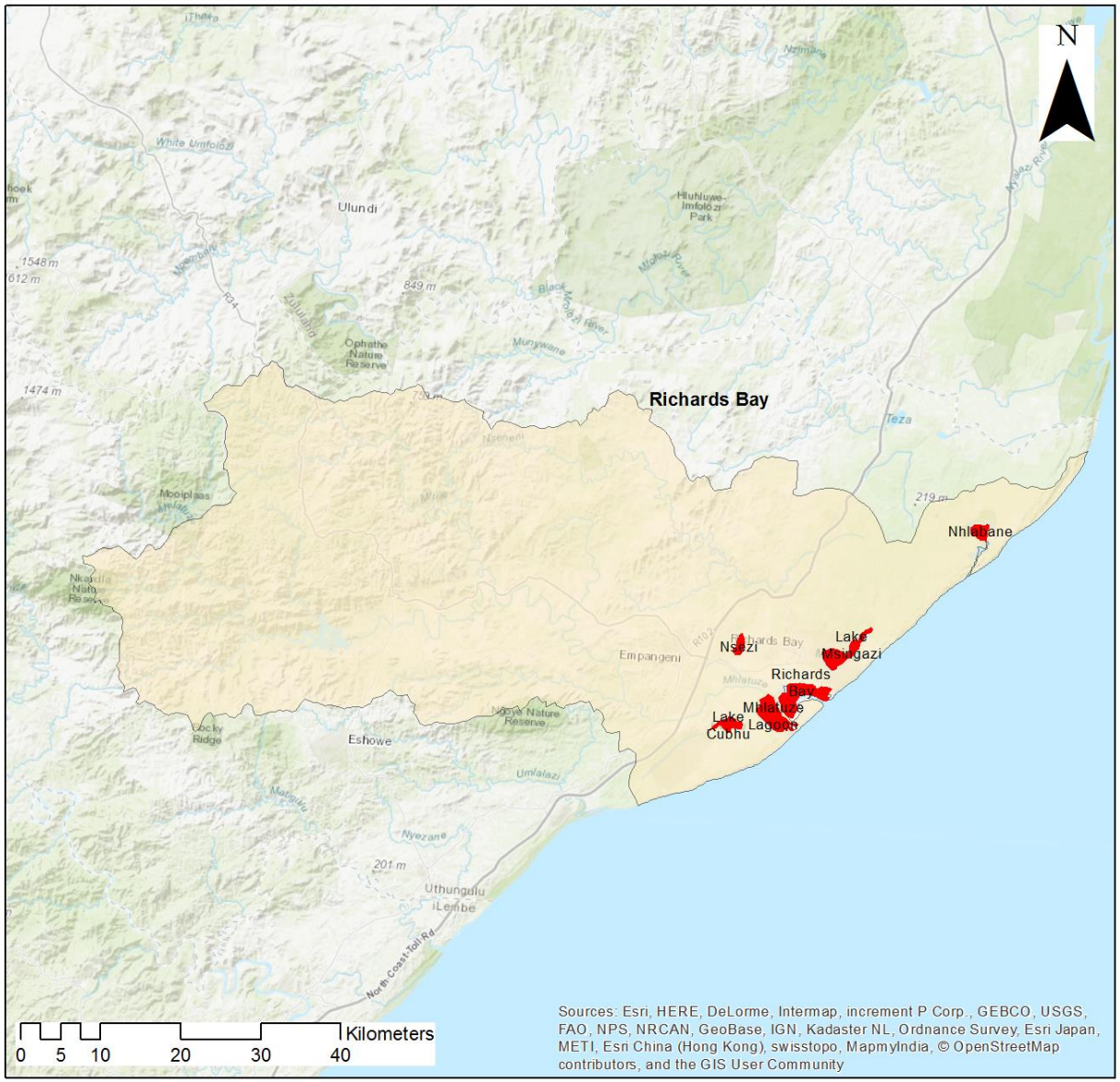


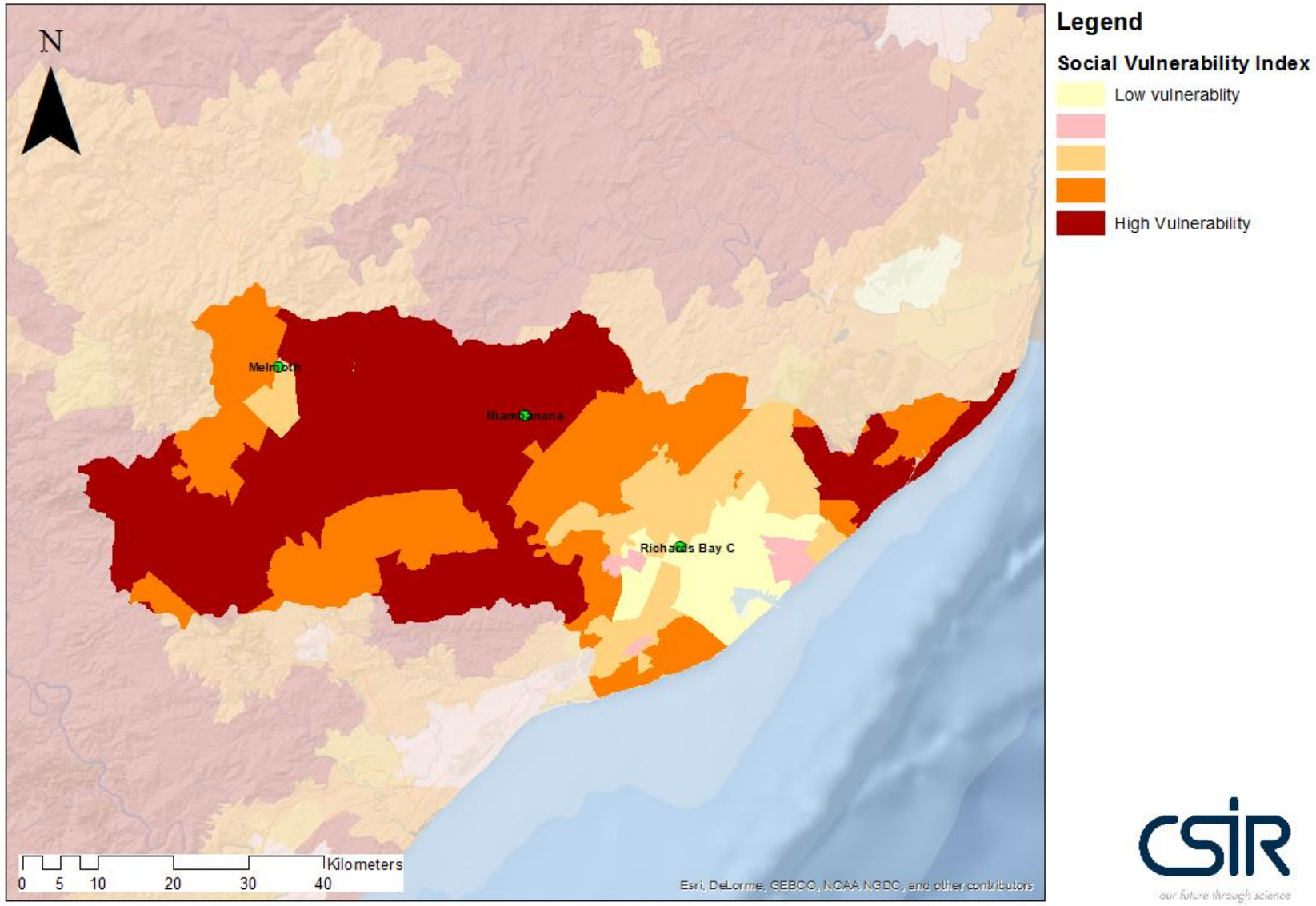

N
Legend
RMP
Available
Not available
Western Cape
Ceres
Bokkeriviere
Cape Winelands
Ben Etive
Keerom
Worcester
Pietersfontein
Paarl
Brandvlei
Kwagaaskloof
Moordkuil
Stettynskloof
Poortjieskloof
Hawequa Provincial Nature Reserve
Stellenbosch
Berg River
Elandskloof
Klipberg
Kleinplaas
Theewaterskloof
Somerset
Paardevlei
Zwiegelaars
Eikenhof
Steenbras (Lower)
Applethwaite
Kogelberg Biosphere Reserve
Hermanus
Overberg
Bredasdorp
Wellendam
De Hoop Nature Reserve
Kilometers
0 10 20 40 60 80
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


N
Riebeek Kasteel
Worcester RSC
Paarl/Wellington RSC
Montagu
Robertson ST
Ashton
Franschhoek ST
Bonnievale
Cape Town CR
McGregor
Villiersdorp
Swellendam ST
Grabouw ST
Kilometers
0 5 10 20 30 40
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability

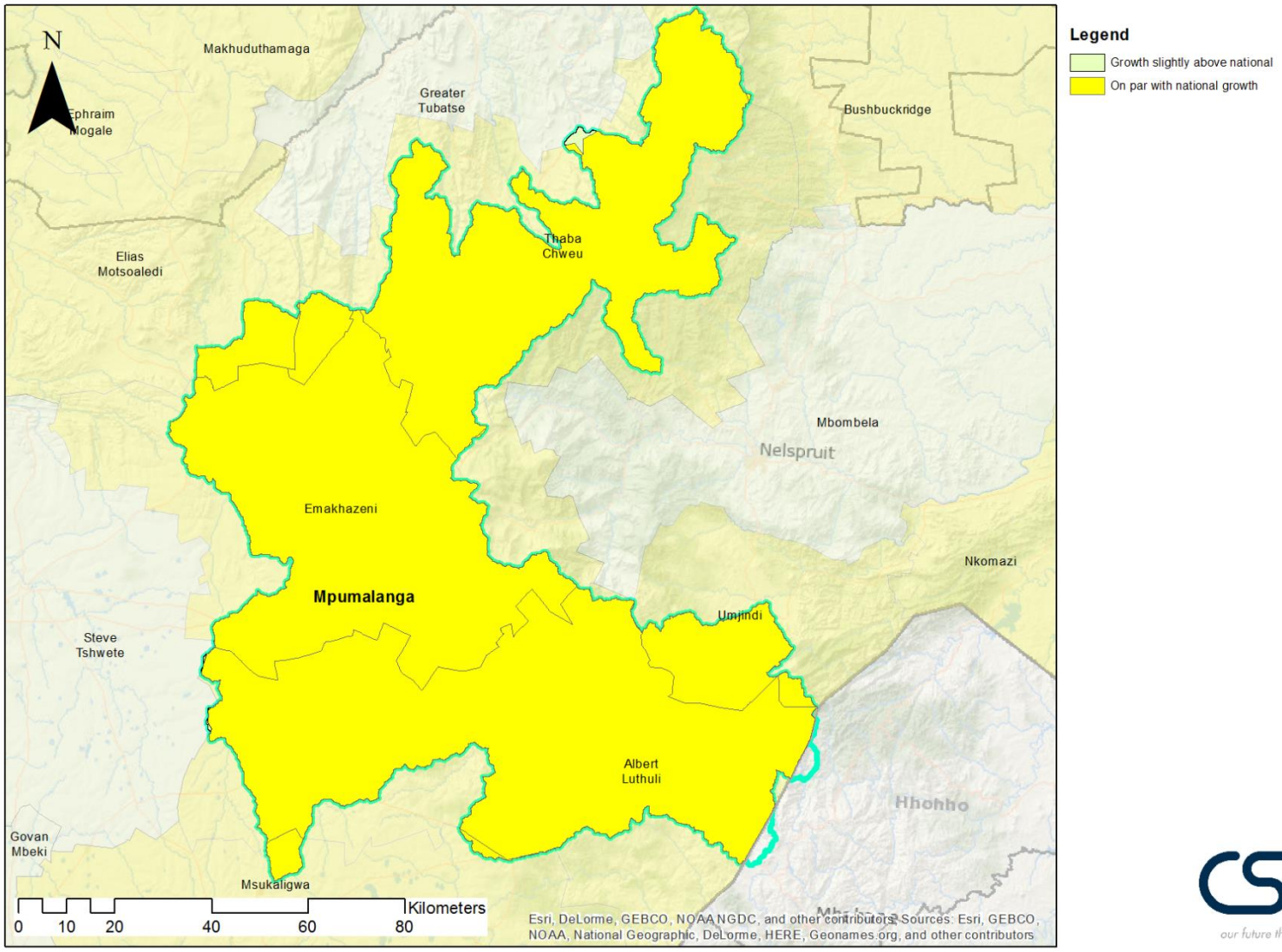
A.7 Richards Bay

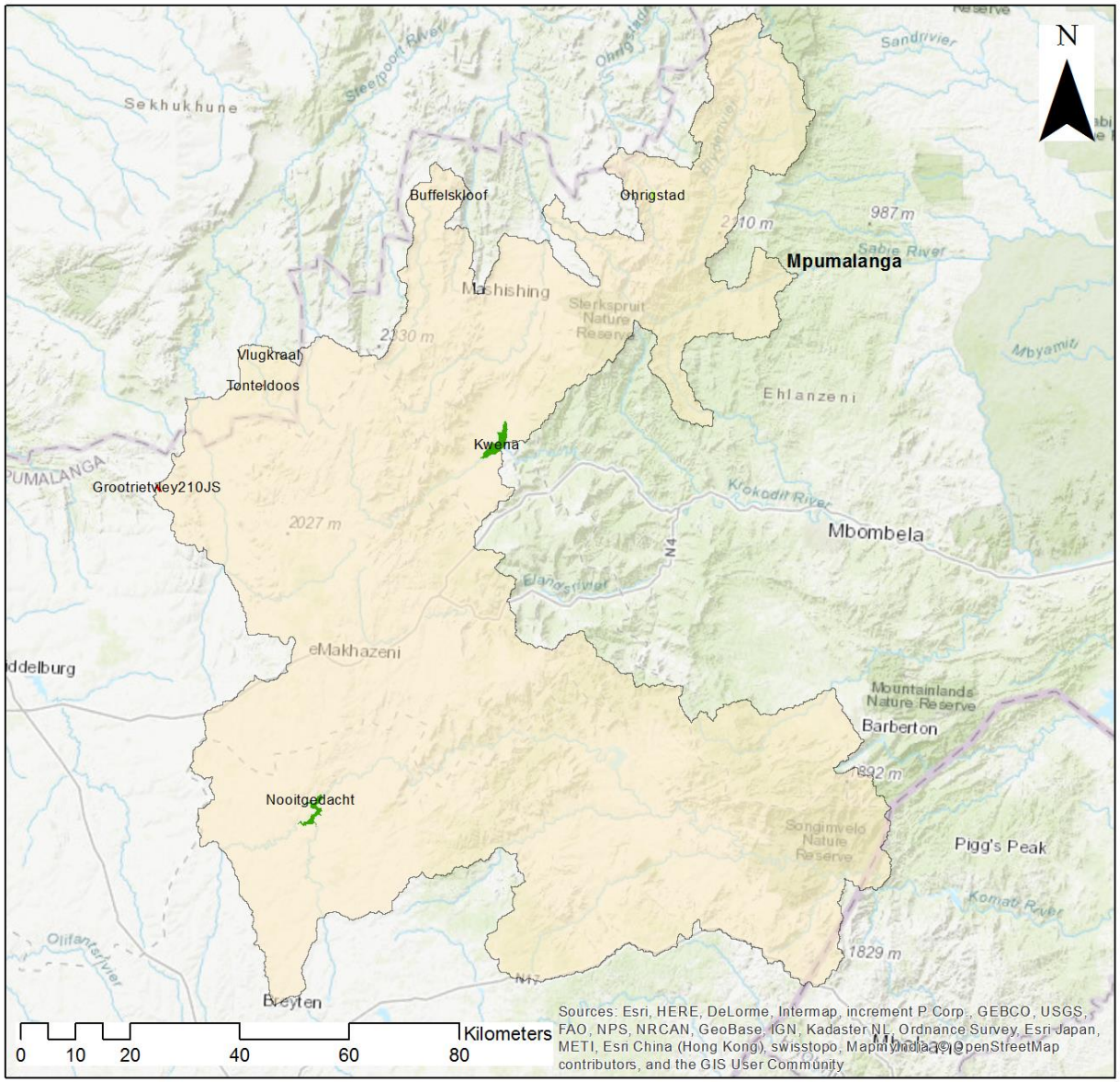


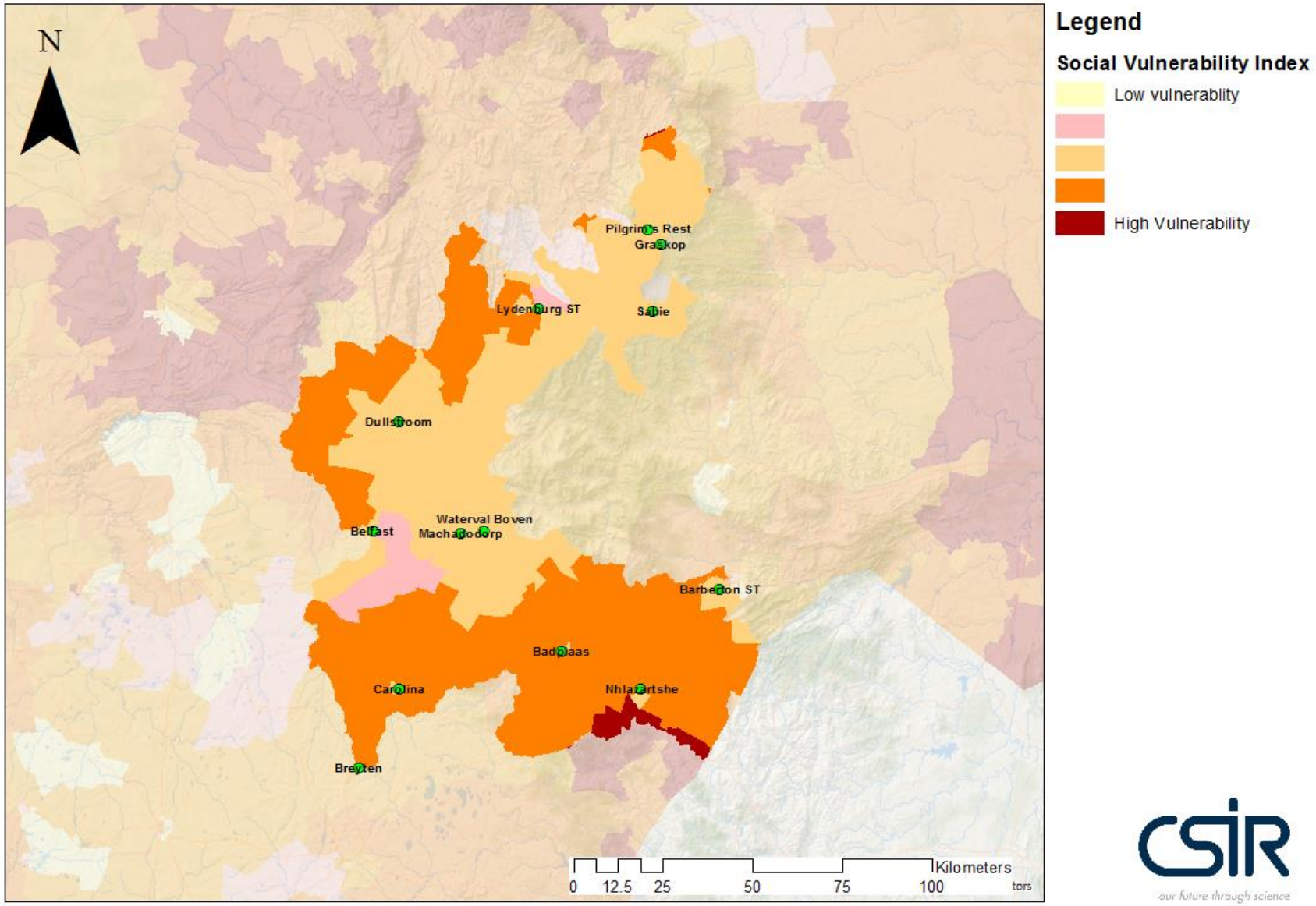

N
Legend
RMP
Not available
Richards Bay
Ulundi
Hluhluwe-Imfolozi Park
Ophathe Nature Reserve
Nhlabane
Nsezi
Lake Msiligazi
Richards Bay
Mhlatuze
Lake Cubhu
Lagoon
Empangeni
Eshowe
Umlalazi
Nyezane
Uthungulu
iLembe
Kilometers
0 5 10 20 30 40
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


N
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability
Richards Bay C
0 5 10 20 30 40
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

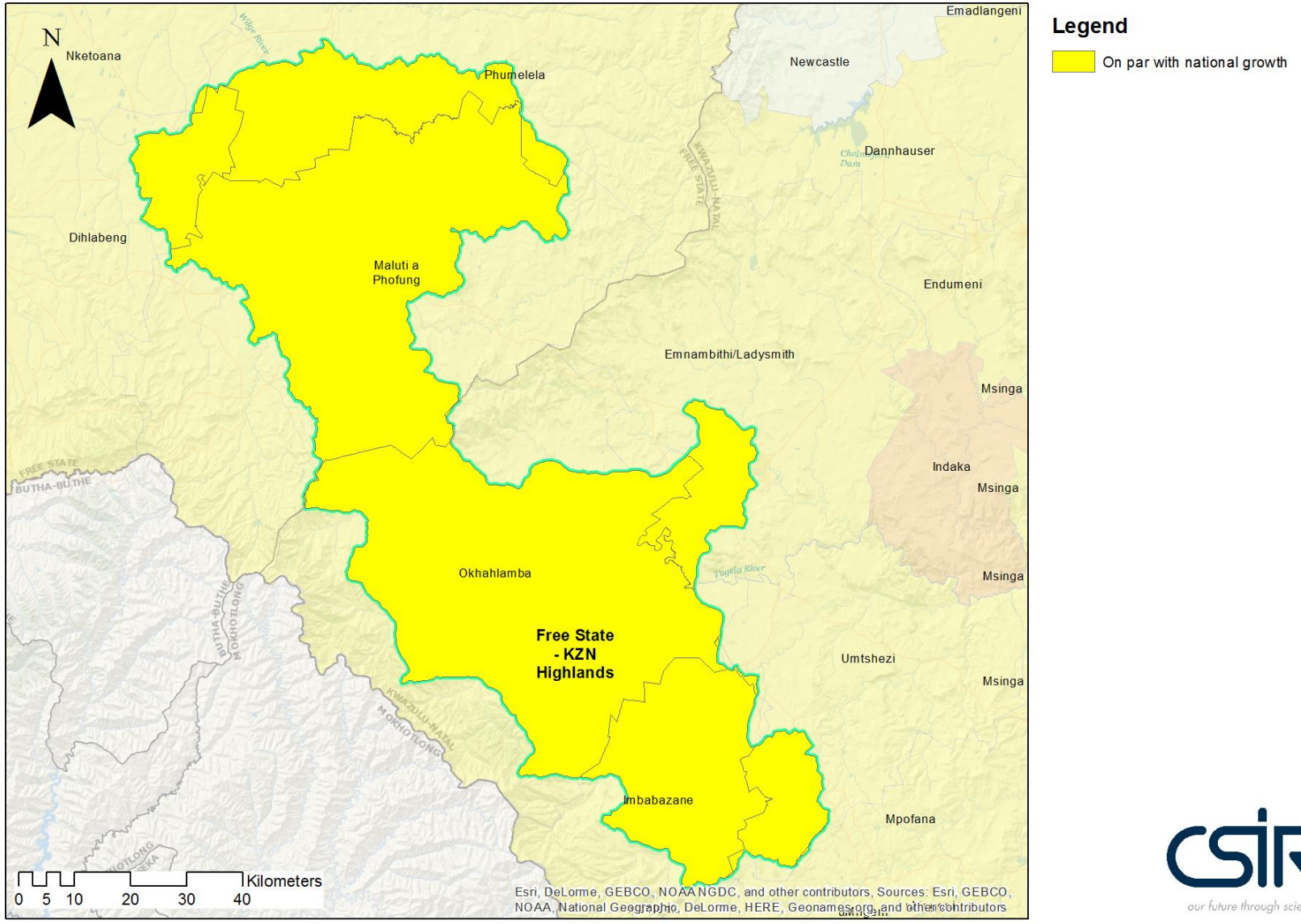
A.8 Mpumalanga

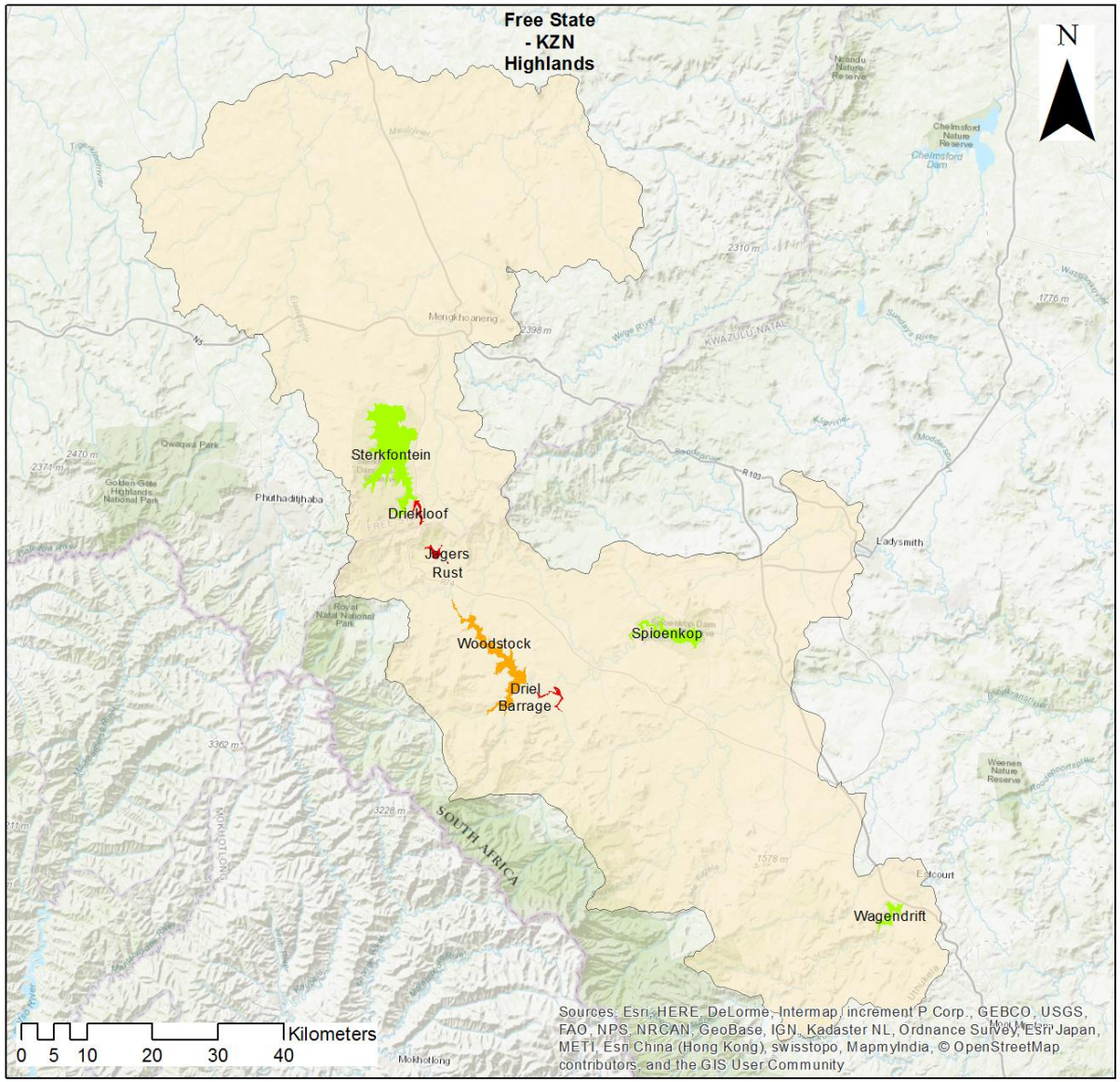



N
Legend
RMP
Available
RMP development in progress
Not available
Sekhukhune
Buffelskloof
Ohrigstad
Mpumalanga
Mashishing
Sterkspruit Nature Reserve
Vlugkraal
Tonteldoos
Kwena
Grootrietvlei210JS
Ehlanzeni
Mbombela
Krokodil River
N4
eMakhazeni
Middelburg
Mountainlands Nature Reserve
Barberton
Nooitgedacht
Songimvelo Nature Reserve
Pigg's Peak
Komati River
Olifantsriver
Breyten
N17
Kilometers
0 10 20 40 60 80
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


N
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability
Pilgrim's Rest
Graskop
Lydenburg ST
Sabie
Dullstroom
Waterval Boven
Belfast
Machadodorp
Barberton ST
Badplaas
Carolina
Nhlazatshe
Breyten
Kilometers
0 12.5 25 50 75 100
tors

A.9 Free State KZN Highlands

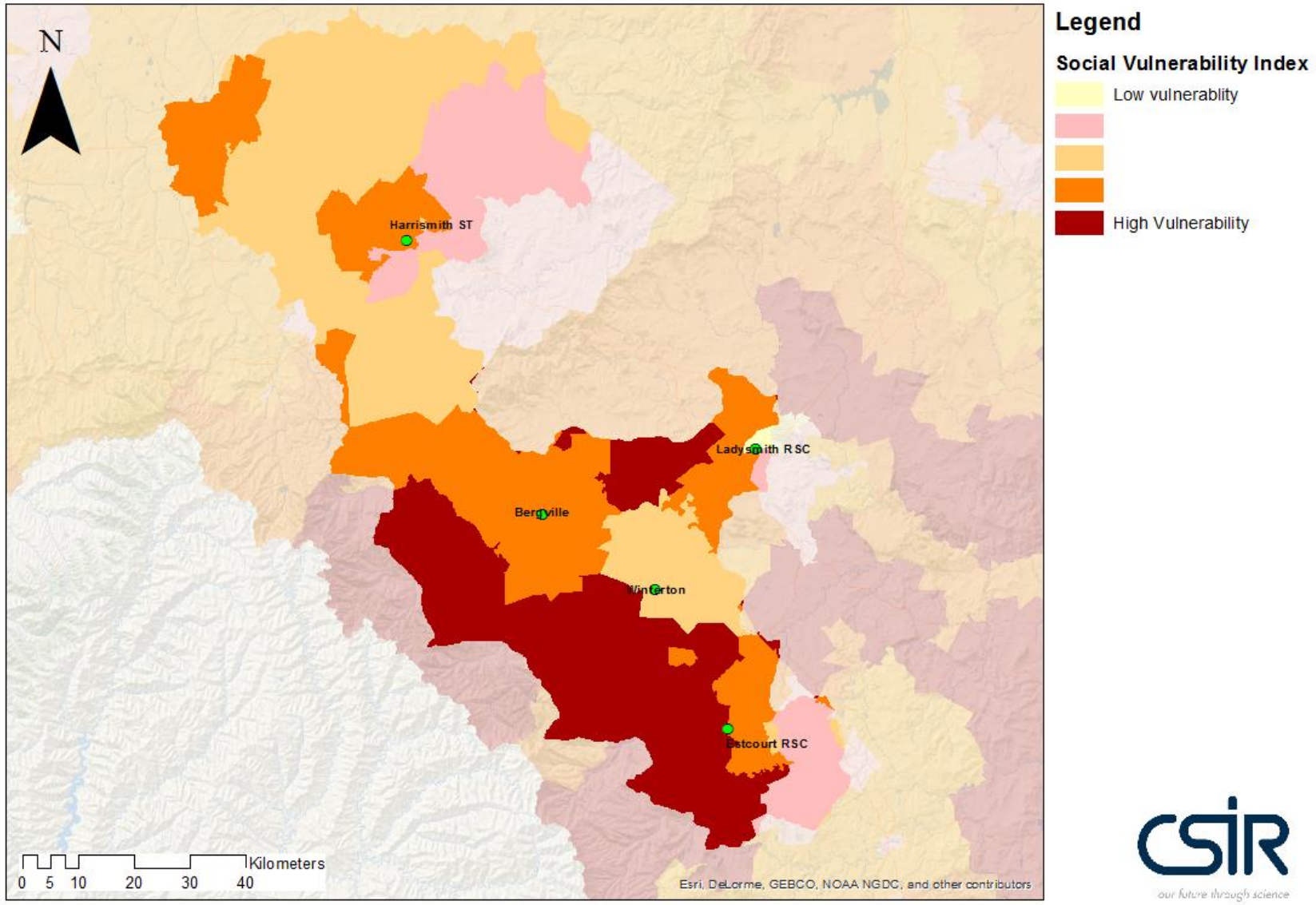




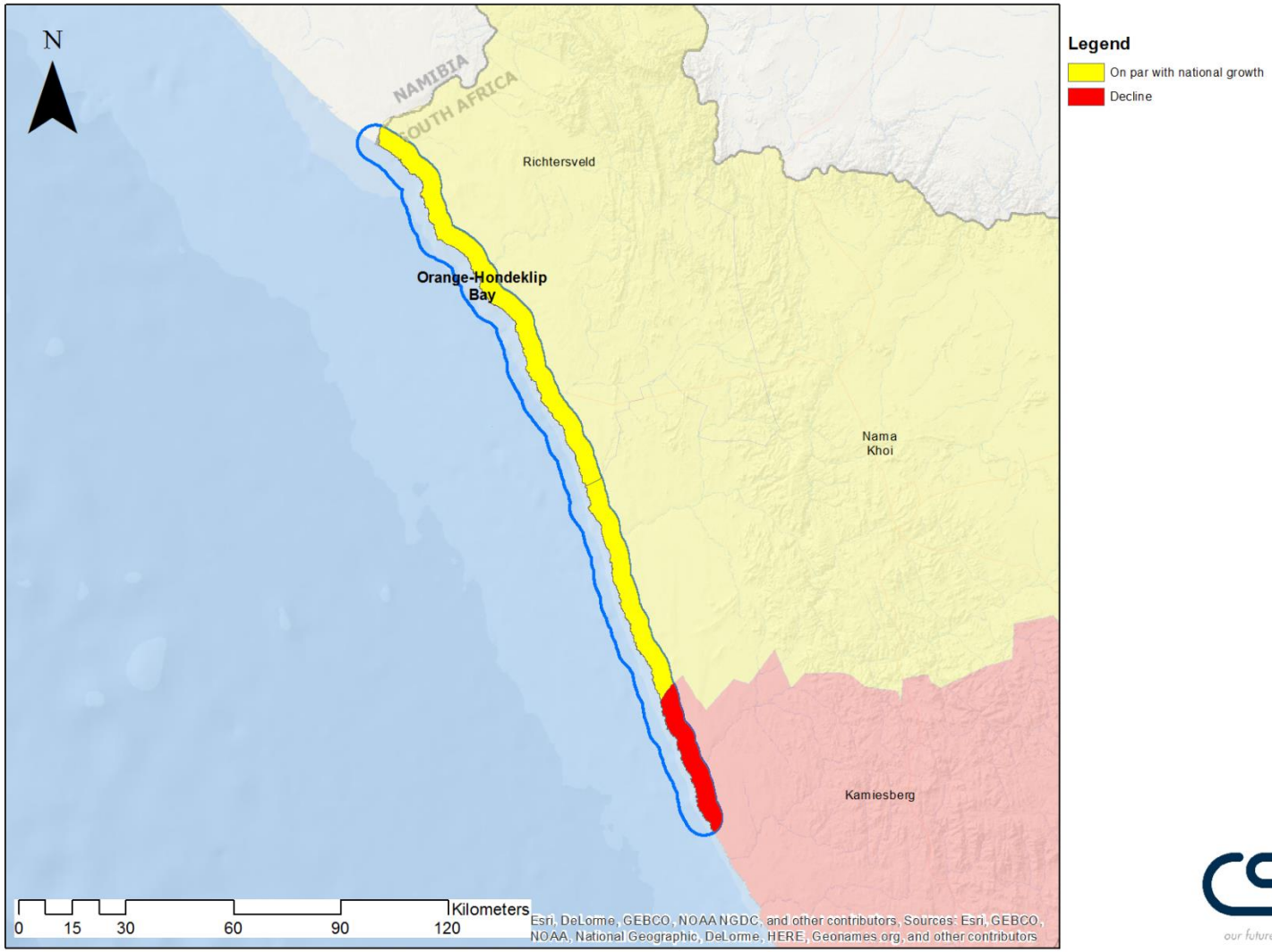
Legend

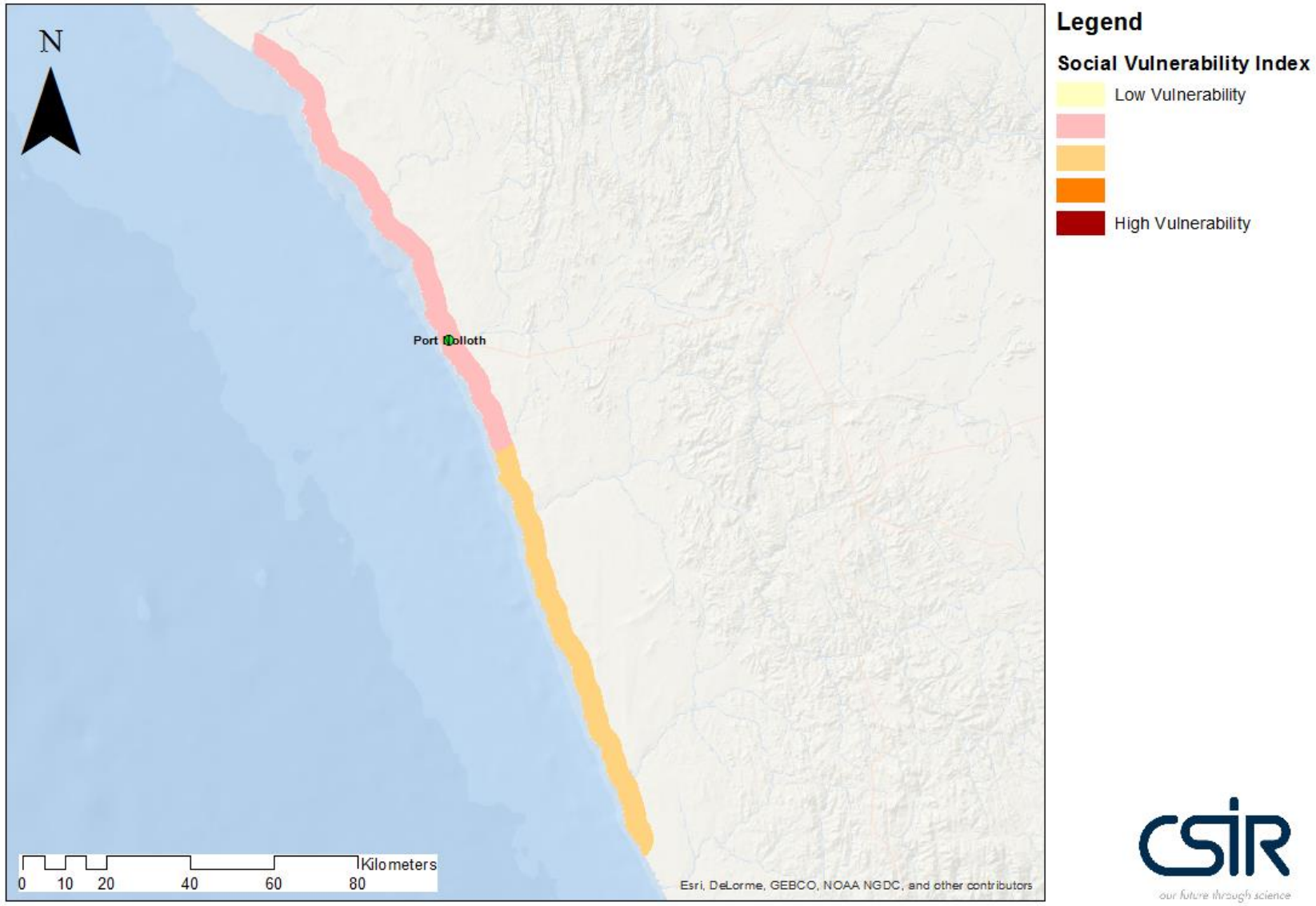
RMP

- RMP development in progress
- RMP development on hold
- Not available

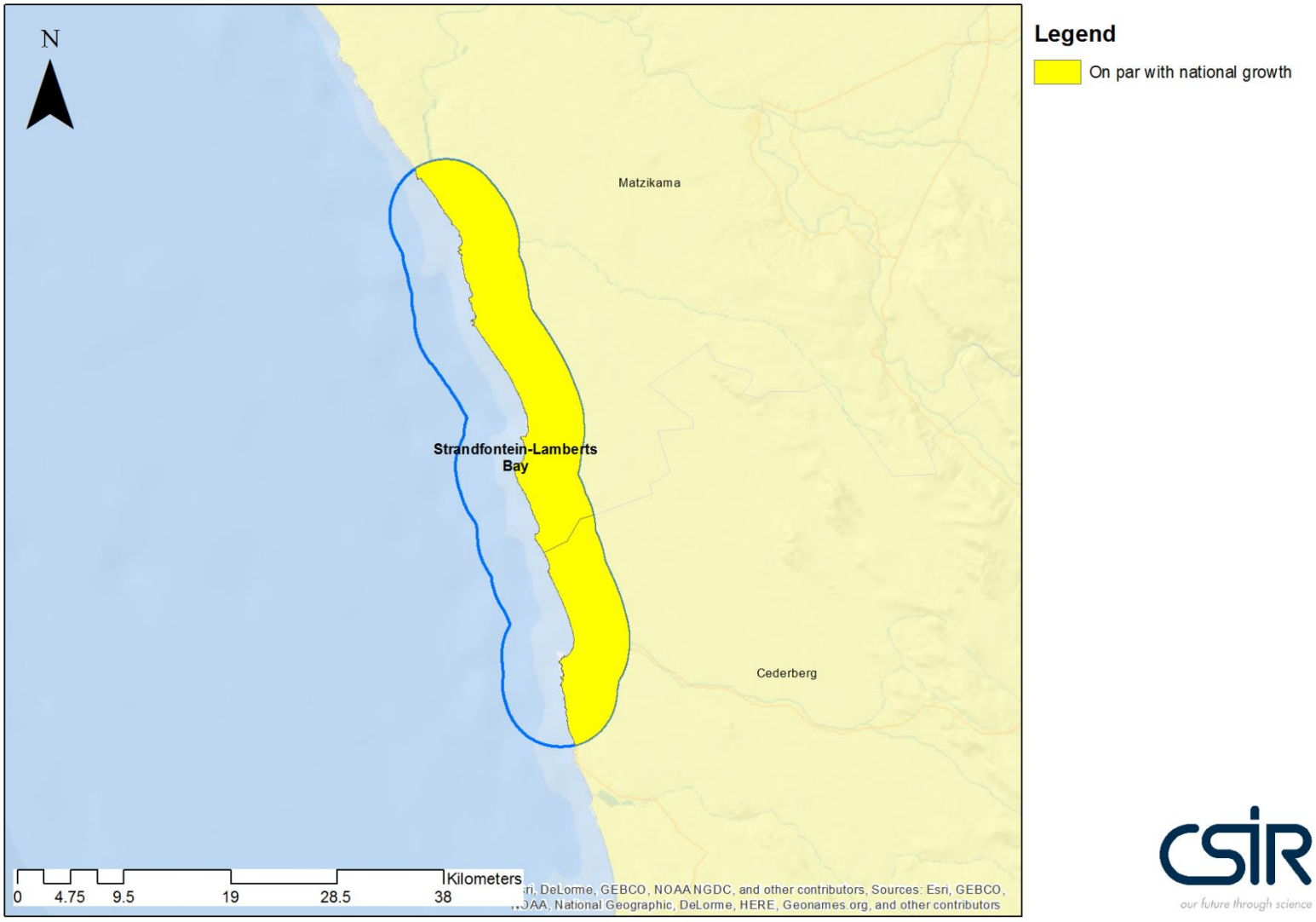

N
Harrismith ST
Ladysmith RSC
Bergville
Winterton
Estcourt RSC
Kilometers
0 5 10 20 30 40
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low vulnerablity
High Vulnerability

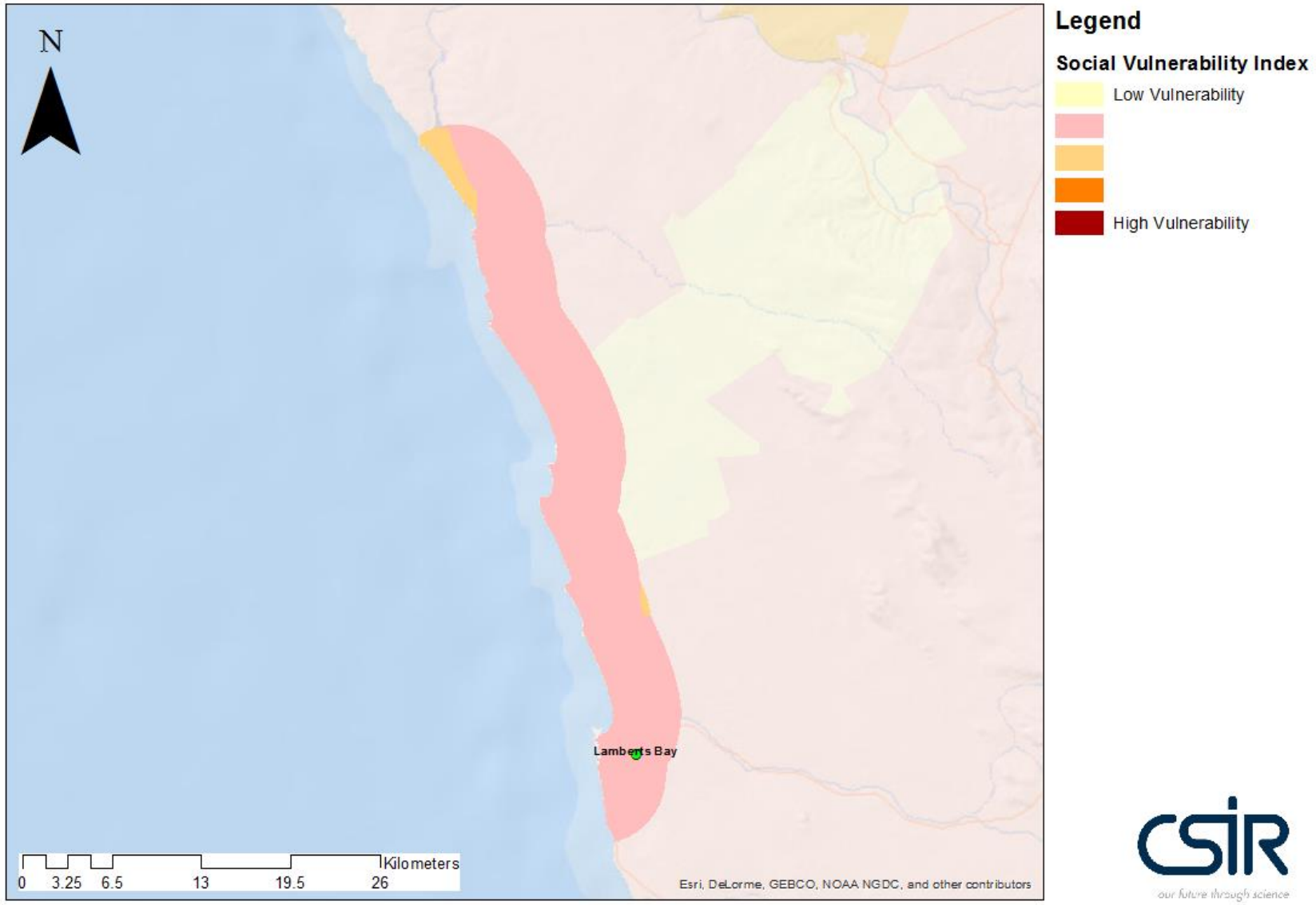
A.10 Orange Hondeklipbaai



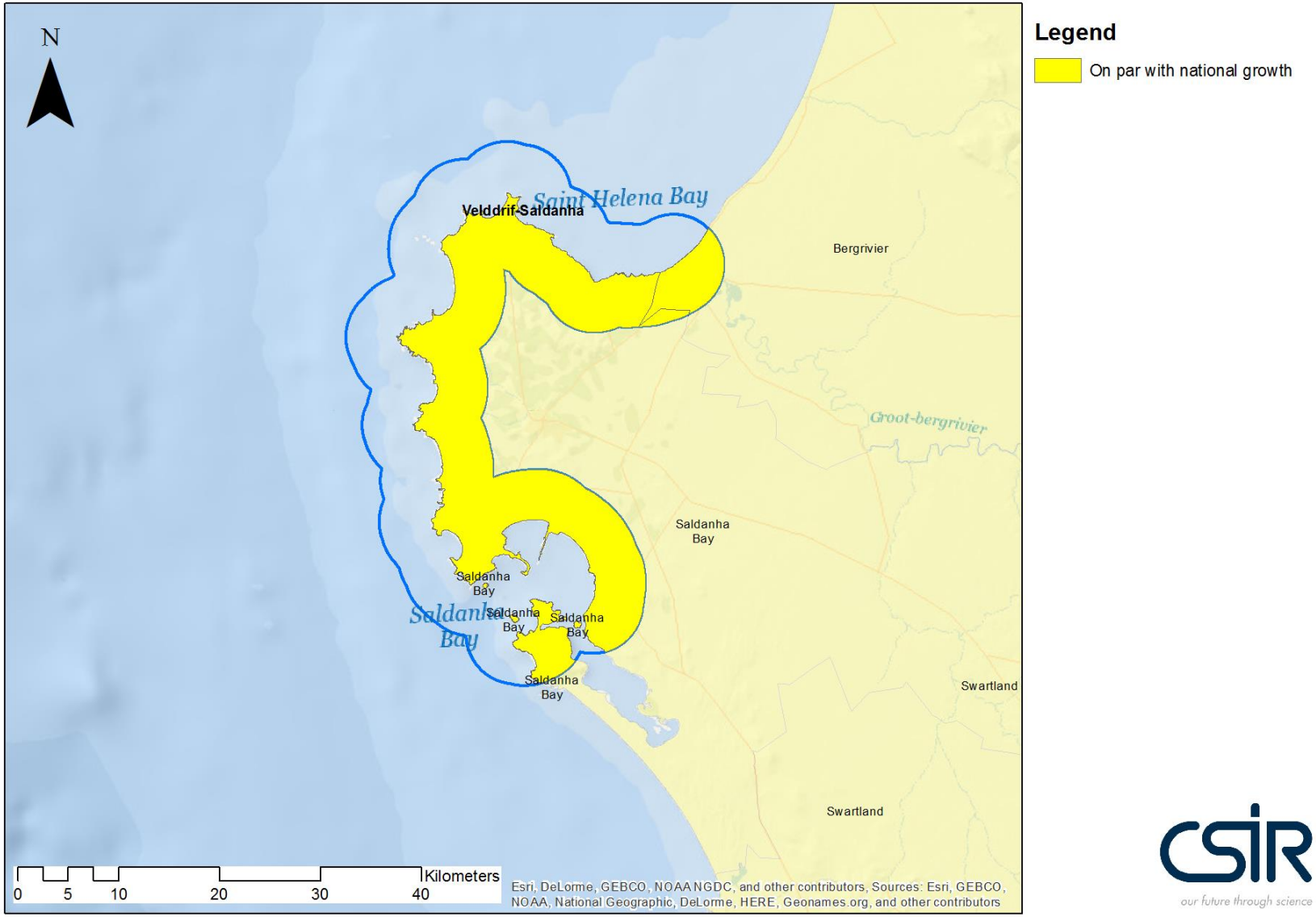

N
Port Elizabeth
Kilometers
0 10 20 40 60 80
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability

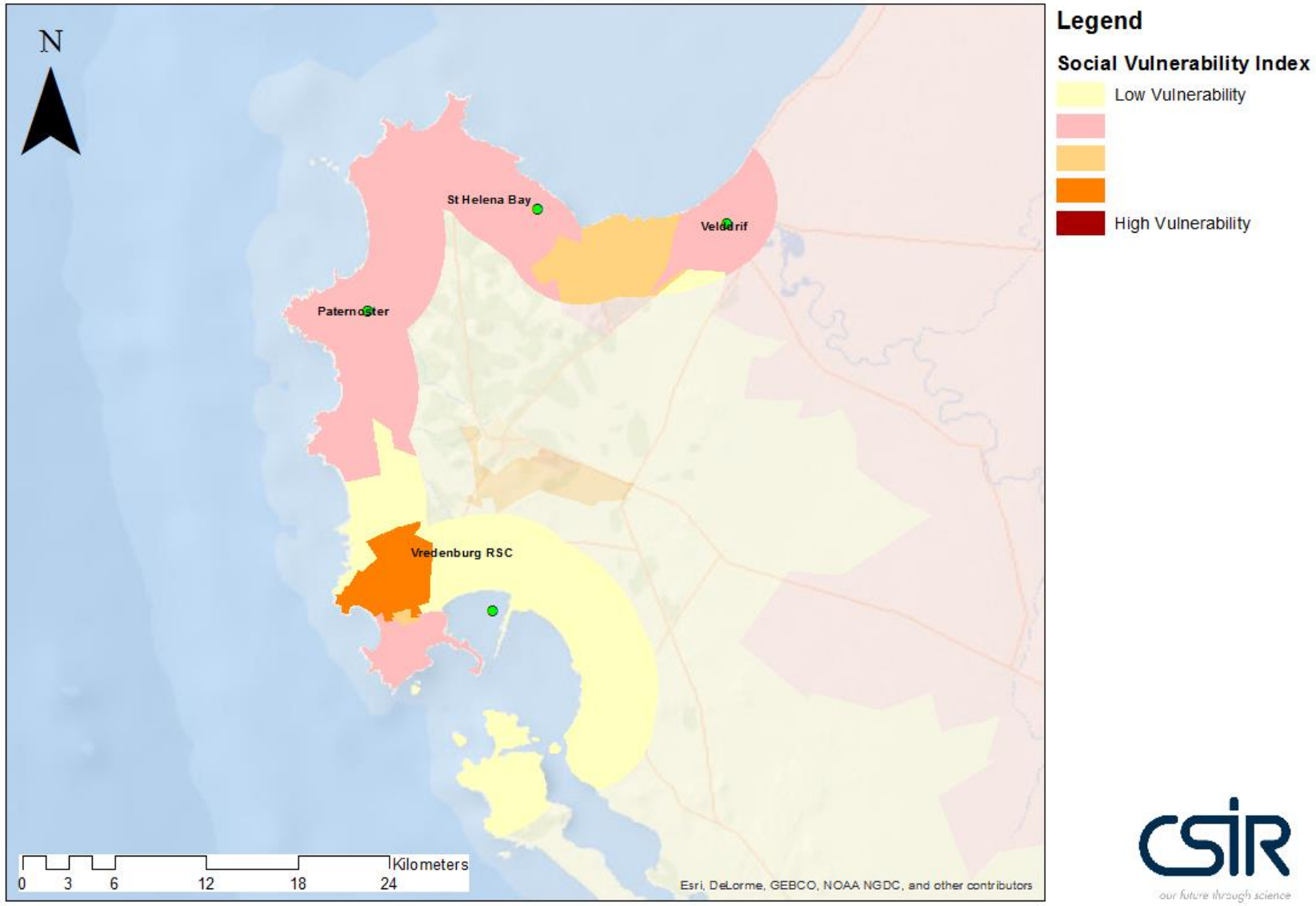
A.11 Strandfontein Lambertsbaai



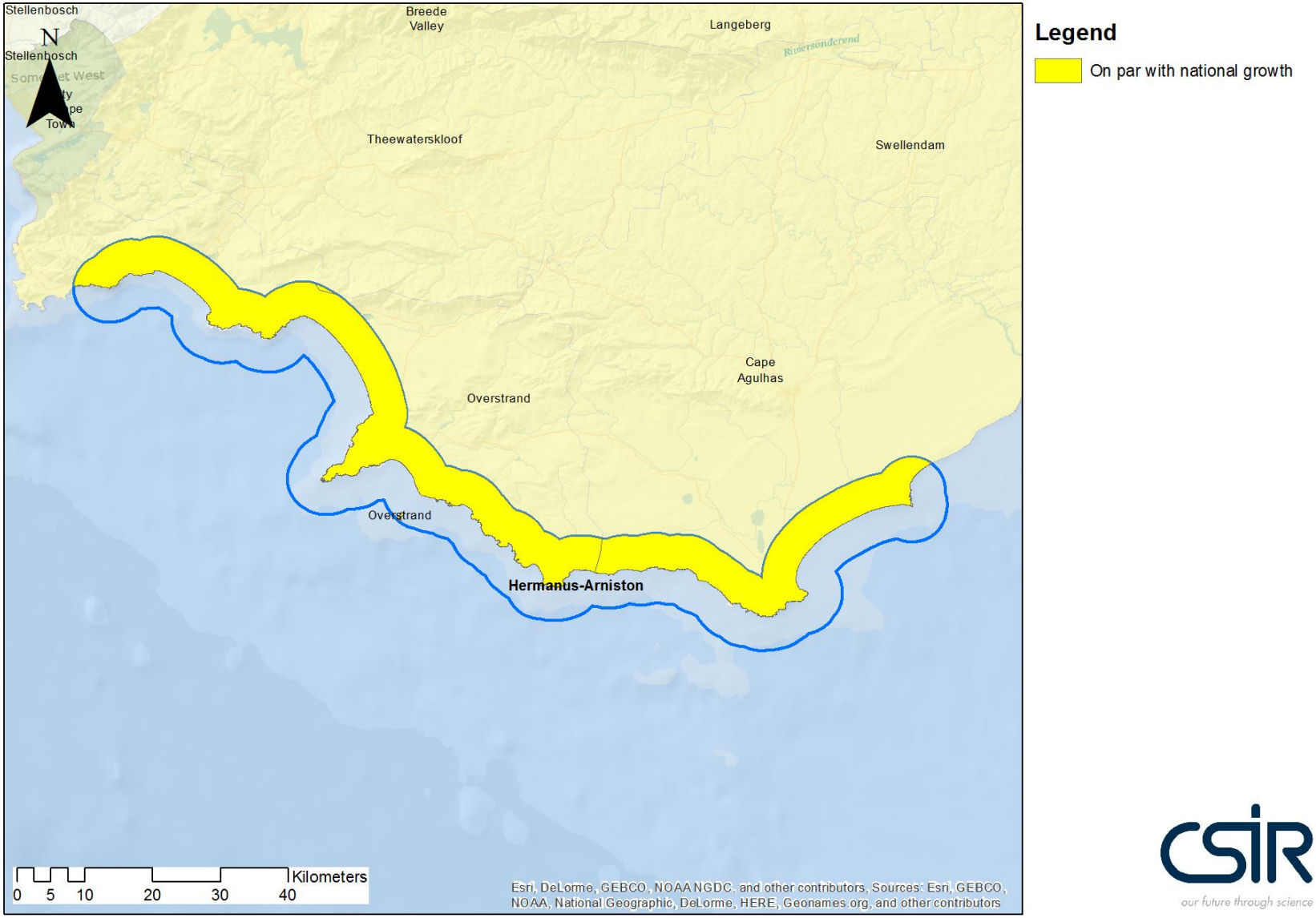

N
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability
Lamberts Bay
0 3.25 6.5 13 19.5 26
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

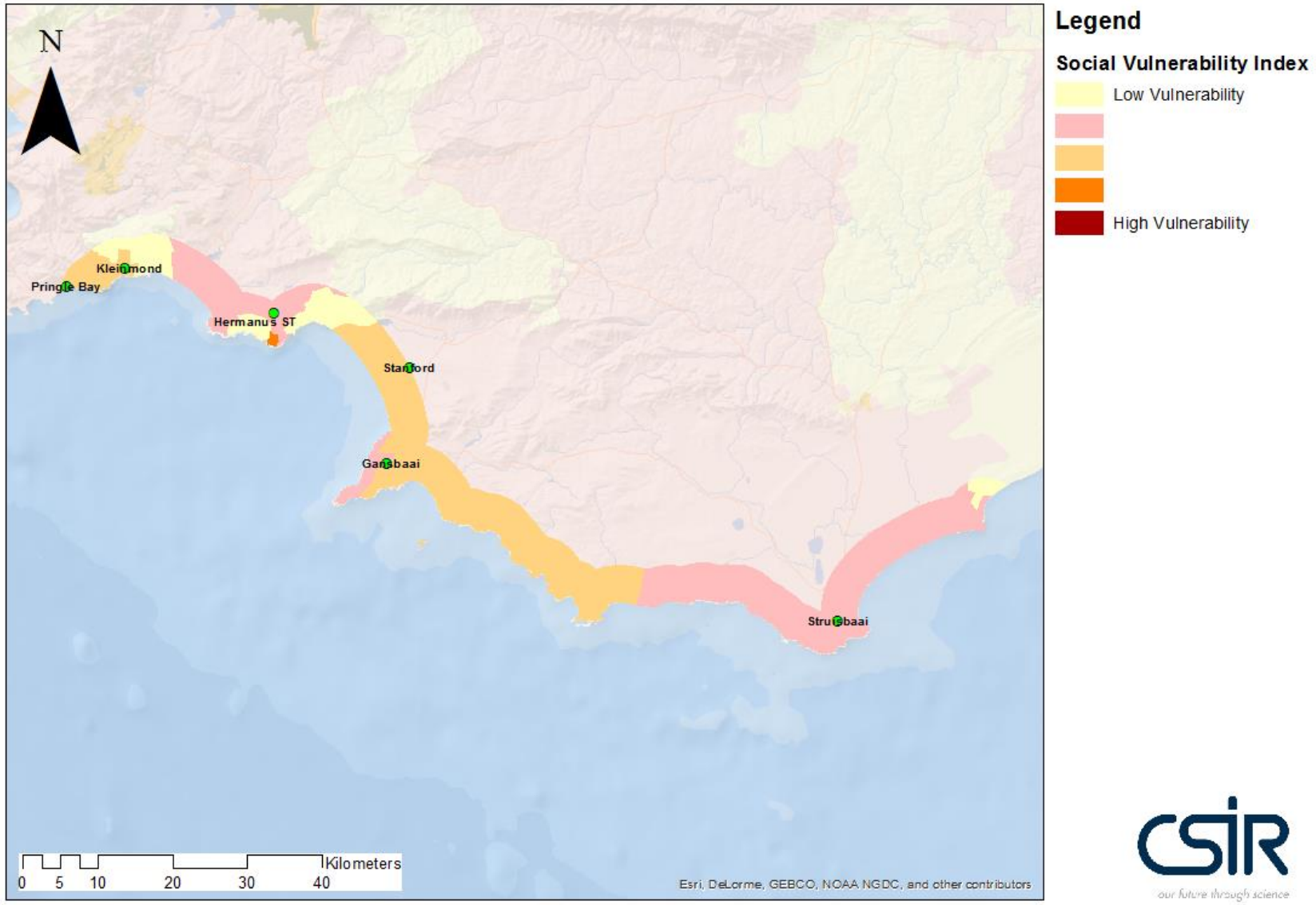
A.12 Velddrif Saldanha



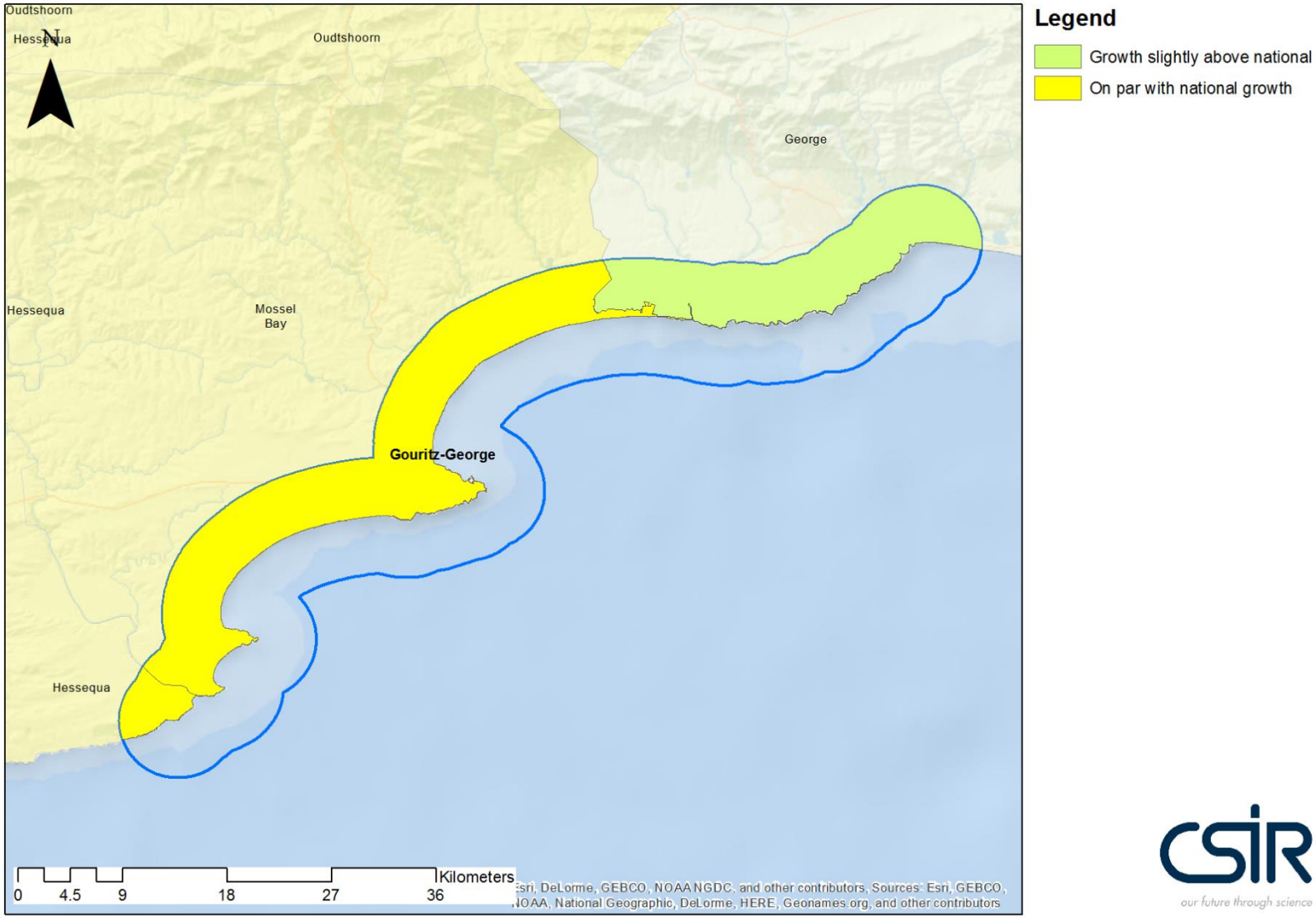

N
St Helena Bay
Velddrif
Paternoster
Vredenburg RSC
Kilometers
0 3 6 12 18 24
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability

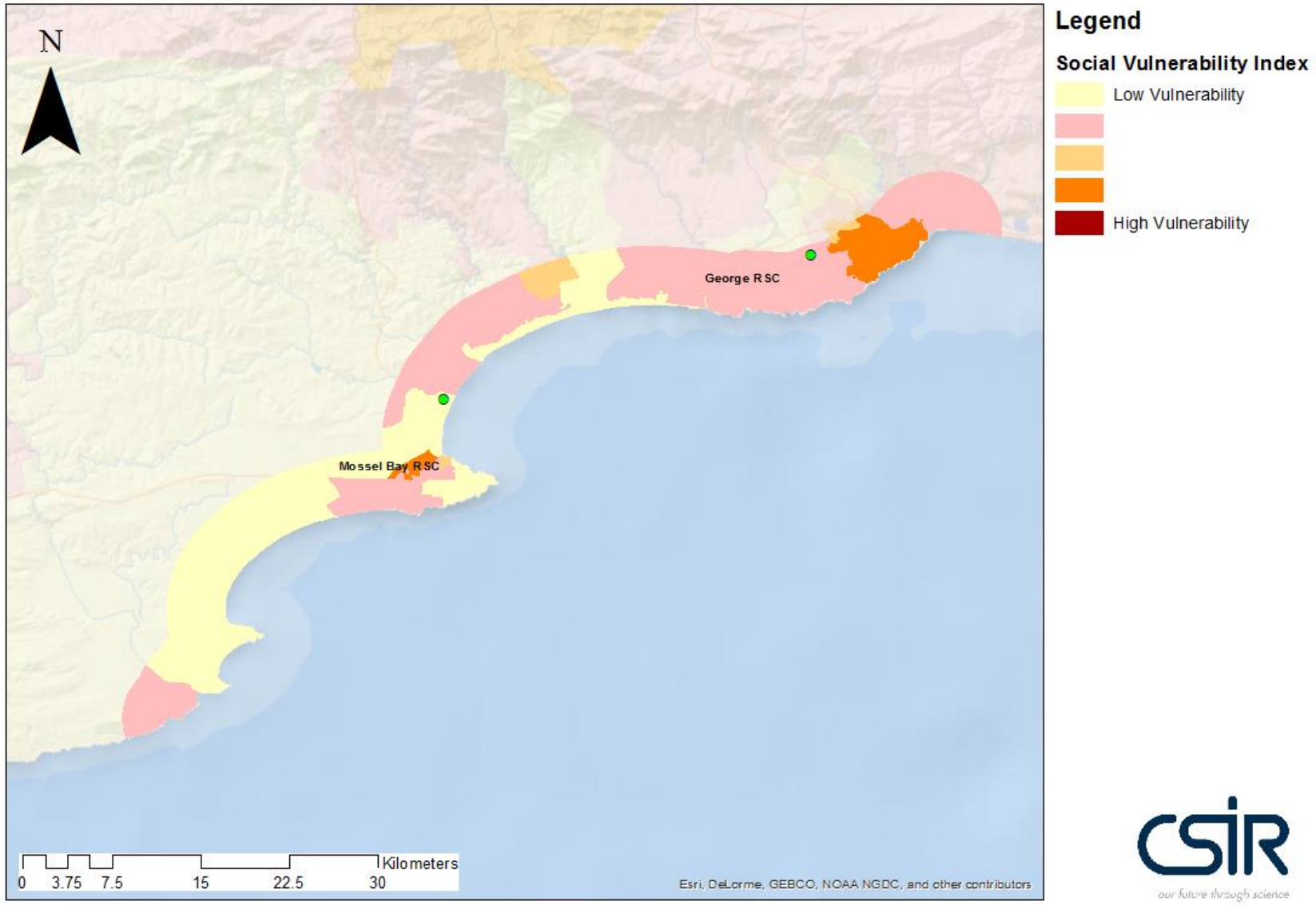
A.13 Hermanus Arniston



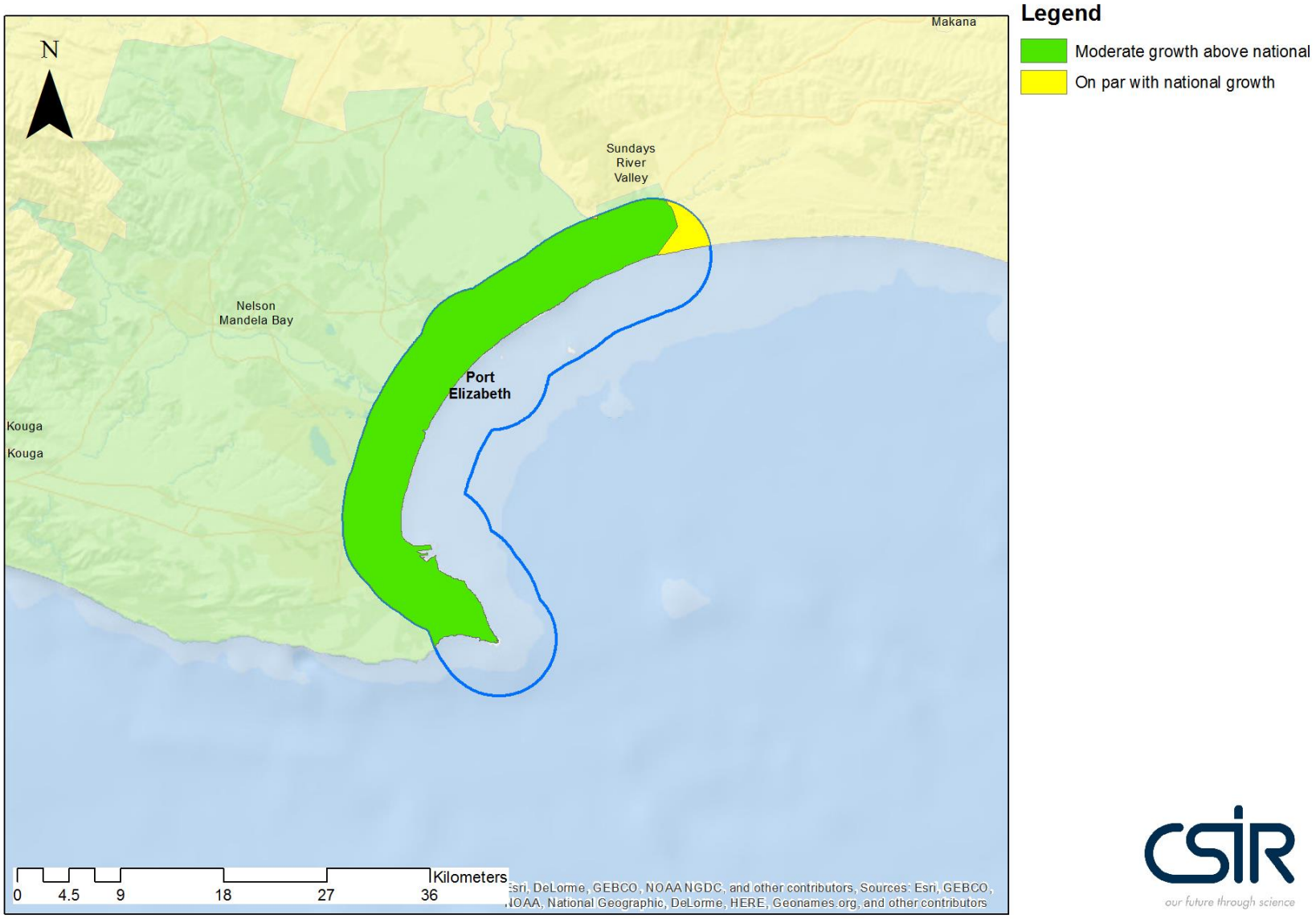

N
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability
Kleinmond
Pringle Bay
Hermanus ST
Stanford
Gansbaai
Struisbaai
0 5 10 20 30 40
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

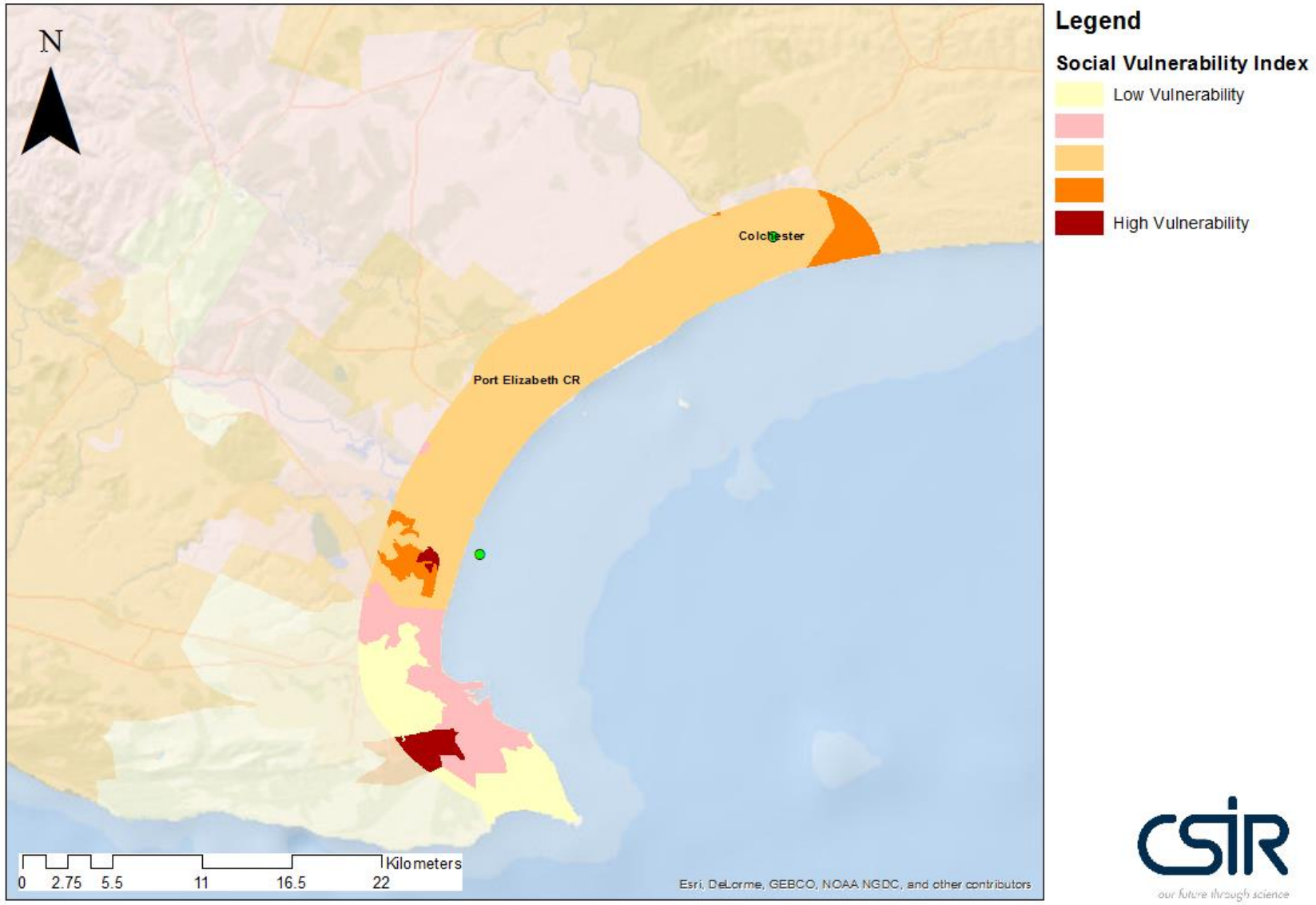
A.14 Gouritz George



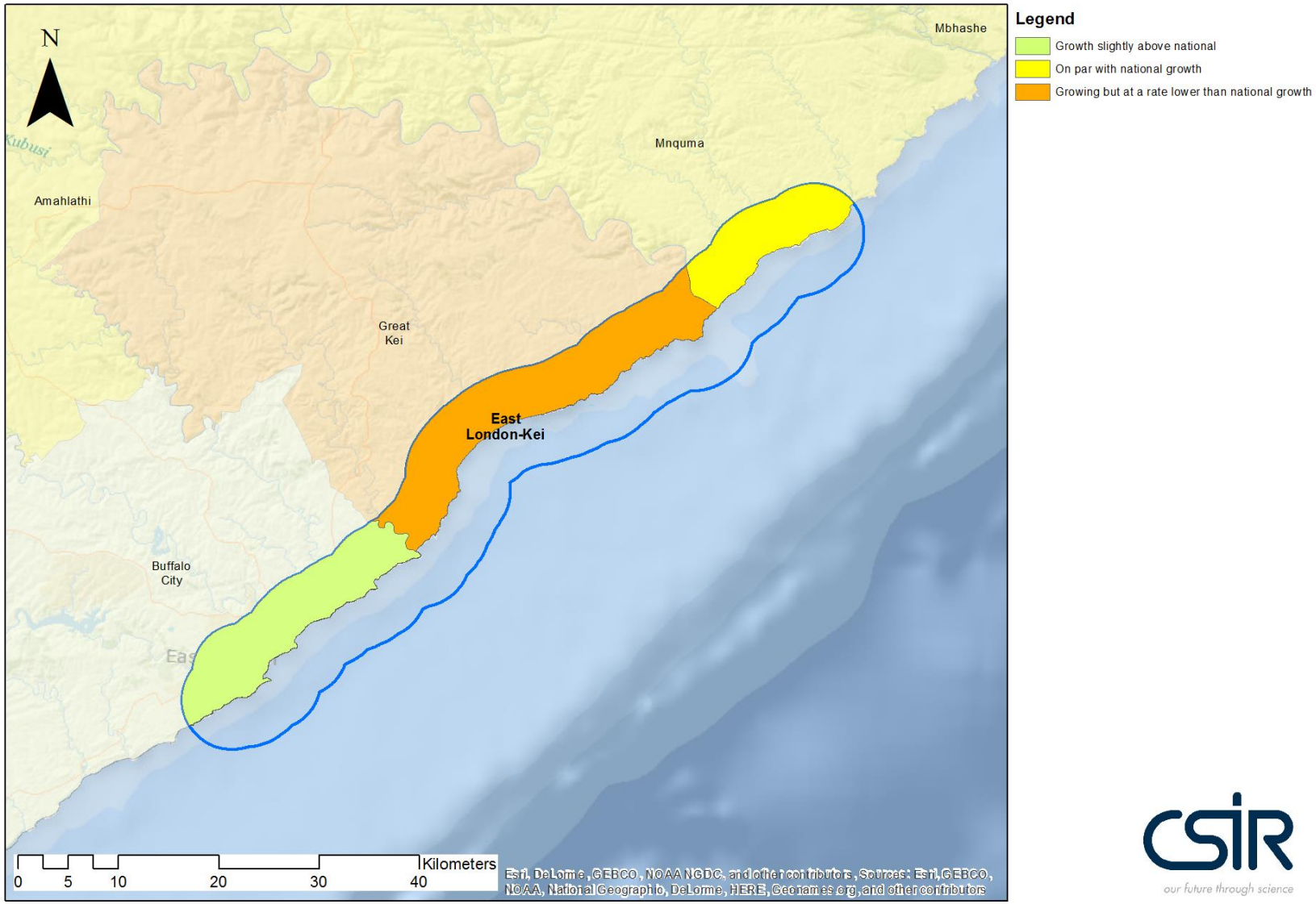

N
George RSC
Mossel Bay RSC
0 3.75 7.5 15 22.5 30
Kilometers
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability

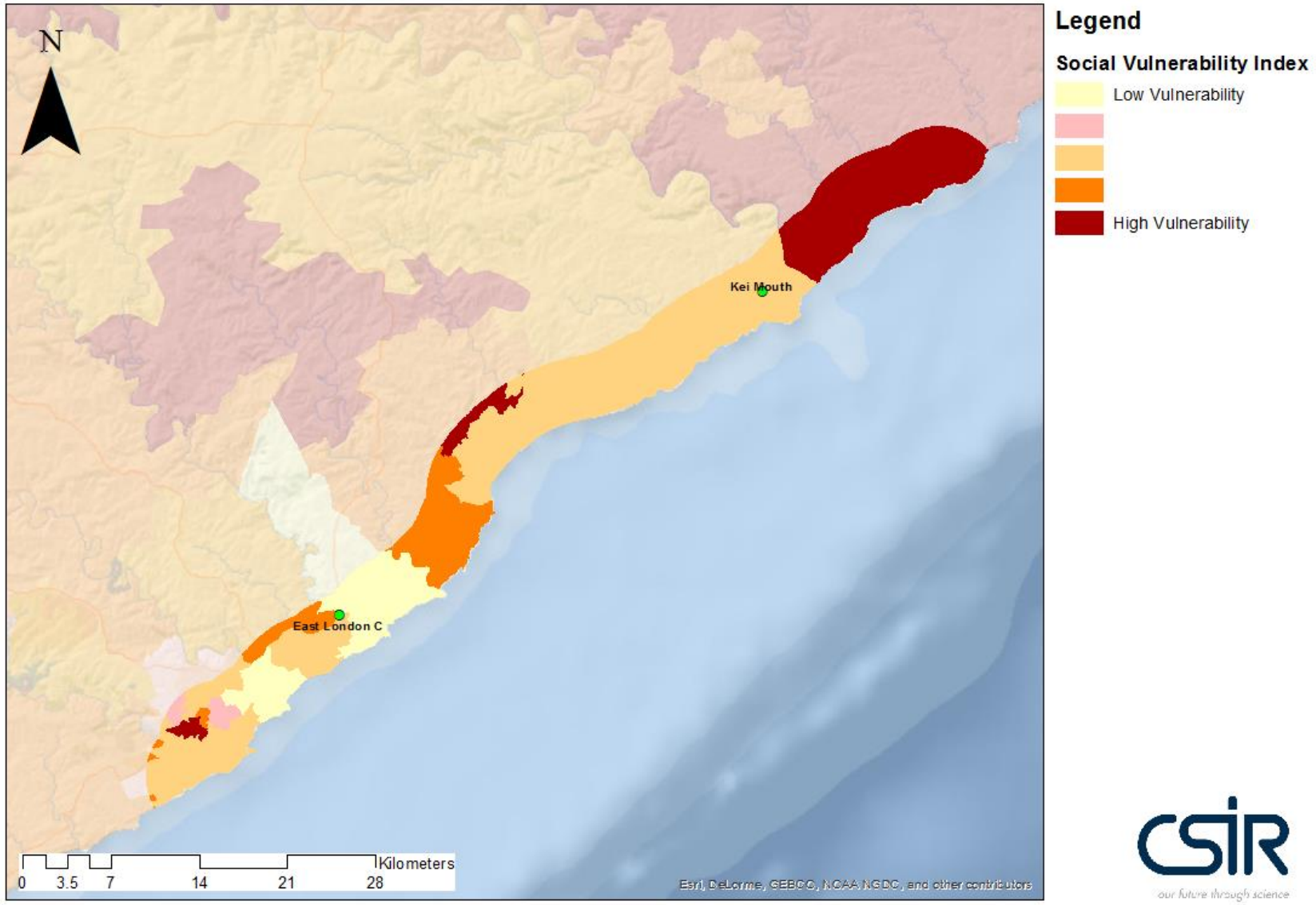
A.15 Port Elizabeth



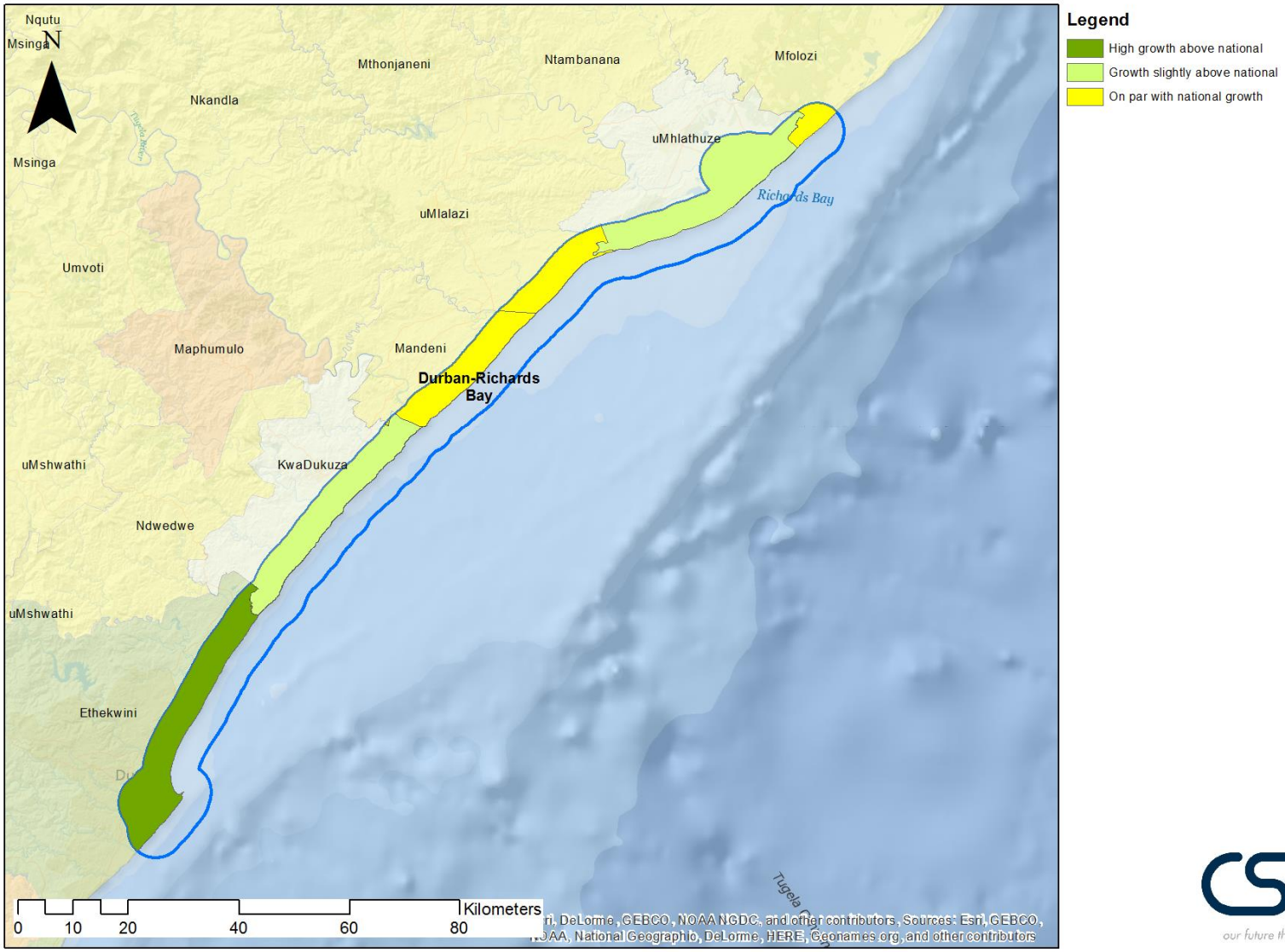

N
Colchester
Port Elizabeth CR
Kilometers
0 2.75 5.5 11 16.5 22
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability

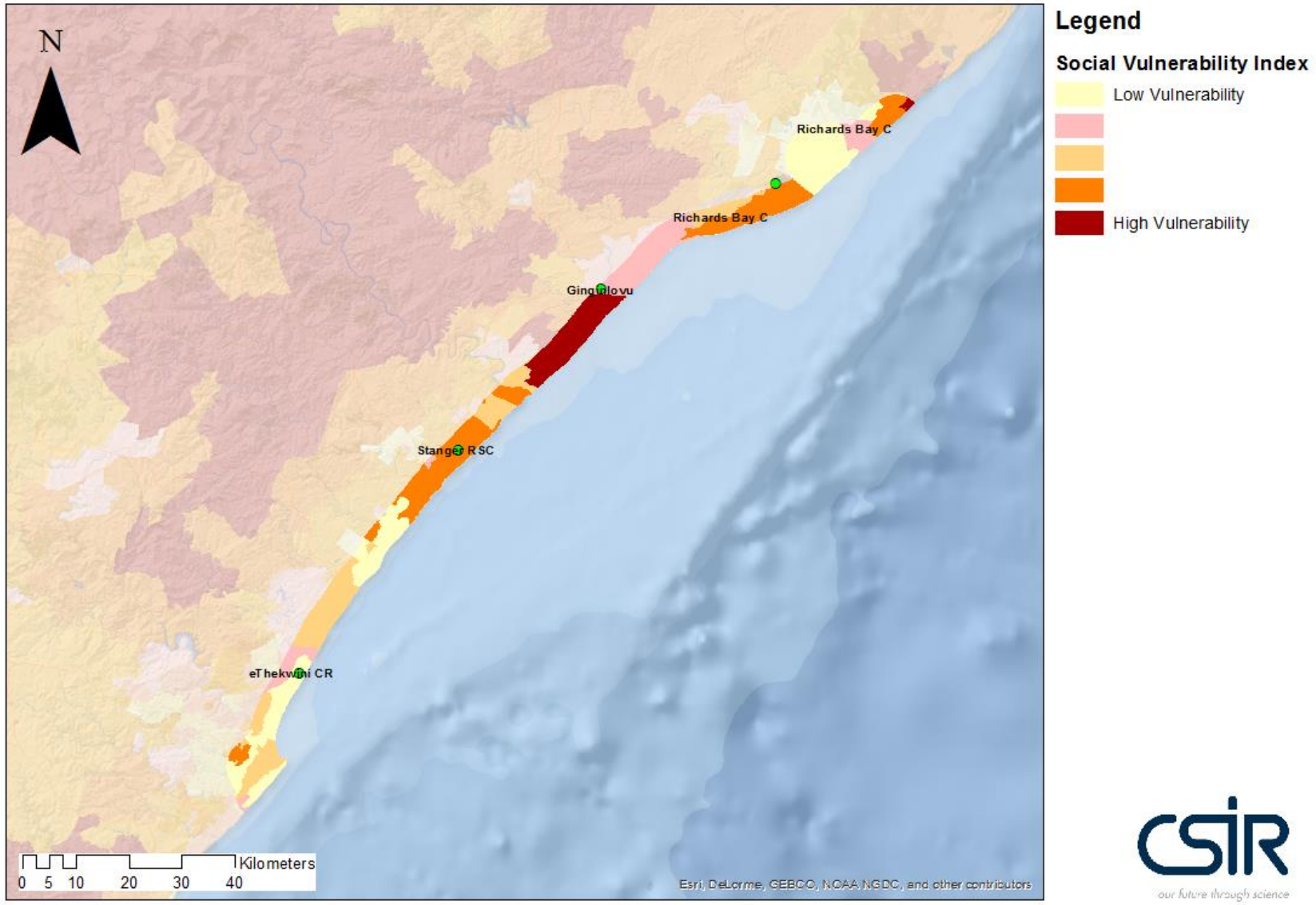
A.16 East London-Kei




N
Kei Mouth
East London C
Kilometers
0 3.5 7 14 21 28
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability

A.17 Durban Richardsbay




N
Richards Bay C
Richards Bay C
Stanger RSC
eThekwini CR
Kilometers
0 5 10 20 30 40
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Legend
Social Vulnerability Index
Low Vulnerability
High Vulnerability