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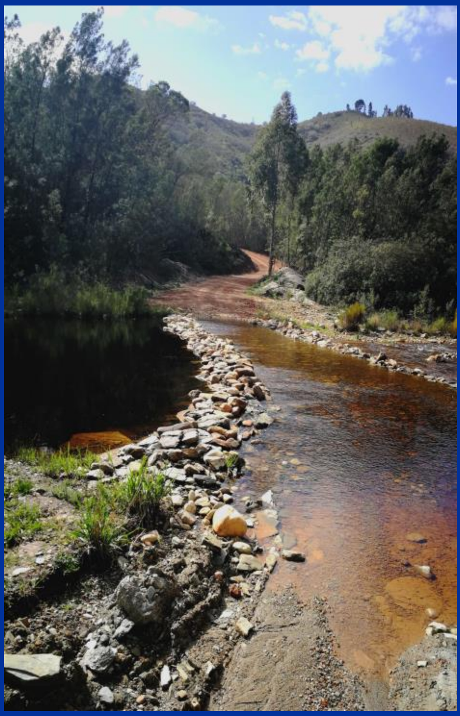

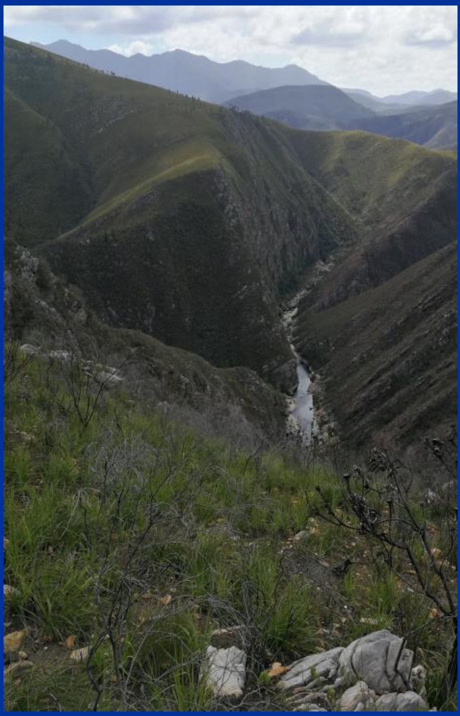

BUSINESS CASE FOR KEURBOOMS AND KARATARA RIVER CATCHMENTS

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EXECUTIVE SUMMARY

Through the establishment of the Western Cape Provincial Ecological Infrastructure Investment Framework (EIIF), the Province of the Western Cape presents a business case that demonstrates to investors (private sector and local municipalities) the feasibility of alien clearing and restorative work as an instrument towards enhancing water availability in the key strategic water provisioning areas of the Karatara and Keurbooms river catchments. Furthermore, in the said business case appropriate Payment for Ecosystem Services (PES) opportunities have been investigated and proposed (for local municipalities) towards operationalising a payment scheme that re-invests the offset value of water gained into further alien clearing and restoration[1] activities.

A process of extensive land accounting, ecosystem service mapping and valuation assessments was conducted to quantify the socio-economic value of missed natural benefits resulting from invasive alien plant (IAP) infestation in the Karatara and Keurbooms catchment areas.

Cost-Benefit Analysis

The lost (due to IAP infestation), yet retrievable, ecological infrastructure value was conservatively estimated for the Karatara and Keurbooms catchments to fall between R31.5 mil and R315 mil per year. This value took into account the restoration of water provisioning, disaster regulation (fire regulation) and habitat supporting services.

The provisioning of additional water was shown to have by order of magnitude the greatest proportion of the total value lost. The volume of water lost through the current distribution of IAPs in the region is estimated to be in the order of 25 000 ML per year (approximately 20% of the capacity of Berg River dam). As a result the opportunity value of additional water is estimated to fall between R25.1 mil and R307.3 mil per year.

The high variation between minimum and maximum values indicated above is a result of firstly, the marginal value of water having a steep curve in water scarce regions such as the WC. This can best be described by indicating the significant difference in cost per litre between say constructing additional dams and installing and operating desalination plants. Secondly, limited spatial data and evident spatial heterogeneity resulted in extreme marginal values specifically being chosen to remain confident that the "actual value" falls within the range.

[1] Please note that ecological restoration is consistent with Alien clearing programmes.

The average value for Bitou Local Municipality is in the order of R75 mil per year. The average value of for George Local Municipality is in the order of R50 mil per year. The average value of for Knysna Local Municipality is in the order of R47 mil per year.

Through alien clearing and restoration activities the water benefits alone would contribute an average ecological infrastructure value of R166.2 mil per year. This represents a substantial opportunity for maximising benefits through internalisation of this lost value into the economy.

Furthermore through ecological restoration and IAP clearing the disaster regulation (or insurance risk) value through saved insurance costs is in the order of R4.8 mil per year and the additional habitat support value, based on improved condition of ecosystems is estimated at R1.6 mil and R2.9 mil per year.

Additional, more direct benefits of IAP clearing and restoration include job creation and stimulation of the local economy. The clearing and restoration of the total current extent of IAPs in the region would require an average of 100 000 person days per year over the first five years (approximately 400 jobs per year). Furthermore, the total market value received through the sale and use of alien plant biomass has been identified to average R270 mil (between R35 000 and R47 000 per ha of high density stands). With the region faced with an unemployment rate of 32%, IAP clearing provides a vital opportunity to improve local socio-economic conditions.

Moreover, the benefits of ecological restoration and IAP clearing significantly outweighs the input costs required for the actual clearing and restoration. In fact, for every R1 invested in IAP clearing and restoration, there is a multiplied return of investment to the catchment of R3.87 through reclaimed natural benefits: demonstrating a strong case for investment that will lead to sustainably-managed ecological infrastructure, while improving local and regional socio-economic well-being.

Implementation Strategy

A comparative risk assessment methodology combined with SWOT analysis was applied to identify Economic Policy Instruments (EPI) that could serve as local tools to internalise the value of ecosystem services into economic decision-making. The EPIs attempt to influence behaviour and decision-making through the introduction of economic incentives/disincentives into the economic decision-making processes.

Driven by the significant opportunity in the restoration of the water provisioning service the key proposed EPI is an Alien Clearing Water Charge EPI.

The Alien Clearing Water Charge would constitute a payment by the water service authority to the land owner for initial clearing and maintenance. The Department of Water and Sanitation (DWS), in all its reconciliation strategies, recognises that alien invasive clearing is a form of raw water supply. If a landowner therefore does alien clearing the water yield of the catchment will increase. The increased water yield is the water provisioning benefit resulting from alien clearing. The direct beneficiary of the additional yield would be the water management authority (WMA) downstream of the cleared area. This could be a government water scheme, a water board, or a water service authority (WSA). In this case the direct beneficiary would be the George, Bitou and Knysna Local Municipalities, which are all referred to as WSAs.

The magnitude of the water charge may also vary depending on the marginal cost of water supply. In the most expensive case desalinated sea water, at an approximate cost of R12 /Kl serves as the highest marginal cost of supply. In the best case, the cost of alien clearing provides a minimum water charge which is equivalent to R1/Kl. The actual charge would lie within this range of value and would be negotiated between the landowner and the WSA on a case-by-case basis. In this case, we estimate the potential value of additional water to be between R25.1 to R307.3 mil per year with a net present value equivalent to R76 000 to R933 000 per ha.

The implementation of the Alien Clearing Water Charge EPI requires detailed planning, multiple organisations and new institutional arrangements to be implemented. It is therefore important that a concise measurable and time bound strategic goal be defined to guide strategy implementation.

The business case goal proposed by stakeholders reads as follows:

"By 2021 the private landowners and municipalities of the Karatara and Keurbooms catchment areas in collaboration with key stakeholders, develop market-driven Economic Policy Instruments (EPIs) for alien invasive plant species removal and rehabilitation[2], that link with the benefits of restored ecological infrastructure to economic decision making."

As the key beneficiary of restored ecosystem services through IAP Clearing programmes the strategy must be led by the relevant local municipality (Bitou LM, George LM and Knysna LM). As part of the broader EIIF process, the Western Cape Government will provide support and oversight to the process.

Land owners, on whose land IAPs occur, would play a central role to enabling the implementation of the strategy. A number of key stakeholders will have important strategic roles. Such stakeholders include the Department of Environmental Affairs Natural Resource Management programme, South African National Biodiversity Institute (SANBI), Biodiversity Finance (BioFin), World Wildlife Fund (WWF), Breede Gouritz Catchment Management Agency (BGCMA), Southern Cape Landowners Initiative (SCLI), Fire Management Agencies, Garden Route Rebuild Initiative (GRI),

[2] Rehabilitation is defined here as the continued actions required for the restoration of an impacted system

Landcare, Catchment Management Agencies, Garden Route Biosphere Reserve (GRBR) and others.

Conclusion

The analysis demonstrates a highly feasible opportunity for investment as well as an evidence based EPI and implementation strategy that must be utilised towards operationalising a payment scheme that re-invests the offset value of water gained through alien clearing and restoration activities. It is imperative that the local municipalities utilise the results of this assessment to achieve the dual purpose of sustainably managing ecological infrastructure and increasing water available towards improving local and regional socio-economic well-being.

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1 PROJECT RATIONALE

Impacts of climate change have impacted socio-economic and development progress on a global scale and are expected to continue into the future. The Western Cape in particular, faces a key risk from impacts on a decreased water supply through less predictable rainfall and increased evaporation from open water sources. The availability of water is crucial for economic growth towards improved social well-being and environmental sustainability. There is a critical need for investment into improving the resilience of water sources and water availability in order to reduce the risks of impacts on social well-being. Currently there is little to no scope remaining for large infrastructure projects and as a result the focus must be placed on the effective and improved management of existing water-related infrastructure. The province thus requires significant investment into improved management of water catchments and the restoration and maintenance of native ecological infrastructure to ensure improved availability and resilience of water supply, and thus economic and social well-being.

The Western Cape Government, through the development of the provincial Ecological Infrastructure Investment Framework (EIIF), have identified that for effective and sustainable maintenance and management of ecological infrastructure, not only a top-down approach to management should be applied (involving national and provincial stakeholders) but also a bottom-up approach whereby the end-users (private land owners and municipalities) should facilitate the driving of the ecological infrastructure management and investment process.

As key strategic water provisioning areas, the Keurbooms and Karatara catchments, found in the Bitou, George and Knysna Local Municipalities are currently under severe stress from Invasive Alien Plant (IAP) species which threaten water supply. This has placed increased pressure on the largely tourism-based local economies of the towns of Sedgefield, Plettenberg bay, Knysna and associated communities. The presence and spread of alien plants specifically, as a direct impact, has introduced a significant threat to natural ecological infrastructure, which in turn reduces the magnitude of natural benefits and thus impacts the socio-economic well-being of affected communities in the area.

Coupled with these threats however, is the opportunity for ecological restoration of which will result in the reclamation of both naturally-derived and socio-economic benefits. The extent, distribution and socio-economic value of ecological infrastructure in these key catchments, however, had not been determined. As a result, the opportunity to restore natural benefits lost through the spread of alien plant species has not been fully understood. The need was therefore identified to develop a business case and value chain opportunities in the Keurbooms and Karatara catchments associated with riparian and catchment alien invasive clearing. Additionally, it is crucial to investigate and operationalise Payment for Ecosystem Services (PES) opportunities with the local municipalities where the water gained through alien clearing and restoration could be offset through a payment scheme that re-invests in further restoration activities.

It was essential to develop a business case that could prove to investors (private and government) the value of alien clearing and restorative work in order to enhance water catchment and availability for sustainable development.

By classifying the natural systems within the catchment in socio-economic terms, the implications that invasive alien species have on the natural benefits provided by ecosystems can be better understood. This would ensure an improved and inclusive account of the actual magnitude of benefits received through IAP clearing programmes. The spread of invasive alien plants is a dynamic phenomenon and requires investment in both ensuring that their spread is controlled and that the land invaded is managed in perpetuity.

The aim of this report is therefore to develop a business case for the Keurbooms and Karatara river catchments and to develop PES approaches.

This aim was explored and achieved through the following set of objectives:

1. Development of a Land Account for the study catchments;
2. Map the flow of ecosystem services;
3. Perform ecosystem services valuation;
4. Explore the feasibility of IAP clearing programmes;
5. Explore strategic policy options with special focus on PES;
6. Develop a business case and strategic implementation plan for IAP clearing programmes in the study catchments.

1.1 Problem Scope

The Karatara and Keurbooms catchments are characteristic of extensive distribution of IAPs which have replaced natural and degraded ecosystems. The spatial signature of land transformation by IAPs is largely limited to riparian valleys but are also closely associated with plantations of which are spread throughout the study area (Figure 10-8).

Degraded land classifies approximately 14 600 ha (14%) of the study area and is characteristic of regions where anthropogenic activities have altered the natural environment. This may include impacts such as moderate alien infestation, old ploughed fields and fragmented habitats. Heavy alien degradation classifies approximately 2 900 ha (3%) of the study area and is characteristic of areas where aliens have had a 60 to 75% cost on biodiversity value. Alien transformed classifies approximately 1 500 ha (1%) of the study area and is defined as areas where alien vegetation has almost or fully replaced natural vegetation.

The key problem species occurring in the study area include Montery Pines (*Pinus radiata*), Black Wattle (*Acacia mearnsii),* Blackwood (Acacia *melanoxylon*), Silky Hakea (*Hakea sericea*) and Eucalyptus Spp.

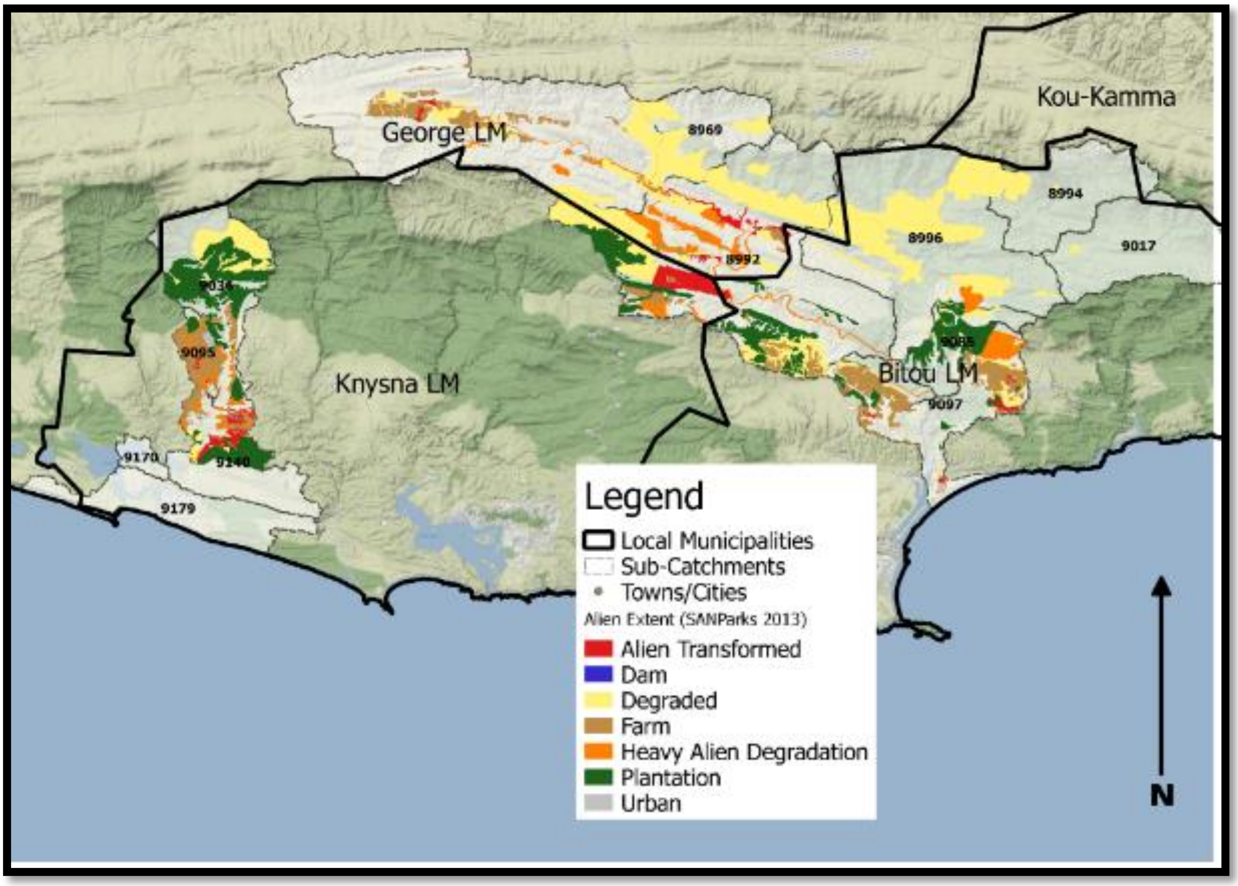

Figure 1-1:Broad land cover classifications for the Study Area (SANParks 2009)

1.2 Ecological Restoration and Environmental Value Chains

As natural features in the landscape, ecosystems provide environmental, social and economic benefits to communities. The value of ecosystems in providing these services is becoming increasingly evident and there is a growing recognition of their importance to human well-being.

This flow of benefits is reliant on the ability (presence and condition) of ecological infrastructure to supply services to beneficiaries that have a demand for such services. According to SANBI (2012), ecological infrastructure refers to functioning ecosystems that deliver valuable services to people such as fresh water, climate regulation, storm protection and soil formation. It is the nature-based equivalent of built or hard infrastructure.

The relationship between the ecological asset (balance sheet item) and the delivery of ecosystem services (income statement items) can be described as the annual rent received from an asset i.e. a house for example. Ecosystem services are delivered every year (more or less in the same quantity) and are dependent on the condition of the ecological infrastructure as well as external factors such as rainfall, land use change etc. If the condition of the ecological infrastructure is modified, there may be a corresponding change in delivery of ecosystem services.

The classification of the relationship between ecological infrastructure and beneficiaries of ecosystem services is vital to appropriately manage natural resources in a sustainable manner. Furthermore, informed appropriate natural resource management empowers natural benefits and opportunities to be maximised towards contributing to socio-ecological and economic well-being. The classification of this relationship requires an understanding of the role that ecological infrastructure and the presence of beneficiaries plays in the delivery of ecosystem services. One approach to understanding these systems is through ecosystem service valuation.

The process of ecosystem service valuation aims to quantify the natural benefits provided by ecosystems in socio-economic terms. This socio-economic yard stick allows for a comparison of trade-offs to development towards understanding the costs of environmental damage and restoration to the economy. Furthermore, by understanding the flow of services from the environment to beneficiaries, decision makers are empowered to identify opportunities towards the maximising of the natural benefits received. The opportunities may include the improvement in functionality of a system or even provide support services or infrastructure necessary for sustainable utilisation by beneficiaries.

One obvious opportunity towards the promotion of natural benefits is through the restoration of lost or compromised ecosystems. The UN Environment has identified ecosystem degradation as a key constraint achieving international sustainability goals and have deemed ecological restoration as an urgent priority at a global scale (UNEP 2017). Through the restoration of lost or degraded ecosystems the natural benefits that were once provided can be reclaimed. A relevant case is that of the Kubuqui Desert Reclamation Project (UNEP 2017), where more than 600 000 Ha of once unproductive degraded desert ecosystems have been restored towards reclaiming a functional productive system. The reclamation project has provided immense "Ecological Wealth" to the region in the form of social, financial and natural returns. Furthermore, and perhaps most importantly, the socio-economic returns have become the key driver of ongoing reclamation of land.

Although restoration efforts do not necessarily reclaim lost pristine ecosystems, it is a step in a direction of sustainable use of these systems. It is important to highlight that there is a continuum between a pristine ecosystem and a heavily degraded one. The key objective would be to tend towards a healthy system however, through restoration efforts we ensure that natural benefits and value provided are realised by beneficiaries.

Through this reclamation of ecosystems there are two key value chains that arise. Firstly, the restoration of functional ecosystems provides for the renewal of flow of benefits to the socio-economic well-being of a region. This value chain is not typically linear and with renewed functionality of systems comes exponential growth in value added to communities at a local, regional and international scale through an array of services. Secondly, the value chain associated with the management activities involved with the land restoration. The management activities involved stimulate local economies through job creation and utilisation of by-products. When referring to ecosystem restoration, these two value chains are inexplicably linked and therefore through such activities provide direct natural and economic benefits.

Understanding the mosaic of elements along these value chains provides for an improved ability to make informed decisions regarding the feasibility of management options and the maximisation of natural benefits to the local economy and associated communities. This understanding of value chain dynamics at a strategic level provide insights into the evidence-based development of policy instruments that would drive user behaviour towards sustainably restoring "Ecological Wealth" to an ecologically degraded region. This type of policy would essentially aim to provide land users and beneficiaries with incentives towards ecological restoration and continued maintenance and management of the health of associated natural systems.

1.3 Approach to case development

The approach to defining, dissecting and understanding key value-chains in a catchment, involved the classification, quantification, valuation, feasibility assessment and proposal of strategic management opportunities. The approach included 6 key processes:

1) **The development of a Land Account**: This was done in line with the methodology developed in the System of Environmental Economic Accounting (SEEA) and involved the identification and classification of the focal region. This classification involved quantifying the extent and magnitude of all environmental, social and economic characteristics. Outputs included extent, presence and condition of ecological infrastructure, demographics and well-being, breakdowns of communities as well as economic drivers and characteristics. This step provided an understanding of the flow of natural benefits from ecosystems to beneficiaries. When dealing with ecosystem restoration it was vital to include the extent and impact of ecosystem degradation in the region (in this case IAPs) (Refer to section 10.2.1).
2) **The mapping of ecosystem services**: This process involved the linking of ecosystems with beneficiaries through the supply of natural benefits. This approach utilised best practice methodologies utilised in frameworks such as the Millennium Ecosystem Assessment (MEA 2010), The Economics of Environment and Biodiversity (TEEB 2013) and Final Ecosystem Goods and Services (FEGS 2014) (Refer to section 10.2.2).
3) **Ecosystem Service Prioritisation**: The prioritisation step was undertaken during an in-house workshop whereby the impacts of IAP clearing programmes on all

ecosystem services were prioritised using a Comparative Risk Assessment (CRA) methodology. The CRA methodology utilises the likelihood and consequence of impact to rank ecosystem services (Refer to section 10.2.3.

4) **Ecosystem Service Valuation:** The valuation step was conducted for the prioritised ecosystem services in-line with international best-practice towards quantifying, in socio-economic terms, the value of ecological infrastructure across the landscape (Refer to section 10.2.4).
5) **Management options:** The management opportunities and options towards ecosystem restoration were then explored in terms of the costs involved and the benefits received through their implementation. The costs of restoration activities were then assessed against the benefits received (both socio-economic and natural).

2 THE BENEFITS OF IAP CLEARING PROGRAMMES

IAPs in South Africa cover an estimated 10 million uncondensed hectares of the land surface, and continue to spread (Versfeld *et al.* 1998; Le Maitre *at al.* 2000, Le Maitre *et al.* 2011). The clearing of IAPs and subsequent rehabilitation of land will result in ecological restoration and the reclamation of various natural benefits as well as provide economic empowerment. In the Karatara and Keurbooms catchments specifically, such efforts would result in two key immediate benefits. Firstly, the improvement of a range of natural ecosystem services and benefits. The most significant of which have been identified to include the following:

1) The increased availability of water to the catchment (yield);
2) Increased biodiversity value; and
3) Increased disaster regulation services with special focus on the regulation of fires in the catchment.

Secondly, clearing and land rehabilitation programmes will provide socio-economic benefits through local economic empowerment and diversifying rural livelihood options.

2.1 Supporting green economy through improving ecosystem services

The study area is situated within the Fynbos biome of which specifically falls into the Southern Fold Mountain and South Eastern Coastal Belt ecoregions. The combination of Fynbos and Renosterveld vegetation groups result in ecological wealth that is unique to the region. The region is host to extensive biodiversity, representing the Eastern regions of the Cape Floristic Kingdom of which is globally recognised as a centre of high endemicity and species richness.

The ecosystems present display a range of key ecological infrastructure of which provide extensive natural benefits to local, regional and international beneficiaries. The unique combination of geomorphologic, hydrologic and biological characteristics of fynbos ecosystems support ecosystem services that are relatively unique in their supply to these regions.

Key ecosystem services include habitat support (Aerts and Honnay 2011, Braatz 1992), multiple provisioning services such as fresh water, food, genetic resources (DEA 2014) and raw materials, regulating services such as biological control and hydrological regulation and cultural services (Barnhill 1999, Krieger 2001, Knudston and Suzuki 1992), such as tourism and educational opportunities and of course aesthetics values.

Ecological degradation reduces the ability to provide natural benefits. The current extent of IAP in the study area is limiting the flow of services due to reduced extent and condition of the natural ecological infrastructure. IAP as a driver of ecological degradation threaten key regulatory services of which undercut and impact the provision of final services to the catchment.

IAP clearing programmes are thus being proposed as a key opportunity towards supporting the green economy through ecological restoration of the study area. The green economy in this case refers to the growth and development of socio-economic well-being that are in line with sustainable development of natural resources. This approach to ecological restoration is a valuable mechanism for managing and reclaiming these ecosystem assets, as well as providing a level of security for these assets to continue to provide ecosystem services over time.

Understanding and building the case towards the benefits of ecological restoration in the Keurbooms and Karatara, there must be an understanding of the current flow of ecosystem services in a catchment. The study area was thus subject to a full Ecosystem Service Assessment (ESA) process whereby best international practice in land accounting, ecosystem service mapping, prioritisation and ESV were undertaken. The approach of the assessment was to define the current flow of ecosystem services and compare this to the potential flow post IAP clearing programmes in the catchment. Please note, although this was the approach taken to the entire ESA, due to limitations in available data, when it came to the valuation step it was the difference between current and post-rehabilitation (the marginal value) that became the focus. The full methodologies and results of this process can be found in Annexure A, B and C.

Key ecosystem services identified to display the greatest beneficial response post IAP clearing and rehabilitation in the Karatara and Keurbooms catchments are included Table 2-1. The services identified in Table 2-1 are by no means exclusive, but rather given the ecological and socio-economic landscape of the study area, these services were identified to display the greatest probability of improvement due to the reduction of the key threat (in this case IAPs). The marginal value provided to the region due to IAP clearing and rehabilitation was thus focused on additional available water, biodiversity value and fire regulation services Table 2-1.

Table 2-1: Ecosystem services identified to be significantly impacted by IAP clearing programmes in the Karatara and Keurbooms catchments

Ecosystem Service	Category	Approach to Valuation
Fresh Water Provisioning	Provisioning Service	Final benefits value- Marginal cost of supply
Habitat Support (Biodiversity and species)	Supporting Service	Ecological value (Quantified using conservation importance hectare equivalence)
Natural Disaster (Fire prevalence)	Regulating service	Insurance value (Insurance premium)

2.1.1 Fresh Water Provisioning

The Keurbooms and Karatara catchments have been identified as key water provisioning areas for the region and as they are situated within the Western Cape (of which is classified as water scarce, especially in light of the recent drought) thus represent regions of highly strategic importance for the management of systems (especially those that impact on water availability).

IAP clearing programmes have been identified as key towards increasing water availability to the catchments.

In a study (conducted in the Olifants River catchment) that investigated the financial benefit to clearing IAP, indicated that the cost of clearing IAPs, as a water infrastructure protection option, is less than the cost of the infrastructure (Morakong *et al*. 2016). Furthermore, an investigation on the cost-effectiveness of natural capital in generating additional water as result of clearing IAPs from riparian areas, showed that clearing IAPs recovered significant additional volumes of water (Marais and Wannenburgh 2008).

In 2000, it was estimated that in South Africa, 3 300 million m^3 of water is used by IAPs each year. More significantly the Western Cape and the Mpumalanga provinces display the highest proportions of total water use by IAPs (Le Maitre at al 2000). The water consumed by IAPs is significant, thus IAP clearing programmes are an obvious opportunity to ensure that less water is lost and is instead made available to support local (and regional) socio-economic growth.

Knowledge on IAP species occurring in the study area clearly indicate the increased use of water compared to indigenous vegetation and natural ecosystems (Table 2-2).

Table 2-2: Impacts on water availability of primary IAP species in the Karatara and Keurbooms catchment

IAP Species	Impacts on Water Availability	Reference
Black Wattle (*Acacia mearnsii*)	*Acacia mearnsii* most extensively distributed alien plant throughout South Africa Stands of *Acacia mearnsii* display as much as double the total evaporation (1500mm) compared to that of grassland or fynbos (600-850mm).	Dye and Jarmain 2004
Silky Hakea *(Hakea sericea)*	H.sericea has high water consumption due to its high transpiration rate	Dye *et al.*, 2008
Montery Pines (*Pinus radiata*)	Pine has dense stands which reduce water runoff and stream flow from mountain catchments which eventually results in reduced catchment water yields	Bosch and Hewlett 1982

IAP Species	Impacts on Water Availability	Reference
Eucalyptus spp	Plant-water relationship in Eucalyptus is specific, because of its high-water uptake ranging from 50 to even 90 L/day/plant. The plant roots can grow up to 6–9 m in water stressed conditions and extract more water.	Joshi and Palanisami, 2011
Blackwood (Acacia melanoxylon)	Uses larger supplies of water than native vegetation so large thickets result in changes in soil moisture conditions. Water consumption is estimated at approximately 21.8 million m^3 per year	Rutherford *et al*., 1986.

Assuming an average evapotranspiration (ET) rate of 904 mm/a and 520 mm/a for IAPs and fynbos vegetation respectively (Meijninger and Jarman 2014) the water use by IAPs is significantly larger than the natural vegetation in the region. As a rapid demonstration, given the current extent of IAPs in the study area of which would be removed during IAP clearing programmes and replaced with indigenous natural vegetation, The Karatara and Keurbooms catchments would likely result in an addition of water availability to the catchment in the order of 25 mil Kl per year (See Annexure B).

The clearing and rehabilitation of IAP sites in the Karatara and Keurbooms catchments will therefore result in an increased availability of water in the catchment.

2.1.2 Habitat Support

The Economics of Environment and Biodiversity describe a natural habitat as an environment that provides everything that an individual plant or animal needs to survive of which includes food, water and shelter. In general, it describes that ecosystems provide different habitats that can be essential for a species' lifecycle and well as for the maintenance of genetic diversity. The climatic and biophysical characteristics of the ecological infrastructure in the region has resulted in the study area being representative of high biodiversity value of which has local, regional and international significance.

IAP clearing programmes have been identified as key towards improving habitat support and the biodiversity value in the catchments.

Health of an ecosystem is a measure of the conditions of ecosystems with relation to an unimpacted environment. The health of a system therefore falls along a continuum from pristine (or natural biodiversity levels) to fully degraded and showing no biodiversity value. Through the introduction, competing and replacement of indigenous biotic ecological infrastructure or genetic resources, IAPs alter the natural regionally specific processes, availability of resources and habitats naturally present.

This reduces the biodiversity value of an ecosystem and in turn impact regulating, provisioning and cultural services and therefore reduce the magnitude of benefits to beneficiaries along the entire ecological value chain.

As a brief example, increased extent and density of IAPs directly reduces the capacity for a system to maintain the indigenous genetic integrity of the system. The alteration in resource requirements results in an imbalance of competition. Water availability for example (as described above) is decreased and therefore the entire hydrological cycle and regulation capacity of the system is influenced. Altered hydrological regulation may therefore impact on extent to which aquatic vegetation extends throughout a floodplain in the wet season or perhaps the average runoff necessary for the lifecycles of specific fish species. In this example these impacts will impact the ability to maintain biodiversity in the region.

An alteration of these processes therefore results in an alteration of the native biodiversity value present in the region. Although IAPs have been identified to impact on a range of ecosystem services (i.e. Water provisioning) due to the impacts on functionality and natural processes (i.e. fire regime), the impacts identified in the table below indicate the direct impacts to habitat and thus biodiversity value (Table 2-3).

Table 2-3: Impacts on biodiversity by primary IAP species in the Karatara and Keurbooms catchment

IAP Species	Impacts on Biodiversity	Reference
Black Wattle (*Acacia mearnsii*)	Black wattle encroachment has adverse environmental impact on biodiversity loss of indigenous species, as they have the ability to induce simultaneous changes in above- and below ground physical and chemical conditions, and soil moisture and nutrient regimes.	Le Maitre *et al.* 2011; Morris *et al*. 2011
Silky Hakea *(Hakea sericea)*	Hakea alter spatial distribution of nutrients and hydrological patterns	Stock and Allsopp1992
Montery Pines (*Pinus radiata*)	Pines reduce grazing land by shading the grassland resulting in low light penetration. They also alter hydrological patterns, physical and nutritional properties of soils. Reduced species richness of native fauna.	Pilgrim *et al*. 1982. Pryor 1991; Luken and Thieret, 1997
Eucalyptus spp	Reduces species richness of native fauna because of their heavy shading; reduces % ground cover; reduced tree regeneration.	Pilgrim *et al.* 1982.

Blackwood (Acacia melanoxylon)	Drives changes in the nutrient cycle as a result of deposition of large amounts of litter. The dense thickets shades out vegetation and results in indigenous vegetation being outcompeted and threatened.	Weber 2003

The relative conservation importance of vegetation types present in the study area that are currently impacted by IAPs was assessed. This was done through the use of the SANBI Wetland Offset Guidelines (SANBI 2014) of which attribute a specific vegetation type with a Ha equivalent multiplier of which is based on the relative conservation ratio of that vegetation type. The conservation ratio considers the threat status and level of protection of vegetation types. As a demonstration Table 2-4 shows that all vegetation types threatened by IAPs show a multiplier above zero. This indicates that from a conservation perspective the ecosystems are valuable.

Table 2-4: Conservation ratio attributed to vegetation types impacted by IAPs in the Karatara and Keurbooms catchments (SANBI 2014)

Vegetation Type (Impacted by IAPs)	Conservation Multiplier (as per SANBI 2014)
Eastern Fynbos-Renosterveld Sand Fynbos	15
Eastern Fynbos-Renosterveld Sandstone Fynbos	0.25
Eastern Fynbos-Renosterveld Shale Band Vegetation	30
Eastern Fynbos-Renosterveld Shale Fynbos	3.75
Eastern Fynbos-Renosterveld Shale Renosterveld	30

Through IAP clearing programmes, the threat of IAPs will be removed from natural ecosystems and through natural processes that regulate biodiversity and the integrity of habitats will return. When considering the relative extent of vegetation types impacted on by IAPs, the results show on average a conservation ratio of 0.38. As a rapid demonstration, and through the use of the indicators demonstrated above, given the current extent of IAPs in the study area of which would be removed during IAP clearing programmes and replaced with indigenous natural vegetation types, The Karatara and Keurbooms catchments would likely result in an increase in biodiversity value of 38% (See Annexure B).

The clearing and rehabilitation of IAP sites in the Karatara and Keurbooms region will result in the restoration of natural indigenous habitats and therefore an increased value in associated indigenous biodiversity.

2.1.3 Fire Regulation

The Karatara and Keurbooms catchments occur within a Mediterranean climate, displaying cool wet winters and hot dry summers. Fynbos as a vegetation type, is highly prone to fires of which plays an important role in the maintenance of biodiversity (van Wilgen *et al* 1992). The ecological infrastructure in the study area is therefore dependent on fire as a process. Changes to flammable biomass available due to the presence of various species of IAP results in increased frequency and intensity of fires which alter the characteristics of a natural (or indigenous) fire regime.

IAP clearing programmes have been identified as key towards improving the fire regulation service value received by beneficiaries in the catchments.

The alteration of the natural fire regime, influences the functionality and condition of ecological infrastructure, promotes the growth of IAPs and reduces the ability to manage fires thus causing damage to communities and infrastructure.

A specific example in the study area is the "Knysna Fire" occurring in 2017, which claimed 7 people and destroyed at least 1000 homes. It is believed that IAPs in the region exacerbated the fire due to rapid ignition and the production of increased heat intensities compared to that of indigenous vegetation.

A study by SANParks (2009) defined various fuel type groups into fuel hazard risk classes. The groups ranged from indigenous vegetation which were on the lower end of the fuel hazard scale towards medium density IAP sites and through to plantations and high density IAP stands which represented the upper end of the fuel hazard scale. The risk of fires therefore varies with vegetation type, however the risk increases with increasing density of IAPs Table 2-5.

Table 2-5: Fuel type group and corresponding fuel hazard class (SANParks 2000)

Fuel Type Group	Fuel Hazard Class
Indigenous Forest, Dune Thicket,Valley Thicket, Strandveld Spekboomveld, Salt Marsh, estuaries, etc.	Zero
Non-irrigated agriculture,Renosterveld, Grassy Fynbos, Sub-alpine fynbos, Thicket-FynbosRenosterveld, Sandplain Fynbos, Coastal Grassland, pan, floodplains and Fynbos-Forest	Low
Perennial streams, Waboomveld, Thicket-Fynbos, Ericaceous Fynbos, Asteraceous Fynbos	Moderate
Proteoid Fynbos, Sandolienveld & IAP stands of 25-50% density	High
IAP stands of 51-75% density	Severe
Plantations & IAP stands >75%	Extreme

The contribution that IAPs make to increased fire hazard is well understood, with specific contributions of study site specific IAP species outlines in Table 2-6.

Table 2-6: Contribution to fire threat by primary IAP species in the Karatara and Keurbooms catchment

IAP Species	Contribution to Fire Threat	Reference
Black Wattle (*Acacia mearnsii*)	Increase in biomass lead to increases in fuel loads, while dense stands of invasive trees hamper access for fire management purposes.	Van Wilgen and Richardson 1985
Silky Hakea *(Hakea sericea)*	Hakeas substanti ally increase the above-ground plant mass, increasing the amount of fuel available to burn, and make fires more intense and more difficult to control.	Van Wilgen and Richardson 1985
Montery Pines (*Pinus radiata*)	Alter fire regimes through changes in fuel loads and in the structure and continuity of fuels, potentially modifying the flammability of native plant communities. These changes in fuel properties have the potential to affect fire behaviour, increasing fire intensity by almost 30 times	Paritise*t al.* 2018
Eucalyptus spp	These hardy plants have volatile natural oils in all parts of the plant. When the oils in the tree heats, the plant releases flammable gas which ignite.	Crosby 1992
Blackwood (Acacia melanoxylon)	Blackwood acacia is fire-stimulated, with prolific regeneration from seed after fire.	Hill 1982

As a demonstration, the marginal increased fire hazard due to the presence of IAPs in the study area was quantified based on the additional risk and thus increased insurance premium. An insurance model was constructed using a Poisson distribution on the number of claims (Based on a sample set over the past 10 years) and the Bayesian probability on the probability of a major fire occurrence. In other words, the frequency of fires attributed to IAPs in the study area were assessed against the damage to infrastructure caused. The results showed that the annual marginal (additional) insurance premium due to the presence of IAPs ranged from R132/ha for infrastructure associated with low density IAP stands to R 911/ha for infrastructure associated with high density IAP stands.

Given the current extent of IAPs in the study area of which would be removed during IAP clearing programmes, communities in the Karatara and Keurbooms catchments would likely avoid an additional total insurance premium per annum in the order of R4.8 mil (See Annexure B).

The clearing and rehabilitation of IAP sites in the Karatara and Keurbooms region will therefore result in a significant reduction in risk of fire incidents.

2.2 Local economic empowerment and providing rural livelihood options

IAP clearing programmes and the subsequent required ongoing land rehabilitation supports the stimulation of the rural economy through providing additional rural livelihood options, creating nodes of rural development and stimulating job creation and skills development.

Jobs are created directly on alien infested sites though land management and restoration, as well as commercial activities such as processing of biomass and transportation that are complementary to ecological restoration. Through job creation the local economy is indirectly stimulated through the flow of financial remuneration. The use of the cleared IAP biomass further provides value as fuelwood, building materials or processed into various useful compounds (Tannins, charcoal etc.).

The study area is characteristic of relatively low economic well-being. Table 2-7 indicates the percentage of the population that is subject to various living conditions.

Table 2-7: Demographic breakdown of the study area with various indicators of socio-economic classification of well-being (Please note: Assumption was made that the density of populations is evenly distributed across wards)

Indicator of Well-being (Census 2011)	Percentage of Total Population in the study area
Reside in an informal dwelling	20%
No Schooling	2%
Not employed	32%
Employed with income below minimum wage	27%
No Income	15%
No Toilet	2%
Access to bucket or pit latrine	13%
Source water primarily from rivers, streams or springs	4% (Approximately 383 Individuals)

At a rate of 32% of unemployment, the catchment is in dire need of economic activities that create additional employment and stimulate the improvement of local socio-economic well-being.

The sustainable removal of invasive alien species requires a long-term rehabilitation management strategy of which the removal plot must be revisited each year. The average person days for each year of rehabilitation of IAP sites in the Keurbooms and Karatara Catchments over 5 years are given in Table 2-8. The average Jobs for labourers created per year for the next 5 years equates to approximately 337. Please note this only includes the jobs produced for labourers.

Table 2-8: The approximate person days required to remove a high density stand of IAPs (Nel et al 2008)

Year	Person Days Required (Days of employment)	Personnel employed/a (260 work days/a)
1 (initial site visit)	366,800	1,400
2	89,900	350
3	47,900	180
4	5,800	20
5	4,100	16
Total	514 600	2 000

In addition to jobs created, communities also benefit from the biomass provided by alien plants after removal. The woody IAPs specific to the study area have been known to provide significant harvest provisioning services in terms of timber and fuelwood to rural communities. The clearing of IAPs will in effect cause a loss of these services however will result in significant gain of others. Furthermore, the biomass available to rural communities through activities will provide a source of alternative livelihoods. Common uses of the IAP species present in the study area are given in Table 2-9.

Table 2-9: Common uses of primary IAP species in the Karatara and Keurbooms catchment

IAP Species	Typical use
Black Wattle (*Acacia mearnsii*)	The bark produces high quantities of tannin for use in the leather tanning industry
Silky Hakea *(Hakea sericea)*	Hakes are typically used for fuel wood due to their effective burning and high heat energy release. H. sericea is grown as an ornamental and used as a barrier or hedge.
Montery Pines (*Pinus radiata*)	Pine trees are economically used as timber due to their dense and tall sizes and high strength wood system. Common uses include weatherboards, posts, beams or plywood, in fencing, flooring, retaining walls and pulp to make paper.
Eucalyptus spp	Eucalyptus is commonly used for its wood for sawmilling, pulp and charcoal.
Blackwood (Acacia melanoxylon)	Blackwood is commonly used for timber, its value as a timber species reduces exploitation of indigenous species.

Given the current socio-economic context in the study area, the implementation of IAP clearing programmes would drastically benefit communities in the Karatara and Keurbooms catchments (See Annexure B).

3 VALUE FOR MONEY: ASSESSING THE FEASABILITY OF ECOLOGICAL RESTORATION THROUGH IAP CLEARING PROGRAMMES

Prior to discussing the results of the assessment it must be noted that to date there have been numerous feasibility studies conducted that assess the value for money of IAP clearing programmes. Typically, these studies assess the costs of alien removal and rehabilitation against the benefits received through available biomass and local economic stimulation. It is common cause that although IAP clearing programmes are often feasible, the benefits received are marginal and often not sustainable due to contextual limitations within IAP infested catchments.

As an example, alien clearing programmes involve multiyear, labour intensive clearing programmes of which require ongoing maintenance and management of cleared land. Clearing activities occur from terrestrial areas in the upper catchment with steep slopes through to lower lying riparian areas. Variation in species and size dictates the methods of removal and rehabilitation, for instance although biocontrol agents have been developed for some species, these are not effective against others. Furthermore, the effective rehabilitation of "cleared" land requires ongoing attention to ensure the establishment of native vegetation. Extensive alien seedbanks pose a threat to ensuring the control of IAPs. The cost of clearing varies greatly across topography, target species, species age, density and distance from processing facilities. Initial clearing costs, including removal, chipping and transport, were identified to range between R21 000 to R79 000 per ha (Mugido *et al.* 2014). The value of alien biomass removed ranges between R35 000 and R47 000 per ha (high density IAPs).

This result of these two indicators (cost and value) show that although the case for IAP clearing programmes may be feasible, specific conditions during implementation may increase costs therefore trending towards an unfeasible case. Furthermore, the value in biomass is a once off value and the removal and continued management of rehabilitated land continues for numerous years.

The study conducted here has quantified and valued an additional benefit of which to assess the feasibility of IAP clearing programmes and therefore potentially increasing the viability of investment into mechanisms that would internalise these values into the costs of environmental management.

The following section illustrates briefly the results of the valuation step of the three prioritised Ecosystem Services that were identified to provide the greatest impact to beneficiaries due to IAP clearing programmes (Table 3-1).

The values have been represented in three units. The first, Native measurement (R/a) represents the total value provided each year through ecological restoration. The second, R/ha/a represents the value provided each year per ha of restored ecosystems. This second value represents the ecological infrastructure **resource rent** value. The third, R/ha represents the total value restored per ha. This value represents the **capital value** and has been converted to a land value based on the purchase price at 5% discount rate (i.e. the capital value described here is the purchase value of the land inclusive of natural benefits). Results have been presented in this way due to the varying approaches required to quantify the values of the various services provided.

The minimum and maximum values have been utilised as a mechanism to ensure a conservative outcome. On both ends the extreme values have been utilised and it must be stated that although the range differs significantly, there is a high level of confidence that the true value of the services falls within the range indicated. The methodologies applied to determine each range and the valuation methodologies are described in Appendix B.

The results show that through IAP clearing programmes, the total value received through restored 'identified' ecological services range between R31.5 and R315 million per year (Table 3-1). Another way of describing this result is that currently, the catchment is losing the opportunity to receive benefits to the value of R31.5 and R315 million per year, due to the current state of IAPs in the area. The results show that through the clearing of one condensed ha of IAPs, the value received through restored ecosystem services will fall somewhere between R5 000 and R50 000 per year.

Table 3-1: Ecosystem service valuation results

Ecosystem Service	Ecosystem Service Value					
	Native Measurement (R/a)		R/ha/a		R/ha	
	Min	Max	Min	Max	Min	Max
Water Provisioning Service Value	25,100,000	307,300,000	3,800	46,700	76,000	934,000
Biodiversity Value	1,600,000	2,900,000	240	445	4,800	8,900
Disaster Risk Regulation Service	4,800,000	4,800,000	700	700	14,000	14,000
Total Value	31,500,000	315,000,000	4,740	47,845	94,800	956,900

The value of the water provisioning service is by order of magnitude larger than the other services. This reiterates the limitation of which IAPs place on a catchments water supply. The potential value of additional water, currently not being realised due to the status of IAPs in the study area, was estimated to fall between R25.1 mil and R307.3 mil per year. The value is a result of the costs required to provide an alternative source of water to the catchment. The high variation between minimum and maximum values is a result of firstly, the marginal value of water has a steep curve in water scarce regions such as the WC and secondly, in light of limited spatial data and evident spatial heterogeneity, extreme marginal values were specifically chosen to remain confident that the "actual value" falls within the range. An example of the steep curve in marginal value of water in the Western Cape Province is given in Figure 3-1.

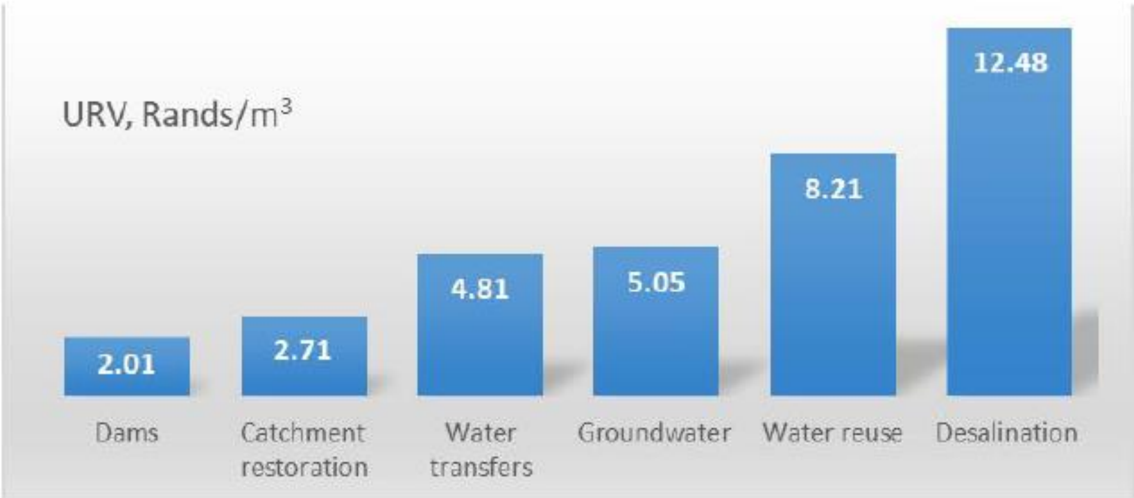

Figure 3-1: Average unit reference value (URV) of water generated through various water supply options in the Western Cape

The results illustrate a substantial cumulative benefit received from restored ecosystem services of which are supplied into perpetuity. The initial cost of clearing of IAPs is by far the largest cost involved in IAP clearing programmes. Once the initial cost of IAP removal has been incurred, the cost reduces yearly as continued rehabilitation and management is undertaken. The traditional economic benefits received through these efforts are similarly largely received in these initial stages of the project after which reduce over time as degraded land is rehabilitated. The benefits received through restored ecosystem services will gradually increase as functionality of ecosystems is restored, at which point the value of ecosystem services will continue to provide benefits (in the order of magnitude identified in Table 3-1) yearly into perpetuity. The cumulative value over time therefore clearly illustrates the feasibility of IAP clearing programmes.

A discounted cash flow simulation was conducted that assessed the feasibility of IAP clearing programmes in the study area based on two scenarios (Figure 3-2):

1) The conventional business case (No PES mechanisms operating and not taking natural benefits lost into account);
2) The case for ecological restoration (Inclusion of PES mechanisms and ensuring natural benefits restored are considered).

The results show that in the conventional case, although benefits are received through the use of biomass, if post clearing rehabilitation and management is successful, these by-product benefits are short lived as the resource is depleted through the initial clearing activities (Figure 3-2). Furthermore, the costs required for ongoing maintenance continue across multiple years. The case to be made is not that clear.

The case for ecological restoration on the other hand shows that through IAP clearing a substantial benefit is received into perpetuity (Figure 3-2). The value of which far outweighs the initial clearing investment. The cumulative value per year of ecosystem services restored, demonstrates the economic case for IAP clearing programmes. In the case that all IAPs are removed in the first year, the value of benefits will be seen from the second year. In other words, the net value received in the second year outweighs the net costs in the first year (Table 3-2).

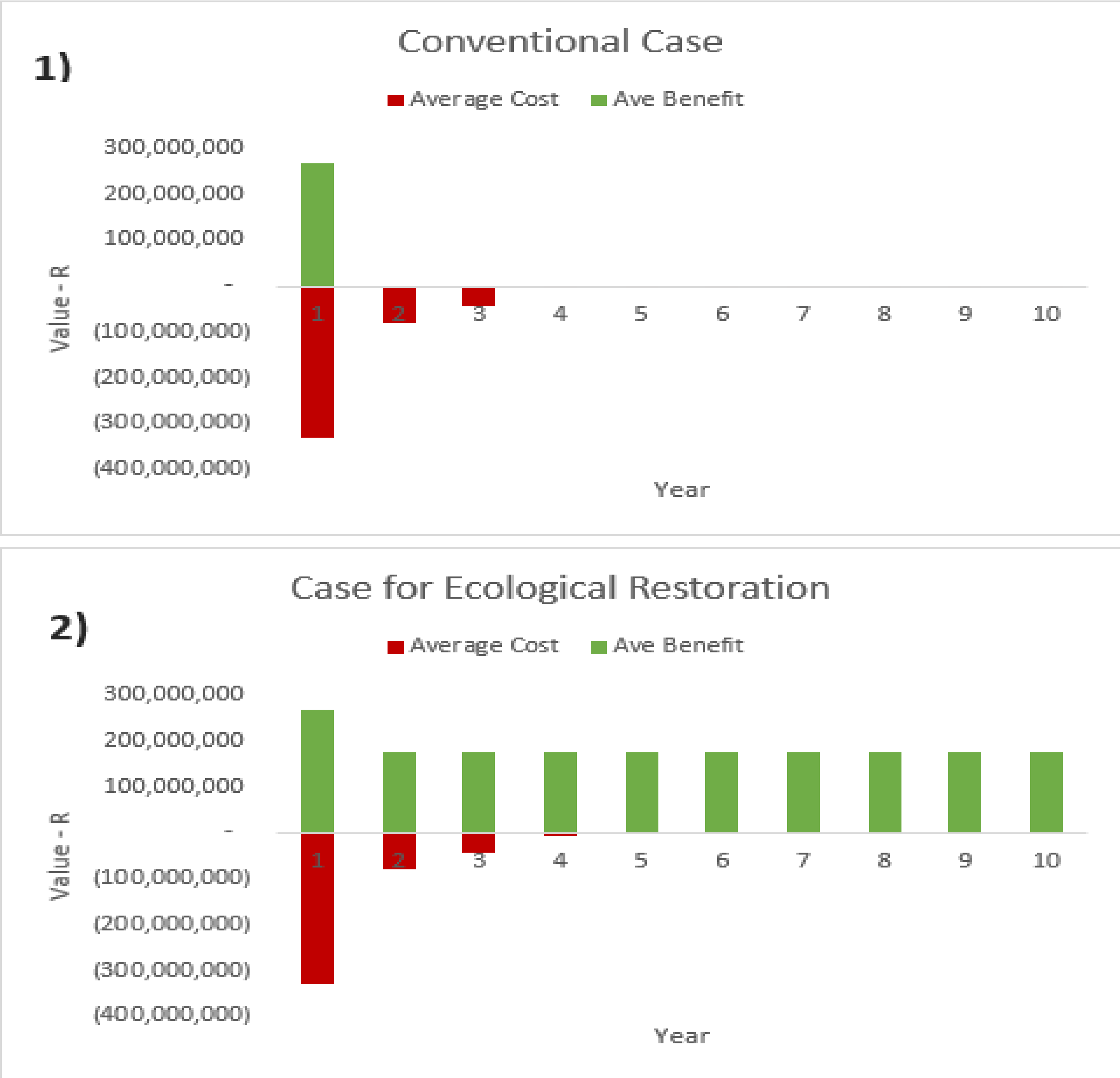

Figure 3-2: Comparison of feasibility of IAP clearing programmes in the 1) absence and 2) presence of PES mechanisms (please note, follow up management costs are included for 10 years, however due to the comparative magnitude are not visible on the figure)

The results presented in Figure 3-2 are a summary of the analysis done for the Keurbooms and Karatara catchments. Figure 3-3 illustrates the net costs and benefits of IAP clearing over a period of 10 years (i.e. Figure 3-3 represents the net difference between costs and benefits for each year). Although the figure simplifies the ability of full clearing into the first year, it illustrates the net feasibility per year once initial clearing costs and follow up management costs have been incurred. The value received through restored ecosystem services far outweighs the costs of IAP rehabilitation. Please note this analysis has been done based on only ecosystem services restored through the removal and rehabilitation of IAP stands in the Karatara and Keurbooms catchments.

Table 3-2: The costs and cumulative benefits of IAP clearing due to additional natural benefits restored

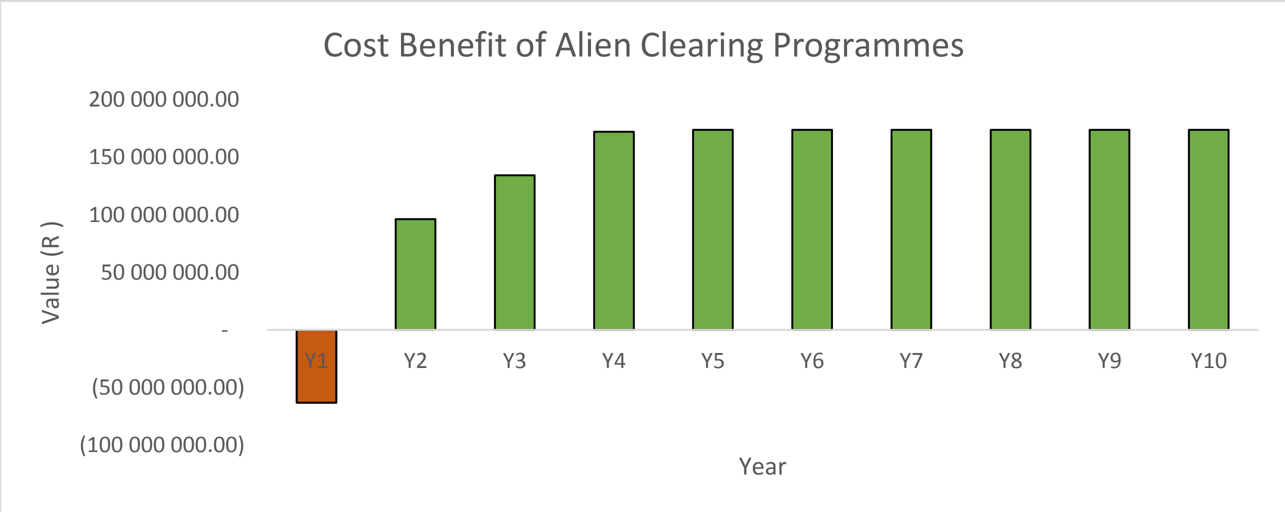

Figure 3-3: The costs and cumulative benefits of IAP clearing due to additional natural benefits restored

The magnitude of IAP extent and therefore the opportunity of ecological restoration across catchments is presented in Figure 3-4 and shows the central Keurbooms catchment to have the greatest opportunity to restore value through IAP clearing programmes (i.e. catchments 8922 and 8996 represent the catchments with the greatest potential for value restoration through IAP clearing).

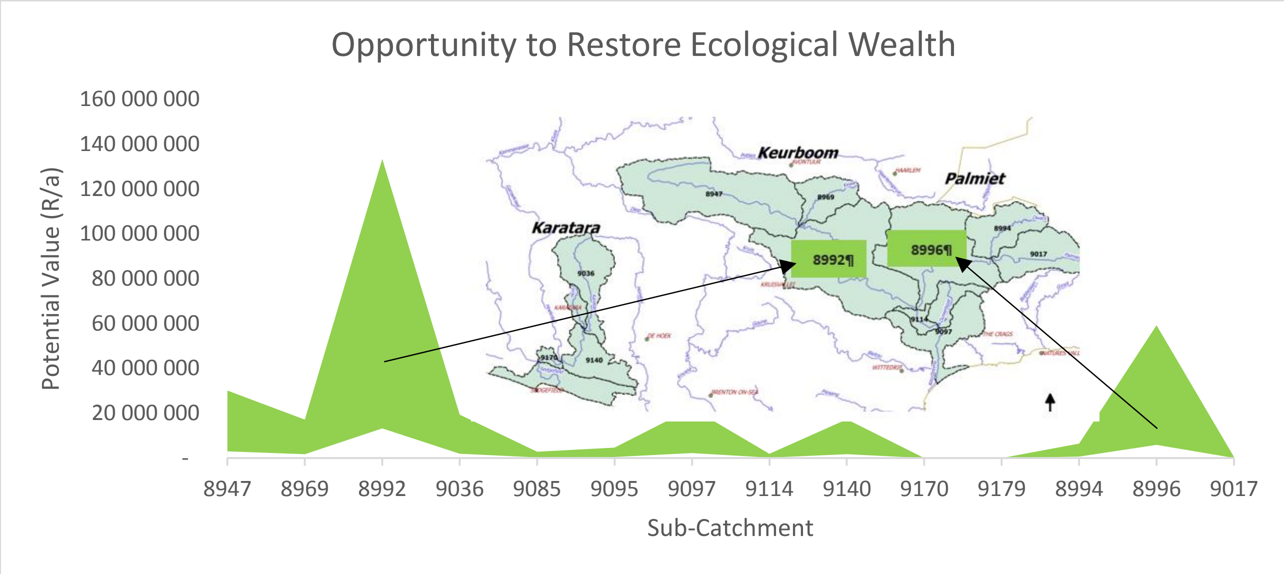

Figure 3-4: Relative ecological value that may be restores across sub-catchments through IAP clearing programmes

The ecological value opportunity through restoration and clearing programmes per municipality is presented in Table 2-1. The average value of for Bitou Local Municipality is in the order of R75 mil per year. The average value of for George Local Municipality is in the order of R50 mil per year. The average value of for Knysna Local Municipality is in the order of R47 mil per year.

Table 3-3: Relative ecological value that may be restores across sub-catchments, catchments and per local municipality through ecological restoration and IAP clearing programmes

ID	Catchment	Municipality	Native Measurement (R/a)
			Average Value
8947	Keurbooms	George LM (mostly)	16,535,000
8969	Keurbooms	George LM	9,415,000
8992	Keurbooms	Bitou/George/Knysna LM	73,310,000
9036	Karatara	Knysna LM	10,635,000
9085	Keurbooms	Bitou LM	1,540,000
9095	Karatara	Knysna LM	2,550,000
9097	Keurbooms	Bitou LM	12,215,000
9114	Keurbooms	Bitou LM	1,035,000
9140	Karatara	Knysna LM	9,490,000
8994	Keurbooms	Bitou LM (mostly)	3,535,000
8996	Keurbooms	Bitou LM (mostly	32,540,000
9017	Keurbooms	Bitou LM	270,000
Approx. Total Bitou LM			**75,572,000**
Approx. Total George LM			**50,387,000**
Approx. Total Knysna LM			**47,112,000**

Although the value demonstrated in this study is tangible, the value that ecosystem services can provide has not been internalised in current policies. There is a need for the development of mechanisms that will capture this value in order to drive IAP clearing programmes.

Based on the above, there is a very strong economic case to be made for internalising the ecosystem service benefits of alien invasive clearing into economic decision making. The total net benefit of alien clearing exceeds the costs of clearing by a ratio of 1:3.87 (if ecosystem service benefits are included).

4 CREATING AN ENABLING MECHANISM FOR ECONOMIC POLICY INSTRUMENTS (EPI) (E.G. PES)

Economic Policy Instruments (EPI) attempt to influence behaviour and decision-making through introducing economic incentives or disincentives into the economic decision-making processes. Typically, these instruments use values and prices to achieve policy objectives. These are used as a way of influencing the actions of individuals and corporations through monetary and fiscal instruments. Examples of economic instruments include subsidies, taxes and fees, tradable permits, administered tariffs, or production incentives. In the case of natural resource management, these economic instruments attempt to either increase or reduce demand for specific benefits or ecosystem service, with the purpose of incentivizing certain desired micro-economic behaviour. Economic policies are thus a mechanism whereby decision makers can both financially reward and penalise behaviour of an impactor.

Payments for Ecosystem Services (PES) is one type of economic instrument designed to incentivise developers, land users or land owners in exchange for managing land to provide an ecological service. A PES scheme in other words functions to provide an economic incentive to ecosystem maintenance and preservation of ecosystem services which in turn promotes conservation of natural resources in the marketplace. The FAO (2007) has defined Payment for Environmental Services as follows: "PES transactions refer to voluntary transactions where a service provider is paid by, or on behalf of, service beneficiaries for agricultural land, forest, coastal or marine management practices that are expected to result in continued or improved service provision beyond what would have been provided without the payment."

Some examples of PES schemes:

- The city of New York opted to support farmers carrying out watershed protection upstream in the Catskill Mountains in order to reduce the high cost of treating water downstream closer to the city;
- Nestle, a multinational drinks company, operates a scheme for subsidising farmers to avoid the use of nitrates in the area from which its bottled water Vittel is drawn;
- In Quito, Ecuador, and in several smaller cities in Honduras and Costa Rica, the water utility and electric power companies pay local people to conserve the watersheds from which water is drawn;
- In Venezuela, the power producer CVG-Edelca pays a proportion of its revenues towards the preservation of the Rio Caroni watershed; and
- Brazil has a Water Producer Programme through its National Water Agency that compensates farmers for safeguarding critical headwaters for the Sao Paulo Metropolitan region.

- South African Breweries (SAB) in South Africa has implemented Water Stewardship in the hops industry in the Gouritz WMA[3]. Through engagement in formal biodiversity stewardship agreements which focus on alien plant clearing programmes, the hydrological and ecological services provided by restored ecosystems are secured.
- Santam (financial services company) in South Africa has initiated the Partnership for Risk and Resilience programme through which a range of PES like schemes have been implemented of which focus largely on restoring ecological benefits of disaster risk management.

PES can be used to persuade users of land or other natural resources to modify their behaviour so as to protect and enhance resources (e.g. shifting to organic farming, converting arable land to pasture, planting trees). PES may compensate them for the extra effort and/or financial cost involved in changing their behaviour. The funding for PES may be provided by governments, international agencies, local communities, water companies, hydro-power producers, flood protection agencies, or private companies, depending on the type of benefits expected and their impact. In some cases, the cost can be passed on to final consumers (e.g. in the higher price of products cultivated organically or sustainably).

The mechanism by which a PES scheme operates depends on the context and characteristics of the case.

It must be noted that typically PES schemes are described as a direct financial payment from the beneficiaries of ecosystem services to the party or parties responsible for their management (as illustrated above). Although this approach does represent a single model for a PES scheme, this approach is limited in terms of opportunities. The broader term of economic instrument that include principles of PES schemes, is able to encapsulate a much broader umbrella that enables the flow of financial incentives through the desired management of natural systems. PES schemes recognise the fact that the task of environmental stewardship is widely dispersed throughout society and this approach should be utilised in the broader scope of economic instruments.

The requirement for such a broader definition of economic instruments that are financially driven by the value provided by ecosystem services is critically required. For the purposes of this document, such an instrument will be referred to as an EPI for the reminder of the study.

[3] https://www.ab-inbev.com/content/dam/universaltemplate/ab-inbev/investors/sabmiller/reports/other-reports/sab-water-stewardship-in-the-hops-industry-report-2013.pdf

4.1.1 Economic Instruments in the Study Area

The goal of IAP clearing programmes in the Keurbooms and Karatara catchments by provincial departments creates a platform from where EPIs can be developed to change the behaviour of stakeholders towards promoting ecological restoration and sustainable land management.

Key prerequisites for implementing an EPI (Maila *et al.* 2018) include the following:

Prerequisites for EPI implementation	Presence in the case of the Karatara and Keurbooms catchment
1) There is a clear demand (need) for ecosystem services, which have financial value to one or more stakeholders;	Ecosystem services identified above; display the highest demand impacted by IAPs;
2) Provision of ecosystem services is threatened;	Threatened by extensive IAP;
3) Specific resource management actions offer feasible solutions;	The feasibility of IAP clearing programs is illustrated in this report;
4) Supportive intermediary organisations to facilitate the EPI mechanism;	Working for Wetlands, local municipality; provincial departments, independent auditors, Bio-Fin etc;
5) Resource tenure is clear, and contracts can be enforced;	Focus will be placed on land owners;
6) Outcomes of actions can be independently monitored and evaluated;	Site investigations/auditing;
7) Supportive national conditions (e.g. policies that promote secure property rights and market exchange).	See Table 10-26.

The development of an EPI scheme that supports the clearance and maintenance of land degraded by IAPs is a feasible option. The specific approach and mechanism whereby the scheme operates must be explored through first understanding the institutional, operational and policy landscape from where the scheme will operate.

Economic instruments are utilised to provide a mechanism by which role players are financially incentivised to manage a system in a desired manner by the regulator. In the case of the Karatara and Keurbooms catchment, the proposed economic instrument will provide a mechanism by which land owners or stakeholders are financially incentivised to conduct continued IAP Clearing Programmes on their land (or other land).

In the context of this wider definition and scope of incentivising sustainable land management, various EPIs currently exist. As the impacts of IAPs in the Karatara and Keurbooms catchments persist it is safe to assume that these alone may not provide sufficient mechanisms to incentivise landowners, however provide a platform from where additional EPIs can be developed and operate Existing EPIs are described and unpacked in Table 4-1.

Table 4-1: EPIs focussing on sustainable land management currently in place in South Africa

Existing EPIs	Funder	Incentive	Strengths	Weaknesses
- Working for Water (WfW)	- Government - Water tariffs	- Increased water supply to associated catchments	- Government organisation that deals exclusively with IAP clearing - Expanded Public Works Program - Makes use of a water pricing strategy mechanism	- Limited to public land - Limited long- term ongoing rehabilitation
- Duty of Care	- Land owner	- Compliance with NEMA	- Cradle to grave, site specific management by land owner	- Limited implementation and monitoring by government allows for avoidance by land owners
- Biodiversity Stewardship Program	- Private Land owner	- Tax incentive through SARS if a portion of land is protected to some degree	- Declared land is managed to an agreed management plan - Options exist for landowners (5, 30 or 99 years) - Cradle to grave, site specific management	- Limited to conserving threatened or depleted ecosystems to support critical species habitats - Low productivity of land does not provide sufficient financial incentive
- Spatial Planning and Land Use Management Act (SPLUMA)	- Land Owner, Municipality	- Certification is required for transfer or registration (Impacts on the sale ability)	- Incentivises land owner to maintain land to a specific standard	- Municipalities face limitations enabling active enforcement of SPLUMA

4.1.2 Strategic Approach to Economic Instrument proposal

The proposal of IAP clearing programmes in the region of the study area is not a new approach or proposal. Studies conducted on the costs and benefits related to IAP clearing have not yet solved the complex problem of IAPs in South Africa. A "business as usual" approach is therefore not an option however the challenge is likely not to have an overnight, one size fits all solution. The existing landscape provides a proportion of the solution and additional efforts will contribute to the resolution of the IAP threat. The approach to identifying the next piece of this complex will be focussed on opportunities identified in the previous section and will place importance on the following criteria:

- Utilisation of existing structures as intermediary organisations;
- Ensuring a clear goal with defined solutions;
- Informed by the value of ecosystem services (conducted in this study);
- Enforcement possibility with clear guidelines;
- Outcomes of actions can be independently monitored and evaluated.

The approach is to focus on the key ecosystem services that were identified to have the largest response to EPI mechanisms operating in the study area. This is a crucial component to successful EPIs, is that the resultant response in natural benefits further incentivises the ongoing management of the EPI landscape operating to ensure IAP clearance. In other words, although the EPIs function to provide financial incentives to land managers, the natural benefits received in response must be clearly realised by drivers of the mechanism. The restoration of key ecosystems will result in the stimulation of a value chain that will be required for the effective implementation, self-regulation and ongoing operation of proposed EPI mechanisms. Table 4-2 describes the value chain and probable transactional linkages between role-players, stakeholders and beneficiaries.

Table 4-2: Description of the value chain in response to restored ecosystem services and possible transactional mechanisms

Service Restored	Direct Beneficiaries	Indirect Beneficiaries	Who Pays	Who Sells	Potential Transactional Mechanism	Proposed EPI
- Water Quantity Regulation	- Municipality (WMA/WSA) - Timber/ agroforestry - Irrigators - Tourism Industry	- All water users	- Municipality - All water users	- Landowners - Local Communities - Municipalities (WMA/WSA)	- Water Tariffs	- Alien Clearing Water Charge
- Disaster Regulation	- Municipality (infrastructure) - Land Owners - Plantations	- All sectors in the region	- Insurance industry	- All residents with infrastructure threatened by fire	- Reduced insurance premium	- Fire Risk Premium
- Habitat Support	- Conservation agencies - Informal communities	- All sectors in the region	- Land developers, investors or industry	- Landowners - Local Communities - Municipalities	- Mitigation Hierarchy (Offsets)	- Alien Clearing Incentive

Three types of EPIs have therefore been proposed of which include:

- For water provisioning an Alien Clearing Water Charge EPI;
- For disaster management a Fire Risk Premium EPI; and
- For habitat support an Alien Clearing Incentive EPI.

4.1.2.1 *Alien Clearing Water Charge EPI*

The Alien Clearing Water Charge would constitute a payment by the water service authority to the land owner for initial clearing and maintenance. The DWS, in all their reconciliation strategies, recognises that alien invasive clearing is a form of raw water supply. If a landowner therefore does alien clearing the water yield of the catchment will increase. The increased water yield is the water provisioning benefit resulting from alien clearing. The direct beneficiary of the additional yield would be the water management authority (WMA) downstream of the cleared area. This could be a government water scheme, a water board, or a water service authority (WSA). In this case the direct beneficiary would be the George, Bitou and Knysna Local Municipalities of which are all Water Service Authorities. Although good scientific evidence of the relationship between tree cover and MAR exists, the relationship between MAR and water yield needs to be quantified to a sufficient level of accuracy in order to provide evidence to the chain of causality. This requires a suitable hydrological monitoring and modelling. The magnitude of the water charge may also vary depending on the marginal cost of water supply. In the most expensive case desalinated sea water, at an approximate cost of R12 /Kl serves as the highest marginal cost of supply. In the best case, the cost of alien clearing provides a minimum water charge which is equivalent to R1/Kl. The actual charge would lie within this range of value and would be negotiated between the land owner and the WSA on a case by case basis. In this case, we estimate the potential value of additional water to be between R25.1 to R307.3 mil per year with a net present value equivalent to R76 000 to R933 000 per ha.

4.1.2.2 *Fire Risk Premium EPI*

With respect to disaster risk management, the devastating wildfires in the southern cape in 2016 serves as stark evidence of the increased fire damage risk that alien tree species introduce to infrastructure. In plantation forestry context, fire risk is mitigated by managing fire breaks and having clear fire safety risk management plans. Similarly, alien invasive clearing mitigates the risk of fire damage. Thus, it is expected that alien invasive clearing would reduce re-insurance risk premiums. The causal effect of alien clearing on insurance risk premiums is not simple. The insurance premium benefit would impact a large multiple of property owners (the insured) and also a large multiple of insurers. However, based on the estimates done in this study the fire danger premium resulting from alien species cover is approximately R4.8 mil per year, with a net present value equivalent to R14 600/ha. Therefore, there is an economic case to be made for a mechanism for linking reduced insurance premiums to alien clearing programs. For a mechanism of this nature to succeed, a collective of land owners would have to engage with a collective of insurers, and agree on likely changes in fire damage risk resulting from alien clearing programs. It is thus required that land owners organisations reach out to the South African Insurance Association (SAIA) to explore potential ways forward.

4.1.2.3 Alien Clearing Incentive EPI

Restoring ecological infrastructure through alien clearing, contributes significant retrieved habitat to the natural capital balance sheet. The benefits of this habitat is indirect to economic decision making. These benefits include for instance the support of indigenous species composition that ensure the native integrity and resilience of ecosystems are maintained and self-regulated not provide the known range of associated ecosystem services. The department of environmental affairs and various provincial environmental departments have been developing biodiversity offset tools as mechanisms for linking economic decision making directly to habitat management. Specific examples include SANBI's Wetland Offset Guideline (SANBI 2014), the Western Cape Governments Provincial Guidelines on Biodiversity Offsets (DEADP 2007) and the DRAFT National Biodiversity Offset Policy (Gazetted March 2017). These offset tools were intended to quantify extent of mitigation measures required as offset conditions following from environmental authorisation processes. In this case, we estimate the potential value of biodiversity (through the use of the offset approach) to be between R1.6 to R2.9 mil per year with a net present value equivalent to R4 800 to R8 900 per ha. In the case of alien invasive clearing, it may be possible for the land owner to obtain biodiversity credits which may be traded with other parties as part of their environmental authorisation conditions. Such a mechanism would require the environmental authority to develop a strategic framework that regulates and enables the institutional requirements of such a credit trading scheme. This approach is currently however rather contentious and will only be introduced here and not explored further.

4.1.2.4 Transactional Clearing Mechanisms

For EPI's to be effectively implemented, it requires a range of transaction clearing mechanisms, i.e. the mechanisms that make markets work. These mechanisms can be thought of as institutional arrangements that enable transactions to be cleared. In other words, they comprise the range of institutional arrangements that enable the completion of all activities required, from the time a commitment in a transaction is made, to the point where the transaction is settled. Transactional clearing mechanisms relevant to the EPIs proposed in this study may for instance include the following:

- Tariff Systems;
- Tradeable permit systems;
- Certification Systems;
- Assigning Property rights;
- Environmental Auditing;
- Valuation Systems; and

- Regulatory Policy Instruments.

5 STRATEGIC IMPLEMENTATION PLAN

Based on the evidence, analysis and discussion in this report, a feasible case has been made for internalising restored ecosystem services into the economy. The sustainable operation of appropriate EPIs however requires the definition, lobbying and implementation of a strategic framework. The potential value of restored water through IAP clearing programmes has been shown to be by orders of magnitude larger than other prioritised ecosystem services. As a point of departure, the Alien Clearing Water Charge EPI will represent the initial focus of the strategic implementation towards funding and driving ecological restoration through IAP clearing programmes.

5.1 Strategic Goal

The implementation of EPI's require detailed planning, multiple organisations and new institutional arrangements to be implemented. It is therefore important that a concise measurable and time bound strategic goal be defined to guide strategy implementation.

The goal proposed to stakeholders at the workshops held on the 25th and 26th July 2018, reads as follows:

"By 2021 the private landowners and municipalities of the Karatara and Keurbooms catchment areas in collaboration with key stakeholders, develop market driven Economic Policy Instruments (EPIs) for alien invasive plant species removal and rehabilitation that links the benefits of restored ecological infrastructure to economic decision making."

5.2 Strategy Implementation

As the key beneficiary of restored ecosystem services through IAP Clearing programmes the strategy must be led by the relevant local municipality (Bitou LM, George LM and Knysna LM).

As part of the broader EIIF process, the WC Government will provide support and oversight to the process.

Land owners, on whose land alien plants occur, would play a central role to enabling the implementation of the strategy.

A range of other role players, responsible for various aspects of EPI transactions, and responsible for market oversight, would be identified for the individual EPIs (refer to section 5.1).

It is envisaged that a number of key stakeholders will have important strategic roles. Such stakeholders would include the DEA NRM programme, SANBI, BioFin, WWF, BGCMA, SCLI, FMA, Garden Route rebuild Initiative, Landcare, Catchment Management Agency, Garden Route Biosphere Reserve (GRBR)and others.

Note that the strategic goal set out in 6.1 above may require revision pending additional consultations with stakeholders that have not yet been consulted.

Various sequential enabling outcomes are required towards achieving the strategic goal. Each enabling outcome requires actions to be performed. The following table describes these requirements in a strategic framework.

Time	Enabling Outcome	Enabling Action	Responsibility/ Driver
Year 1	1) Establish strategy implementation working relationships	1a) Land owners to mobilise an initiative that can contribute to the strategy execution in an organised manner	Local Municipalities/ land owners (Incl. SCLI, FMA, Garden Route rebuild Initiative)or Private sector (e.g. Tourism) deriving benefit from the catchment
		1b) Established landscape initiatives such as SCLI or the GRBR, with the support of Western Cape Government, should drive the establishment of an "EPI Implementation Committee" ensuring representation from: • WC Government • Bitou, George and Knysna LM • Land Owner representation • GRBR • Private sector • Researchers or establish relationships with universities	Driven by landscape initiatives (with support from Western Cape Government)

Time	Enabling Outcome	Enabling Action	Responsibility/ Driver
		A key element is ensuring buy in and ownership by landowners and local municipalities.	
		1d) Agree on committee mandate, constitution and budget.	The EPI Implementation Committee
Year 1	2) Establish of Alien Clearing Water Charge EPI	2a) Engage with CMA/DWS/WSA on implementing Alien Clearing Water Charges	EPI Steering Committee
		2b) Conduct overview of regulatory requirements for implementation (see conceptual schematic Figure 5-1)	
		2c) Analyse existing data on vegetation extent and clearing costs (Assess existing MUCP or develop for Catchments)	
		2d) Conduct hydrological study to quantify water benefit and demand. Model scenarios based on the EPI value chain (as per Figure 5-1).	
		2e) Design monitoring and evaluation system for the EPI	
		2f) Identify transactional market clearing mechanisms required for EPI implementation	

Time	Enabling Outcome	Enabling Action	Responsibility/ Driver
		2g) Develop bankable business case for the EPI. Propose conditions for the pilot study	
Year 2	5) Conduct pilot studies and municipal implementation	5a) Pilot the EPI in one or more locations	Local Municipalities
		5b) Establish monitoring and evaluation system for each pilot site	EPI Steering committee
		5c) Develop municipal implementation plan for each EPI informed by pilot studies	Local Municipalities
		5d) Incorporate municipal implementation plan into municipal IDP and regional strategic development plan	Local Municipalities

5.3 Conceptual EPI Structural Framework

The implementation of the strategic framework requires the formalisation of various institutions and institutional arrangements to ensure a flow of funding and benefits towards the effective implementation of proposed EPIs. As a point of departure Figure 5-1**Error! Reference source not found.** illustrates the conceptual flow of payments, funding, benefits and incentives required for the implementation of the Alien Clearing Water Charge EPI proposed in this document. The development of such arrangements would represent a key step towards implementation.

The conceptual schematic represented in Figure 5-1 illustrates that a clearing house would be responsible for the administration of the entire alien clearing EPI/PES process. The clearing house would collect funds from an investor (The investor would include stakeholders such as municipalities and private land owners.). Through the use of these funds the clearing house would appoint a contractor for the clearing of IAPs. The contractor conducts clearing activities and communicates with the clearing house (through report submission or other approach). The clearing house will appoint an auditor who will audit and certify the site and offer a rating in terms of methods utilised or level of sufficiency of clearing. This rating will inform the clearing house and municipalities of clearing activities. The auditor would provide a report to the clearing house and be paid by the clearing house for their service. The rating would be held by the clearing house for the audited site. Landowners that have a rating associated with their land will receive a financial break/incentive from the municipality through the form of a credit note, tax or rate break. The local municipalities will drive this process and together with national departments will be responsible for the regulation, formalisation and the management of the alien clearing EPI/PES process.

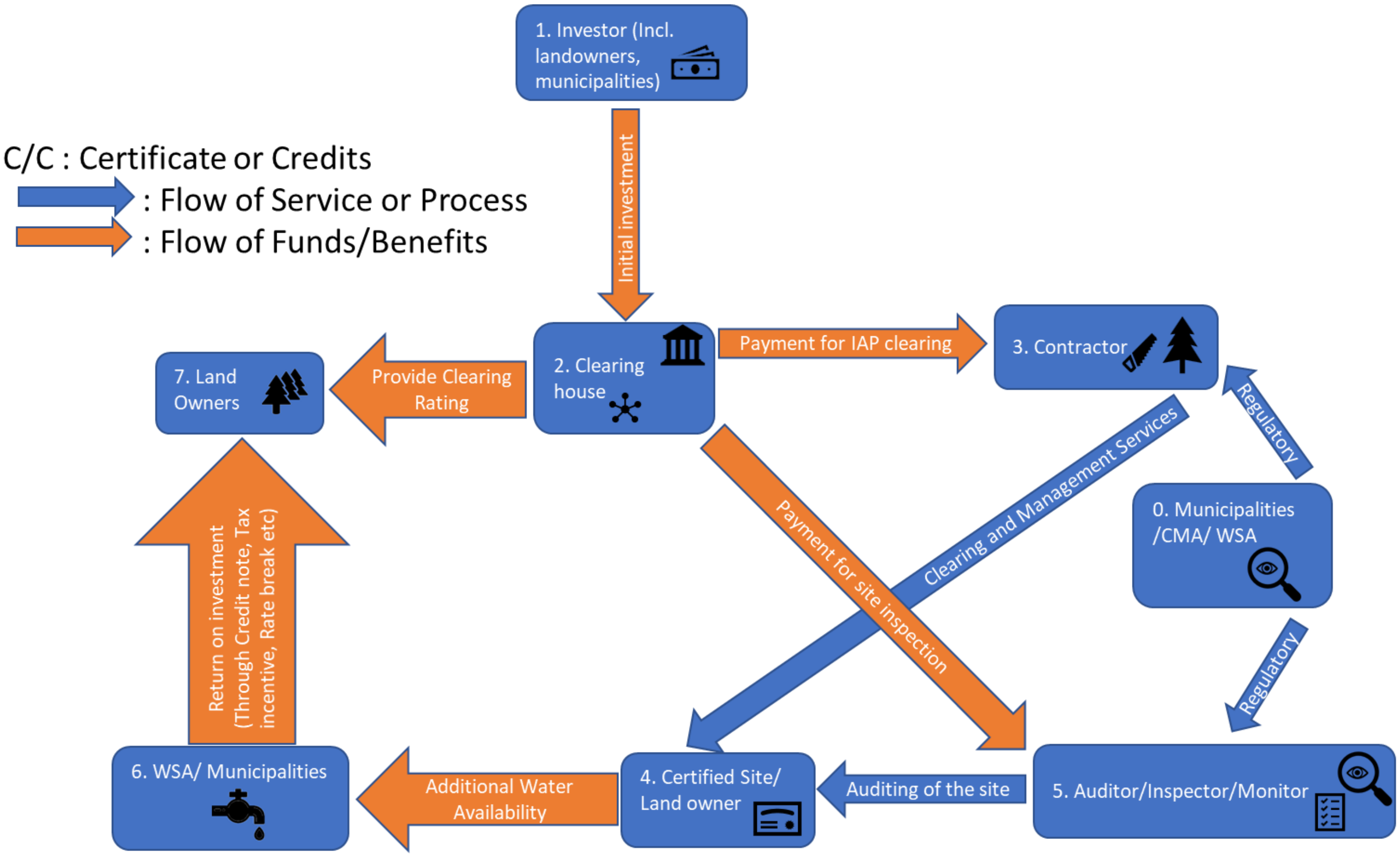

Figure 5-1: A conceptual representation of the flow of payments, benefits and incentives towards ensuring the effective implementation of proposed EPIs

6 CONCLUSION

The lost, yet retrievable, ecological infrastructure value was conservatively estimated for the Karatara and Keurbooms catchments to fall between R31.5 mil and R315 mil per year. This value took into account the restoration of water provisioning, disaster regulation (fire regulation) and habitat supporting services.

The average value for Bitou Local Municipality is in the order of R75 mil per year. The average value for George Local Municipality is in the order of R50 mil per year. The average value for Knysna Local Municipality is in the order of R47 mil per year.

The provisioning of additional water was shown to have by order of magnitude the greatest proportion of the total value lost.

As a result the opportunity value of additional water is estimated to fall between R25.1 mil and R307.3 mil per year. Through alien clearing and restoration activities the water benefits alone would contribute an average ecological infrastructure value of R166.2 mil per year. This represents a substantial opportunity for maximising benefits through internalisation of this lost value into the economy.

The disaster regulation (or insurance risk) value is in the order of R4.8 mil per year and habitat support value estimated at R1.6 mil and R2.9 mil per year.

Additional more direct benefits of IAP clearing and restoration, include job creation and stimulation of the local economy. The clearing and restoration of the total current extent of IAP species as it stands in the region would require an average of 100 000 person days per year over the first 5 years (approximately 400 jobs per year). Furthermore, the total market value received through the sale and use of alien plant biomass has been identified to average R270 mil between (R35 000 and R47 000 per ha of high density stands). With the region representing an unemployment rate of 32% (Census 2011), this provides a vital opportunity to improve local socio-economic conditions.

The assessment demonstrated the benefits of ecological restoration and IAP clearing programmes to be substantial of which are significantly larger than the costs required for clearing and restoration. In-fact for every R1 invested in alien clearing and restoration there is a multiplied return of investment to the catchment of R3.87 through reclaimed natural benefits.

A returns ratio of this magnitude demonstrates a highly feasible opportunity for investment that will sustainably manage ecological infrastructure while improving local and regional socio-economic well-being.

Driven by the significant opportunity in the restoration of the water provisioning service the key proposed EPI is an Alien Clearing Water Charge EPI.

The Alien Clearing Water Charge would constitute a payment by the water service authority to the land owner for initial clearing and maintenance.

The increased water yield is the water provisioning benefit resulting from alien clearing. The direct beneficiary of the additional yield would be the water management authority (WMA) downstream of the cleared area. This could be a government water scheme, a water board, or a water service authority (WSA). In this case the direct beneficiary would be the George, Bitou and Knysna Local Municipalities of which are all Water Service Authorities.

The implementation of the Alien Clearing Water Charge EPI requires detailed planning, multiple organisations and new institutional arrangements to be implemented. It was therefore important that a concise measurable and time bound strategic goal be defined to guide strategy implementation.

As the key beneficiary of restored ecosystem services through IAP Clearing programmes the strategy must be led by the relevant local municipality (Bitou LM, George LM and Knysna LM). As part of the broader EIIF process, the WC Government will provide support and oversight to the process.

Land owners, on whose land alien plants occur, would play a central role to enabling the implementation of the strategy. A number of key stakeholders will have important strategic roles. Such stakeholders include the DEA NRM programme, SANBI, BioFin, WWF, BGCMA, SCLI, FMA, Garden Route rebuild Initiative, Landcare, Catchment Management Agency, Garden Route Biosphere Reserve (GRBR) and others.

The analysis demonstrates a highly feasible opportunity for investment as well as an evidence based EPI and implementation strategy that must be utilised towards operationalising a payment scheme that re-invests the offset value of water gained through alien clearing and restoration activities. It is imperative that the local municipalities utilise the results of this assessment to achieve the dual purpose of sustainably managing ecological infrastructure and increasing water available towards improving local and regional socio-economic well-being.

7 GLOSSARY

Cultural Services	Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, e.g. cultural diversity, knowledge systems, educational values, social relations, sense of place, cultural heritage and ecotourism (MEA 2005).
Ecological Infrastructure	A functioning ecosystem that delivers valuable services to people such as fresh water, climate regulation, storm protection and soil formation (SANBI 2012).
Ecosystem Service	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits (MEA 2005).
Groundwater	Include (but are not limited to), rechargeable aquifers (FEGS-CS 2013).
Provisioning Services	Products obtained from ecosystems, e.g. fresh water, food, fibre, fuel, genetic resources, biochemical, natural medicines and pharmaceuticals (MEA 2005).
Regulating Services	Benefits obtained from the regulation of ecosystem processes, e.g. water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation (e.g. droughts, floods, storms) (MEA 2005).
Rehabilitation	The continued actions required for the restoration of an impacted system
Restoration	The renewal of ecological functionality (in this report restoration is synonymous with IAP clearing)
Rivers and Streams	Include (but are not limited to), major rivers, perennial streams, streams and man-made canals (FEGS-CS 2013).
Supporting Services	Services necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some services, like erosion regulation, can be categorised as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people. Supporting services include primary production, nutrient cycling and water cycling (MEA 2005).

8 ACRONYMS

CRA	Comparative Risk Assessment
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
EIIF	Ecological Infrastructure Investment Framework
ET	Evapotranspiration
FAO	The UN Food and Agricultural Organisation
FEGS	Final Ecosystem Goods and Services
Ha	Hectare
IAP	Invasive Alien Plant
Kl	Kilolitre
MEA	Millennium Ecosystem Assessment
MUCP	Management Unit Clearing Plan
PES	Payments for Ecosystem Services
SANBI	South African National Biodiversity Institute
SEEA	System for Environmental Economic Accounting
TEEB	The Economics of Environment and Biodiversity
WfW	Working for Water

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10 ANNEXURES

Annexures include:

1) A: Catchment Descriptions
2) B: Methodologies and Approach
3) C: Ecosystem Service Map

10.1 Annexure A: Catchment Descriptions

10.1.1 Keurbooms Catchment

The Keurbooms catchment fall under the Breede - Gouritz water management area. In the large Breede-Gouritz water management area, the catchments form part of what is called the Coastal catchment sub-area (4 459 km^2), and in this area it belongs to the Knysna-to-Bloukrans sub-area (K50D-K70) In terms of size, the catchment is relatively small with an area of 1 380 km^2 (CSIR 1983). The Keurbooms River is joined by the Palmiet river and flows into the sea via the Keurbooms Estuary (Figure 10-1). The Keurbooms Estuary has large bedforms in its mouth region which can very easily lead to mouth closure under slight flow reductions as it is currently estimated that a decrease of as little as 5% during the low flow period could cause closure.

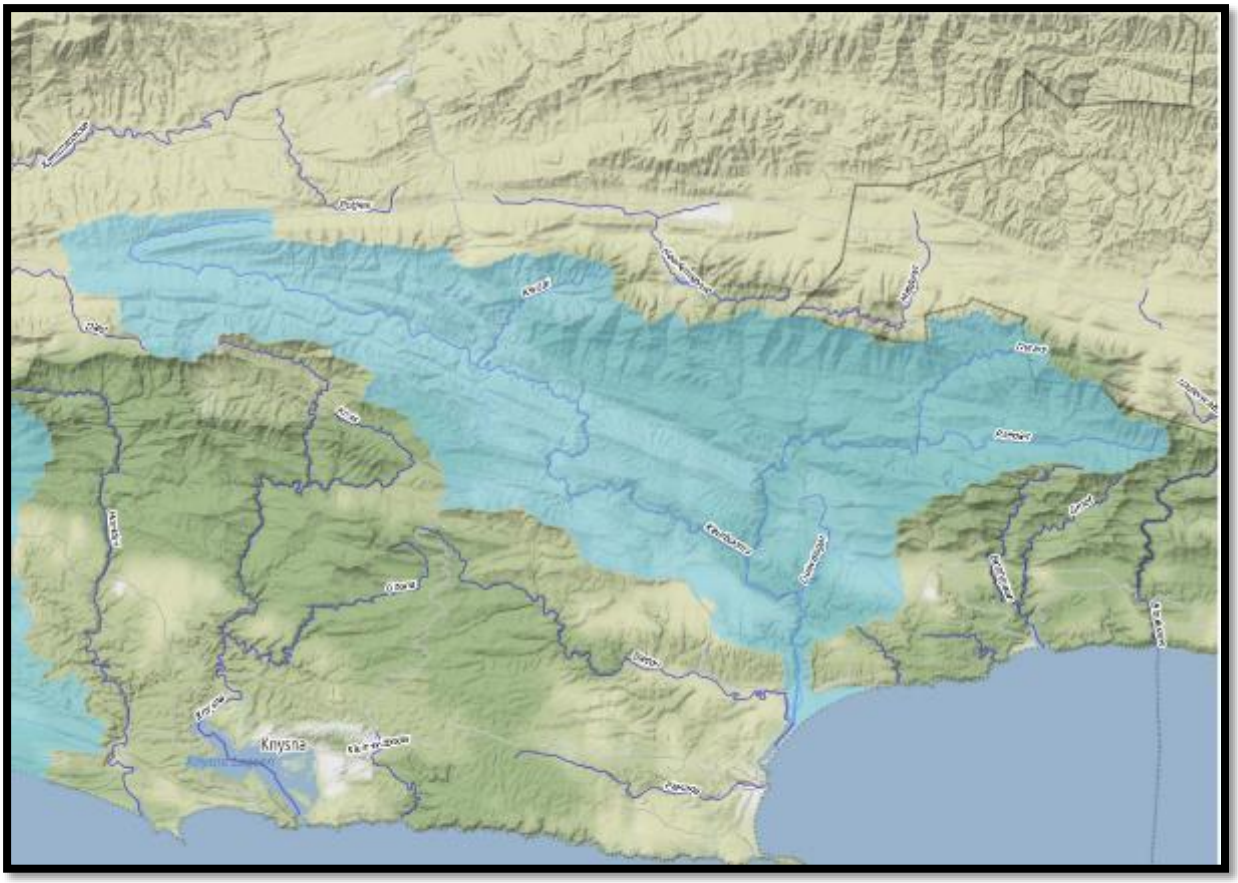

Figure 10-1: Location of the Keurbooms catchment within the Province of the Western Cape, South Africa.

Catchments falls within Bitou and George Local Municipalities (LM) and Eden District Municipality (DM). According to Bitou LM Integrated Development Plan (IDP) 2016/2017, tourism is the largest economic sector in the town and remains the largest source of employment.

The official unemployment rate in Bitou Municipality is 30,1% according to Census data (StatsSA 2011), the highest of the seven local municipalities in the Eden district.

The primary supply of water to Plettenberg Bay is abstracted on a run-of-river basis from the Keurbooms River. The water is pumped from the river to three raw water storage reservoirs from where it flows under gravity to the Plettenberg Bay WTW. A licence for 3.154 million m^3/a is in place for abstraction from the Keurbooms River.

The Keurbooms river and its tributaries are under serious threat from pine and wattle encroachment it has been reported that 54% of the catchment has been invaded to some degree (Le Maitre *et al.* 2002).

The corresponding reductions in the natural river flows attributed to these invasions are about 22.1%. If the invasions are not controlled they could potentially spread, and occupy 77%, of the catchments. At an annual expansion rate of 10–15% this would take approximately 26 years. The projected flow reductions for the catchment would increase to 95.5%. The estimated cost of the control programmes to prevent these losses would be about R59.4 million for the catchment. Should the catchment be allowed to become fully invaded before control operations are started, then the costs would rise to R123 million.

These studies underscore the importance of maintaining adequate control programs for IAPs, given the prognosis for drier climates that would further increase these impacts if alien plants are allowed to spread and dominate catchments.

The Keurbooms River Nature Reserve Complex (KRNRC) falls within the Keurbooms catchment of which is classified within the Cape Floristic Region (CFR). The CFR is one of the world's most biologically interesting ecosystems and is an epicentre of diversity and endemism. It is the smallest and richest of the six floral kingdoms in the world, and it is the only one to be found entirely within one country. At least 70% of the plant species and nearly 20% of the types that make up this region are found nowhere else on earth. This rich biodiversity is under serious threat due to impacts such as conversion of natural habitat to permanent agriculture, inappropriate fire management, rapid and insensitive development, overexploitation of water and marine resources, and infestation by alien species.

10.1.2 Karatara Catchment

Karatara catchment falls within the Knysna Local Municipality (LM) and Eden District Municipality (DM). Knysna town is appropriately located (along the N2, a regional route) as the central and most significant settlement in the municipality, as is Sedgefield, the second most significant settlement in the municipality. The main human settlements in the municipality include Knysna, Sedgefield, Rheenendal and Karatara (Figure 10-2).

Figure 10-2: Location of the Karatara catchment (map supplied by SANPARKS)

According to Knysna LM IDP (2017), the sector which created the most jobs in the Greater Knysna economy is the wholesale and retail trade, catering and accommodation sector (26% in 2015). The municipal area has additionally experienced substantial growth (8,1) in its construction sector over the past few years. This is similarly followed by growth in agriculture at a rate of 7.7 per cent per annum (the fastest in the District). The unemployment rate of Bitou LM currently sits at 19% (Bitou LM IDP).

Similarly to the Keurbooms catchment, there is a significant threat of alien plants to natural ecosystems. The key alien species occurring in the catchment is Black Wattle (*Acacia mearnsii*). Black wattle is a widespread and common alien species in South Africa, and operations to control non-plantation trees are a long-term endeavour. The species often forms dense stands, maintains a high green leaf area throughout the year, and frequently replaces seasonally dormant grasslands and fynbos.

The extent of invasion by alien plant species catchments is reported to lead to a reduction in surface water run-off (yield reduction), resulting in a total water deficit or shortfall. The clearing of these invasive alien plants can therefore, greatly contribute to the additional availability of water to the catchment. An analysis of the impact of invasive alien plants in the Coastal sub-area of the Gouritz WMA indicates a Current Deficit of 43 million m^3/a of which would be decreased through the rehabilitation of alien dense stands.

10.2 Annexure B: Methodology and Approach

The requirements for investigating the feasibility of alien invasive plants rehabilitation in Karatara and Keurbooms catchments is highly data intensive, requiring specific vegetation resource data at both a temporal and spatial scale. An intensive data acquisition process has been undertaken to best identify and source suitable and reliable data to effectively conduct this investigation. *Figure 10-3* gives the strategic approach to achieving these goals.

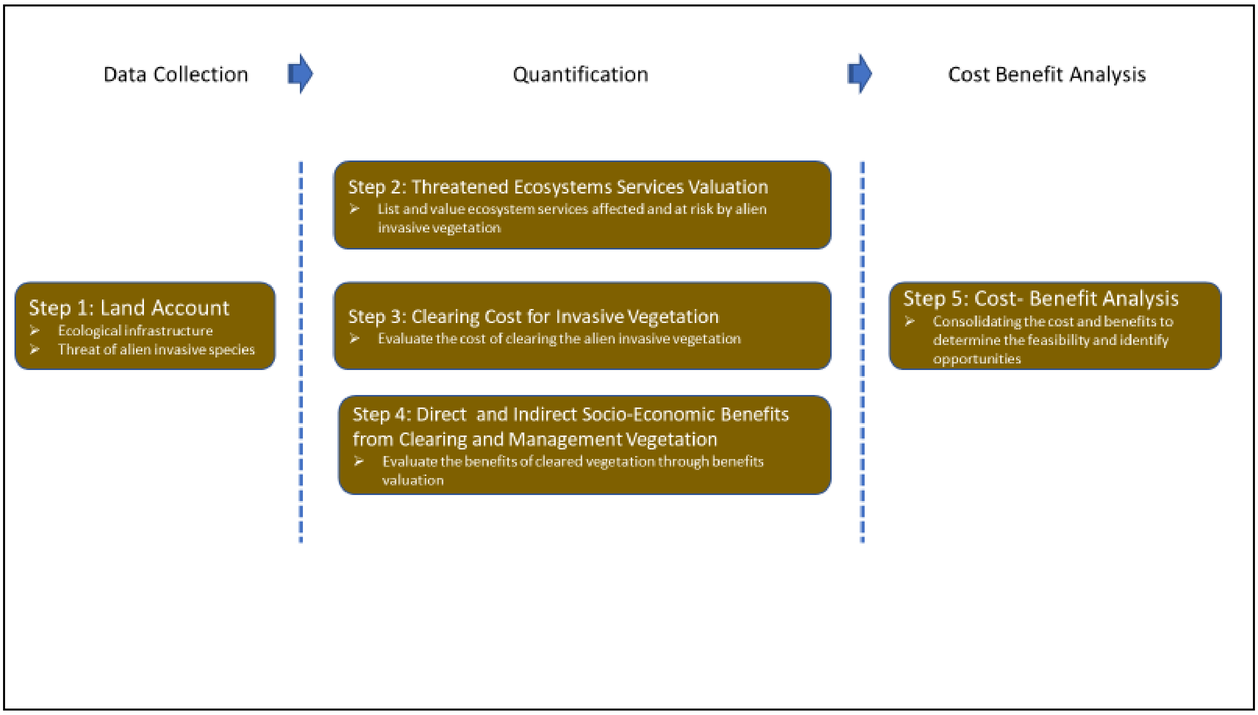

Figure 10-3: Model flow by steps.

10.2.1 Land Account

Prior to a land account being undertaken it is important to delineate management units in the study region. This firstly allows for increased resolution to a region and secondly allows for any future prioritisation of regions for management purposes.

The Karatara and Keurbooms catchments were segregated into 12 sub-catchments. This delineation was based on the sub-quaternary boundaries as developed by SANBI. The delineation of the study area into these units provided a logical approach to increasing the resolution of ecosystem services and their value to local (and national) beneficiaries in the region. The nature and distribution of ecological infrastructure is largely driven by hydrological patterns of which sub-catchments form a logical geographic area of which all water systems, including surface and groundwater, are included. Hydrologically, catchments form a logical unit and as a result are commonly used as water management units of which sub-catchments allow for increased resolution of results. The delineation and codes can be seen in Figure 10-4 and Table 10-1. Please note that 2 additional sub-quaternary catchments were included in the region of Sedgefield. This was done in order to improve the account of value received from ecosystems to downstream beneficiaries.

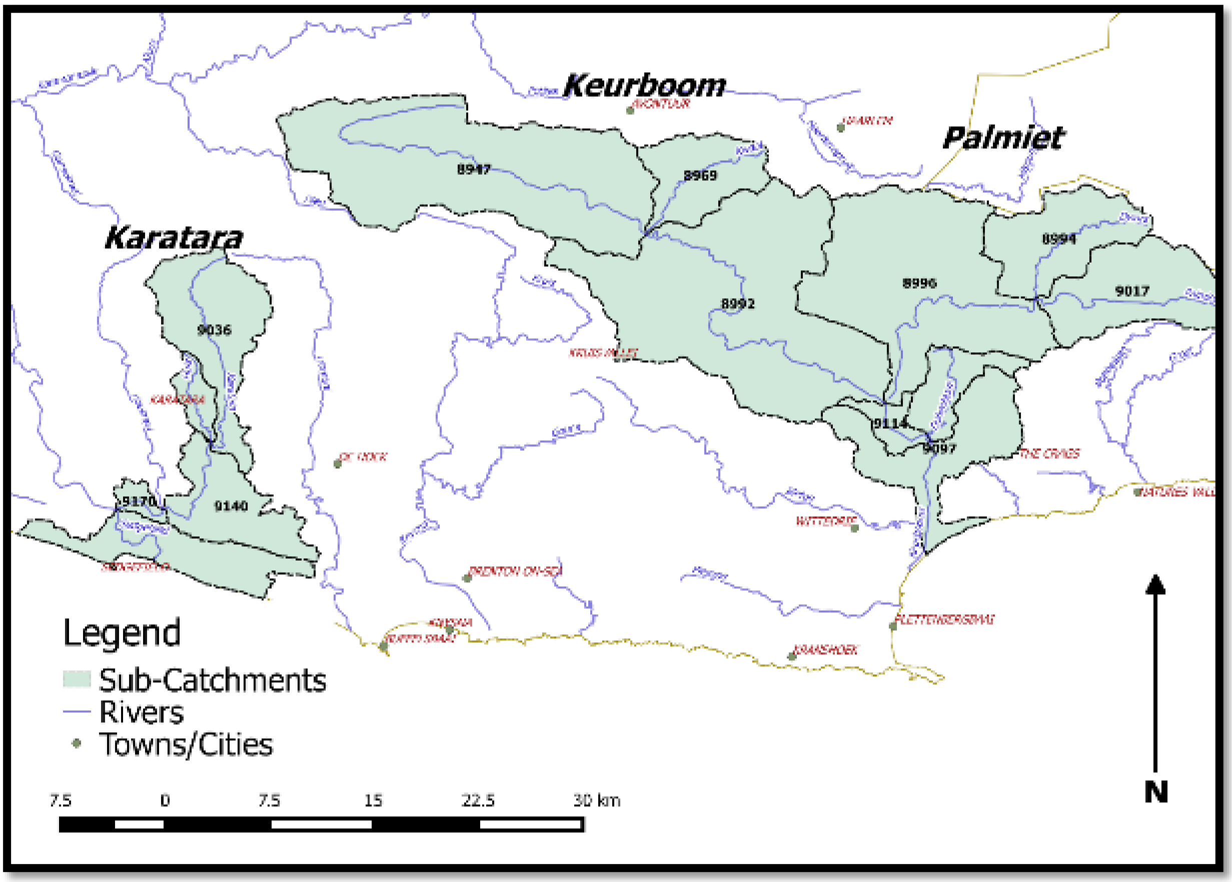

Figure 10-4: Catchment allocation within the Keurbooms and Karatara Catchments

Table 10-1: Catchment allocation within the Keurbooms and Karatara Catchments

Quaternary Catchment	Sub-Quaternary Catchment	Context	Major Town/City
K60A	8947	Keurbooms Catchment	
K60B	8969	Keurbooms Catchment	
K60C	8992	Keurbooms Catchment	Kruisvallei
K60E	9085	Keurbooms Catchment	
K60E	9097	Keurbooms Catchment	
K60E	9114	Keurbooms Catchment	
K60D	8994	Keurbooms Catchment	
K60D	8996	Keurbooms Catchment	
K60D	9017	Keurbooms Catchment	
K40C	9036	Karatara Catchment	
K40C	9095	Karatara Catchment	Karatara

K40C	9140	Karatara Catchment	
K40D	9170	Sedgefield Catchment	
K40D	9179	Sedgefield Catchment	Sedgefield

The catchments were classified based on the delineated sub-catchments of which became the management units of which were each classified from this point onwards.

The land account exercise was largely a data collection and spatial consolidation exercise. Indicators of land use were subdivided into the various management units. Data included in this way are included in Table 10-2.

Table 10-2: Spatial data utilised to classify each management unit in the study area

Data	Data Type Required	Source
Land Cover 2000	Land Use (Spatial)	CSIR/ARC 2000
Land Cover 2013/2014	Land Use (Spatial)	DEA 2014
Protected Areas	Protected Ecosystems (Spatial)	DEA 2015
Critical Biodiversity Areas (CBA) and Ecological Support Areas (ESA)	Ecological Importance/ Biodiversity Value (Spatial)	Western Cape Biodiversity Spatial Plan (Cape Nature 2017)
Alien Transformed Land	Extent of Impact (Spatial)	SANParks 2009 (Mr Johan Baard)
Demographics	Census Data (Database)	StatsSA 2011
Key Economic Sectors	GDP contributions (Database)	Municipal IDP's 2017
Water Use by Economic Sector	Water Allocation (Database)	DWS

The spatial layers were segregated based on management unit and the extent of each key data source was determined. Data attributes were kept disaggregated as far as possible as to ensure a larger resolution however the results have been simplified presented below in a series of figures.

Land Cover classes (simplified) for the year 2000 (ARC/CSIR 2000) can be found in Figure 10-5. The data shows extensive natural extent (68 000Ha) with the largest evident land use being forestry and plantations (4 000Ha). Cultivated land is present to a lesser extent (2 000Ha), with irrigated and dryland agriculture generally being isolated to specific management units. Urban regions are largely limited to the coastal regions.

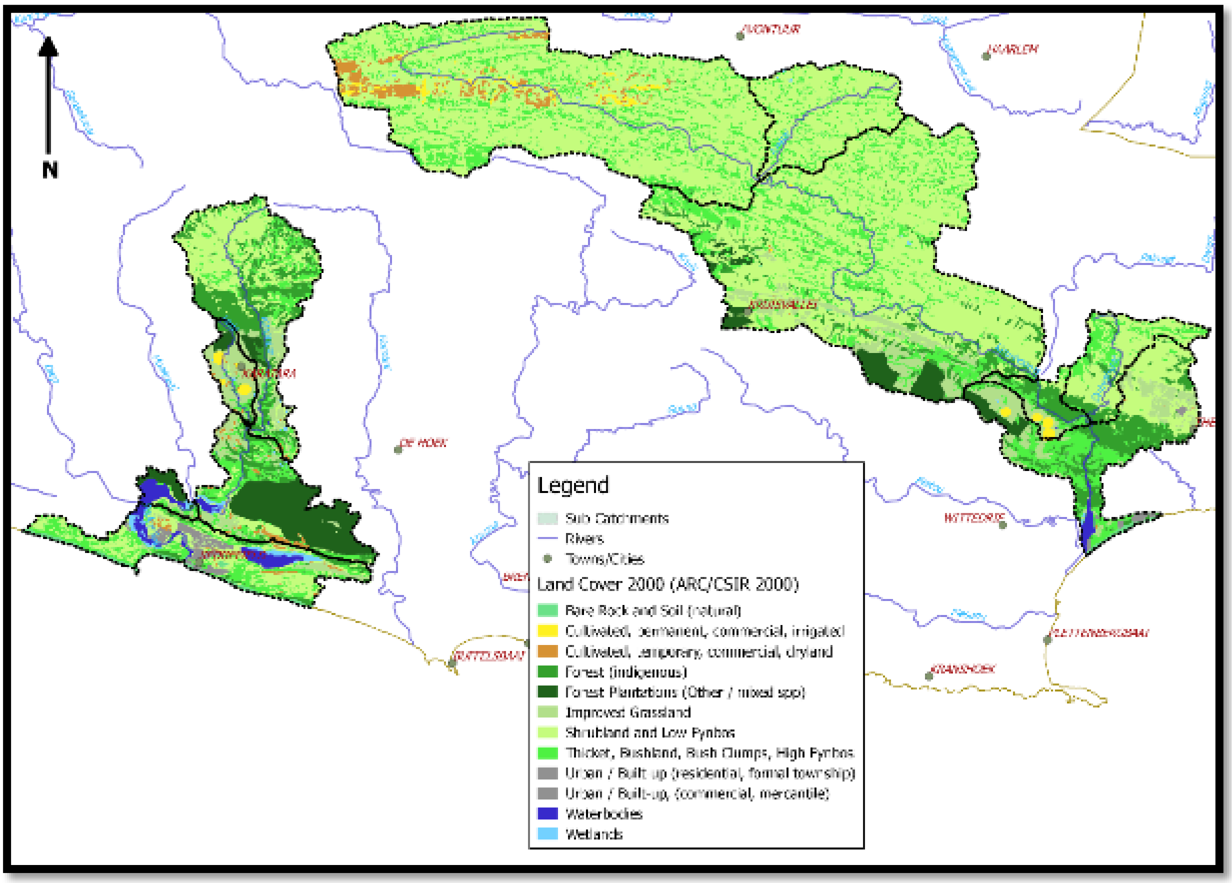

Figure 10-5: Land Cover 2000 in the Study Area (ARC/CSIR 2000) (not including the Palmiet River Sub-Catchment)

Land Cover classes (simplified) for the year 2013 and 2014 (DEA 2014) can be found in Figure 10-6. This data allows for an indication in changes to land use and potentially allows for spatial insight into a loss of ecological infrastructure. A key result is an increase in extent of plantations (7 500Ha) and cultivated land (4 200Ha). The results show a decrease in natural ecological infrastructure of almost 10% in 14 years.

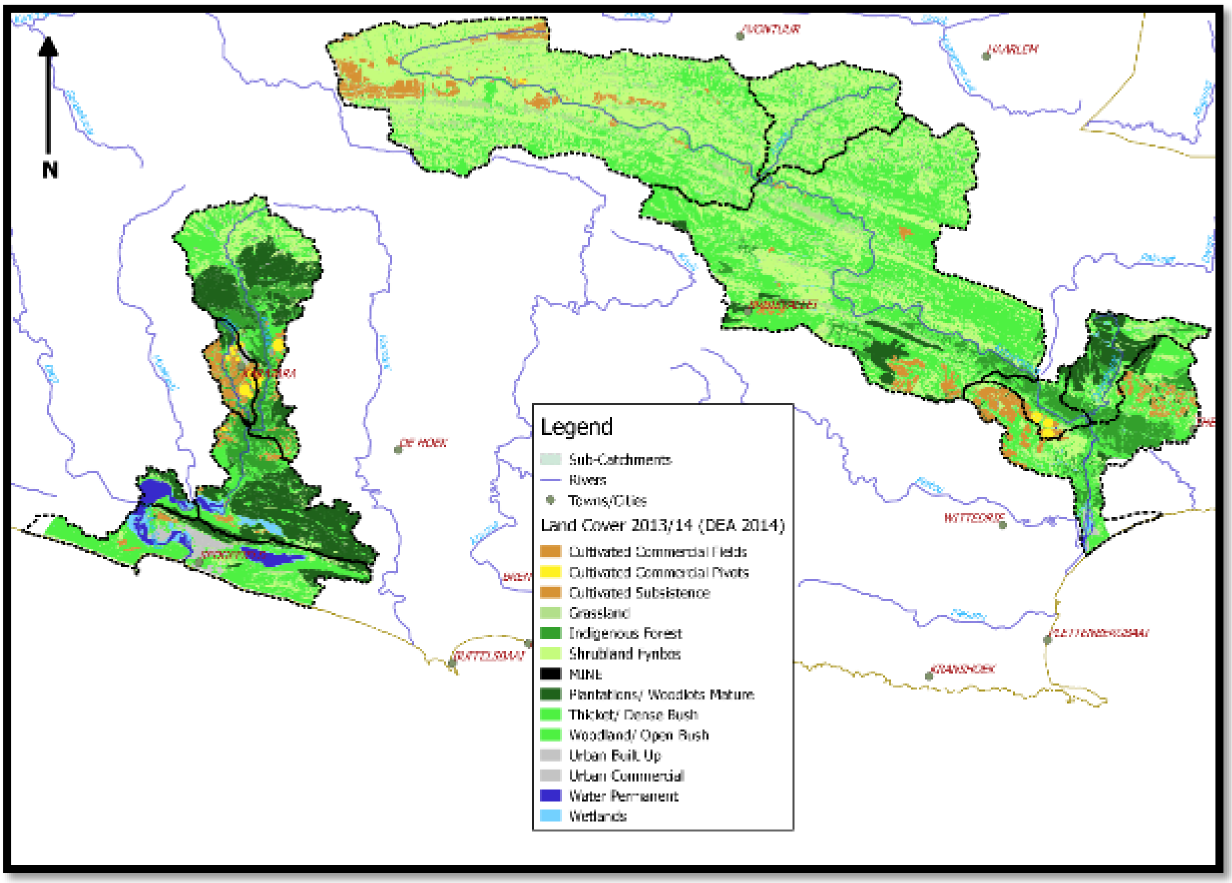

Figure 10-6: Land Cover 2013/14 in the Study Area (DEA 2014) (Not including the Palmiet River Sub-Catchment)

The extent of formally protected areas and regionally important areas for biodiversity (DEA 2016; Cape Nature 2017) can be seen in Figure 10-7. This data allows for insight into the state and condition of ecological infrastructure. Protected areas provide a level of maintenance and management of the health natural areas and therefore typically possess an increased ability to provide natural regulatory and cultural services to downstream and visiting beneficiaries respectively. Critical Biodiversity Areas (CBA's) and Ecological Support Areas (ESA's) indicate regions that have priority in terms of biodiversity planning and allow for insight into biodiversity and ecological infrastructure outside of protected areas.

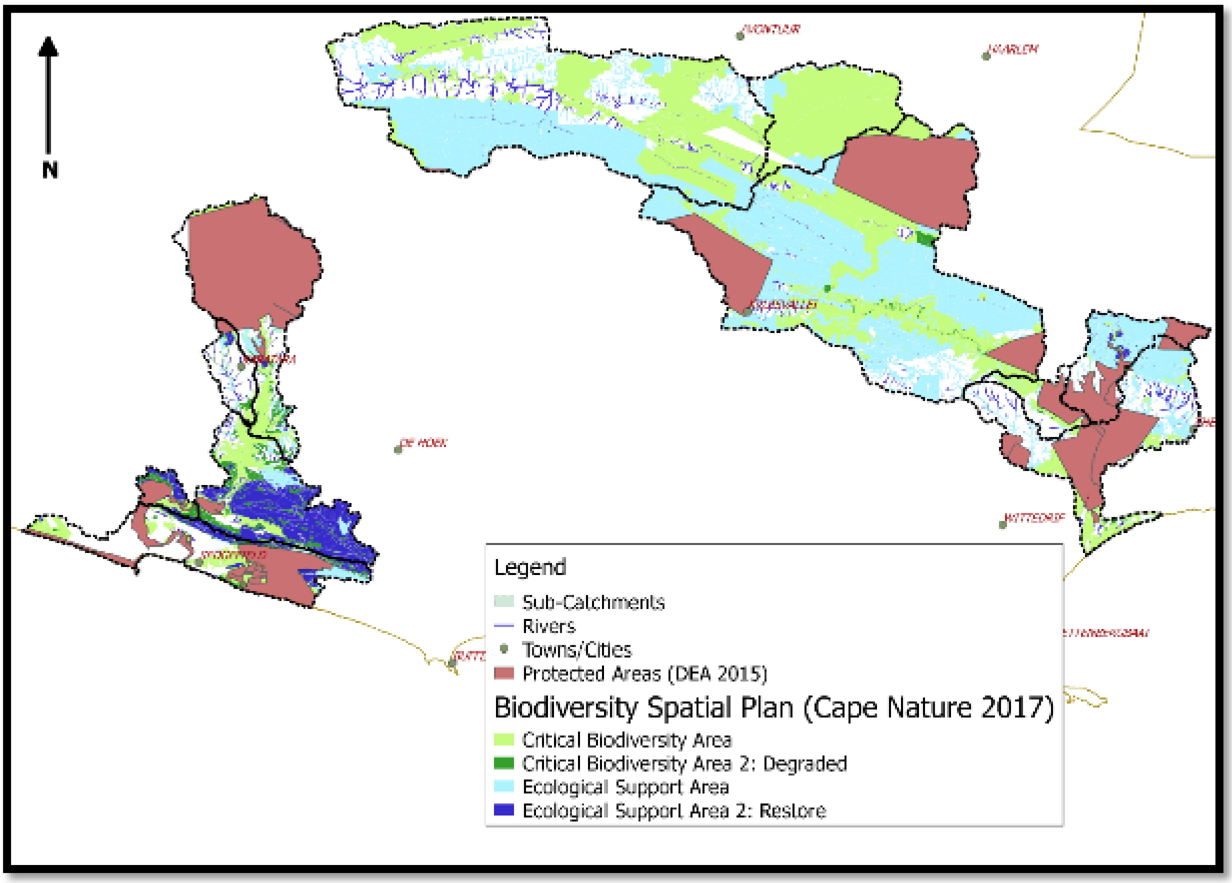

Figure 10-7: Protected areas and regionally important areas for biodiversity in the Study Area (DEA 2016; Cape Nature 2017) (Not including the Palmiet River Sub-Catchment)

Broad land cover classifications were received from SANParks (2009) and can be seen in Figure 10-8. This data provides valuable insight into not only the extent of alien plant species but also indicate the locality of plantations and regions of natural vegetation. Please note this data is not available for the Sedgefield management units. This data was helpful not only to identify the magnitude of alien infestation but also to differentiate between natural forest, plantations and dense alien infestations, insight that the land cover databases did not give. It is notable that the transformation by alien spread is mostly limited to riparian valleys but are also largely associated with plantations. Degraded land classifies approximately 12% of the study area and is characteristic of regions where anthropogenic activities have altered the natural environment. This may include impacts such as moderate alien infestation, old ploughed fields and fragmented habitats. Heavy alien degradation classifies approximately 4% of the study area and is characteristic of areas where aliens have had a 60 to 75% cost on biodiversity value. Alien transformed classifies approximately 2% of the study area and is defined as areas where alien vegetation has almost or fully replaced natural vegetation.

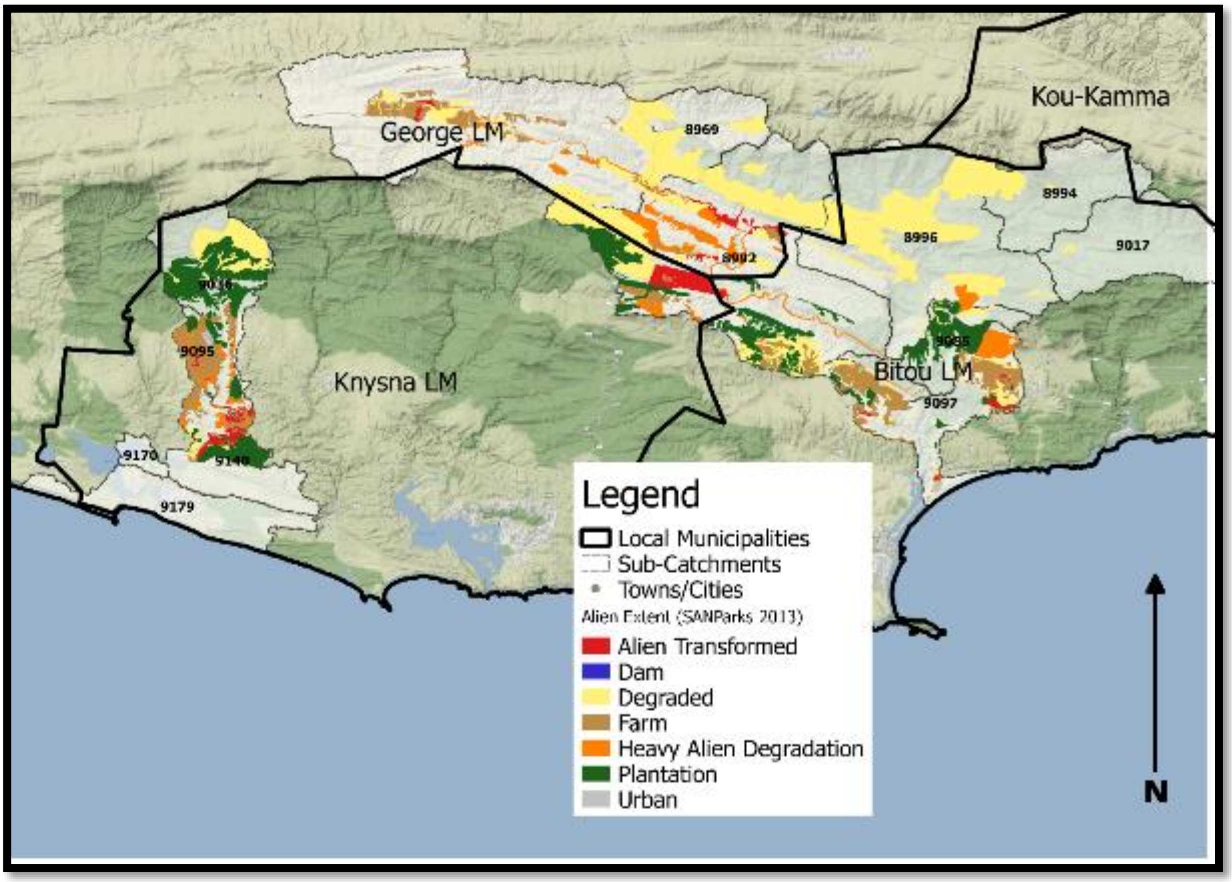

Figure 10-8: Broad land cover classifications for the Study Area (SANParks 2009)

Densities of alien species were inferred based on the spatial data and metadata received from SANParks Table 10-3.

Table 10-3: Transformation category and corresponding density percentage

Classification	Density	Category
Alien Transformed	75%-100%	High Density
Heavy Alien Degradation	60-75%	Medium Density
Degraded	0-60%	Low Density

The classification of beneficiaries required an understanding of the socio-economic heterogeneity across the catchment.

Census data (2011) at ward level was attributed to corresponding sub-quaternary catchments. The complexities in this task lay in the fact that man-made ward boundaries do not correspond to natural catchment boundaries. Ward census data was therefore transformed into a density per unit area and collated back into sub-quaternary data. Although this technique is utilised extensively in catchment classification, the assumption is that the census data is evenly distributed throughout the ward. Only census data that gave an indication of possible use of the environment was utilised for these purposes. The census data chosen included indicators of economic vulnerability and direct environmental use of which results can be seen in Table 10-4.

Table 10-4: Percentage of total population and households in the study area that represent various indicators of economic vulnerability and environmental use (Census 2011, StatsSA) (Not including the Palmiet River Sub-Catchment)

Management Unit (Sub-Quaternary)	8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
% Population	10%	2%	19%	14%	3%	3%	10%	1%	10%	6%	22%
% Households	8%	2%	18%	15%	3%	3%	10%	1%	11%	6%	23%
% Traditional dwelling/hut/structure made of traditional materials	7%	1%	15%	26%	2%	5%	7%	1%	19%	2%	16%
% Informal dwellings	2%	0%	31%	5%	4%	1%	13%	2%	4%	10%	28%
% No schooling	16%	4%	25%	11%	3%	2%	8%	1%	8%	5%	17%
% Not employed	9%	2%	21%	13%	3%	2%	10%	2%	9%	6%	22%
% Earnings below min wage	9%	2%	19%	14%	3%	3%	9%	1%	10%	6%	23%
% No Income	2%	0%	17%	15%	3%	3%	10%	1%	11%	8%	28%
% Water sourced from spring-river-stream	29%	7%	25%	12%	2%	2%	6%	1%	8%	0%	6%
% Pit or Bucket Toilet	21%	4%	31%	13%	1%	2%	6%	0%	10%	1%	10%
% No toilet	14%	3%	22%	14%	1%	2%	5%	0%	10%	6%	21%

The results indicate that there is a varying degree of demands for various environmental services across the study area. For example 35 households rely on rivers, streams and springs as their primary source of water in management unit 8947 and no households require their water in this way in management unit 9170. This negatively corresponds with employment and income in these management units. Economically vulnerable communities are seen to be increasingly vulnerable to changes in ecological infrastructure due to loss of natural benefits. The construction of traditional dwellings for example relies on the sourcing of natural products from ecosystems. The proportion of households that have access to sanitation provides insight into the level of access to services in a region. A lack of services additionally provides insight into vulbnerability of communities to impacts on the associated environment. The prevalence of informal dwellings gives an indication of the level of development in the region and thus insight into the presence of alternative strategies towards survival of the local population.

Economic drivers within the region were identified through a combination of land uses and investigating municipal Integrated Development Plans (IDP). This process gave an indication of key sectors that drive the local economy. The association of the key sectors with environmental use were then investigated. A key association is that of water use and the water requirements of each sector were assessed based on water allocation data (received from DWS for the region). This data again gave an indication of vulnerability to a loss in natural benefits and thus gave insight to the value chain between economic drivers and environmental use.

It must be noted that spatially the municipal IDP's did not correspond directly to the study area, however the key sectors were assumed to remain constant throughout the municipalities (Figure 10-1). Although this assumption was made, the george municipality was ommitted from analysis due to the large extent not included in the study area.

Results show that key sectors contributing to local GDP in both the Karatara and Keurbooms catchments were Wholesale, Retail, Catering and Acc and Finance, Real Estate and Business Services. The Karatara catchment corresponded to a contribution of 18% and 28% and the Keurnbooms catchment with 29% and 23% respectively. This was expected as the tourism sector is well developed in this region.

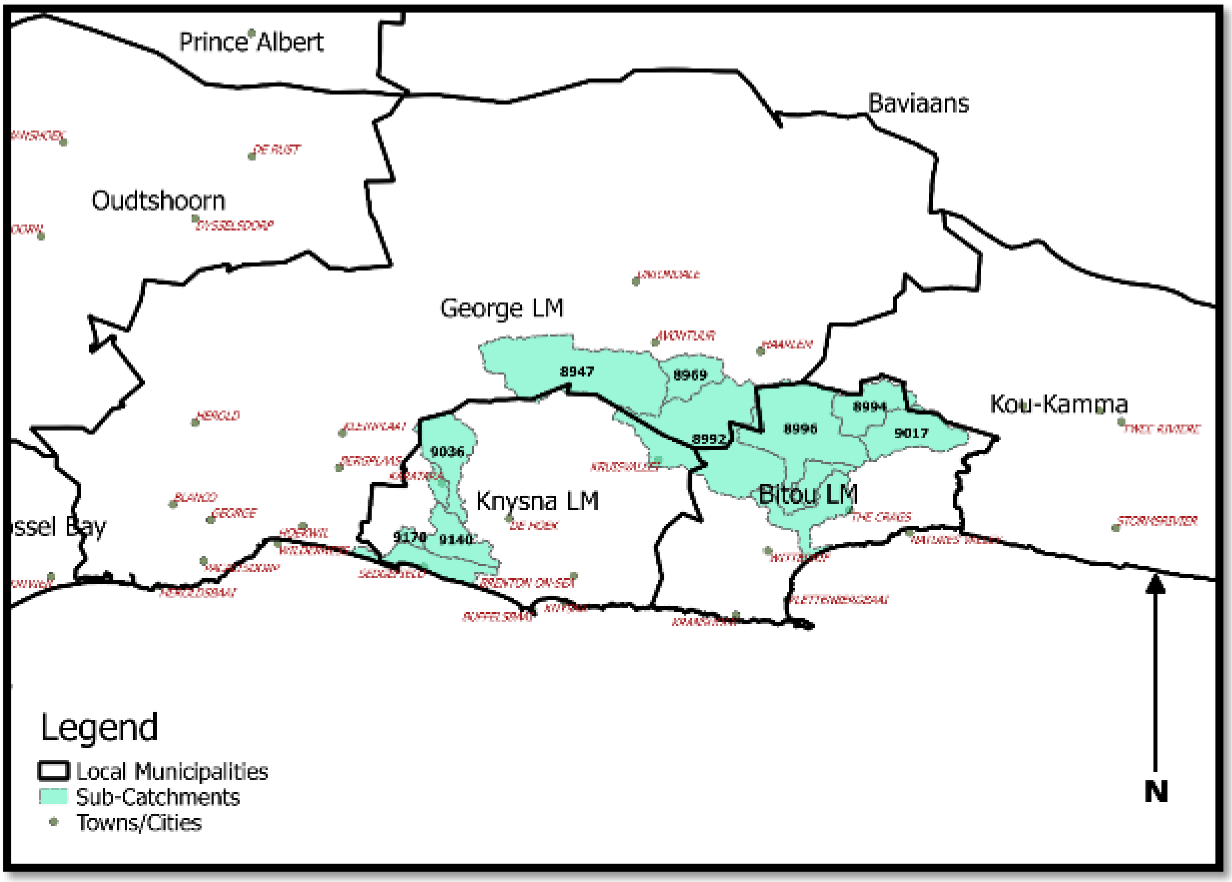

Figure 10-9: The study area in relation to local municipalities

10.2.2 Ecosystem Service Mapping

An ecosystem service mapping exercise was conducted to define the ecological value chain arising from ecological infrastructure and to beneficiaries in the catchment. This is a precursor to valuation as ecosystem service valuation requires firstly, the identification of these linkages (this step) and secondly, the quantification of the flow of services (the next step-next deliverable). The identification of linkages requires the use of Ecosystem Service Frameworks (ESF's) of which numerous frameworks have been developed over recent years.

10.2.2.1 Ecosystem Service Frameworks

The development ESF's frameworks has arisen from the realisation that natural biodiversity and its associated ecosystem services can no longer be treated as inexhaustible and free 'goods' and their true value to society as well as the costs of their loss and degradation, need to be properly described and extent understood (TEEB 2010, de Groot *et al.* 2012).

10.2.2.1.1 The Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (2005) defines ecosystem services as the benefits that people receive from ecosystems and makes the link between ecosystem services and human well-being (2005). The MA classifies ecosystem services into supporting (basic ecosystem functions and processes that underpin all other services), regulating (covering the absorption of pollutants, storm buffering, erosion control and the like), provisioning services (covering the production of foods, fuels, fibre etc.), and cultural services (covering non-consumptive uses of the environment for recreation, amenity, spiritual renewal etc.).

10.2.2.1.2 The Economics of Ecosystems and Biodiversity

The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative to draw attention to the benefits of biodiversity. It focuses on the values of biodiversity and ecosystem services, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of action addressing these pressures. The TEEB initiative has brought together over five hundred authors and reviewers from across the continents in the fields of science, economics and policy (TEEB 2013).

The TEEB initiative can be viewed as the next step in ecosystem service understanding and builds on the MA by providing a focussed approach for dealing with the costs of biodiversity loss and how this impacts society.

10.2.2.1.3 Final Ecosystem Goods and Services – Classification System (FEGS-CS)

The Final Ecosystem Goods and Services Classification System (FEGS-CS) is developed by the US Environmental Protection Agency (US EPA) towards providing a comprehensive framework for the evaluation of ecosystem services (Landers and Nahlik 2013). The FEGS-CS builds on the MEA and similarly defines Final Ecosystem Goods and Services FEGS as "components of nature that are directly enjoyed, consumed, or used to yield human well-being." The goal of FEGS-CS is to "Identify, measure, and quantify FEGS in a scientific, rigorous, and systematic way that can be aggregated from local to regional and national scales" (Landers and Nahlik 2013). In other words, it attempts to accurately identify and value contributions of ecosystem services toward economic well-being.To this end, FEGS-CS takes one step forward from the MEA as it classifies natural resources into FEGS which have corresponding environmental classes (which indicate the source components of nature) and beneficiary classes (which indicate the beneficiaries of well-being) (Figure 10-10). Various combinations of these classes depending on the beneficiary will result in 358 unique FEGS codes which will ultimately all be valued, thus identifying an ecosystems contribution towards a range of specific beneficiaries. The premise is that specific sectors can be attributed with the benefits received from ecosystems and these benefits be quantified and valued. This would allow for the understanding of environmental contributions toward socio-economic well-being.

By taking this comprehensive approach the FEGS-CS contributes threefold: 1) by avoiding double counting of ecosystem services (as only final goods and services are categorised) and 2) by providing a common language among stakeholders when evaluating ecosystem services 3) by attributing ecosystem services with beneficiaries.

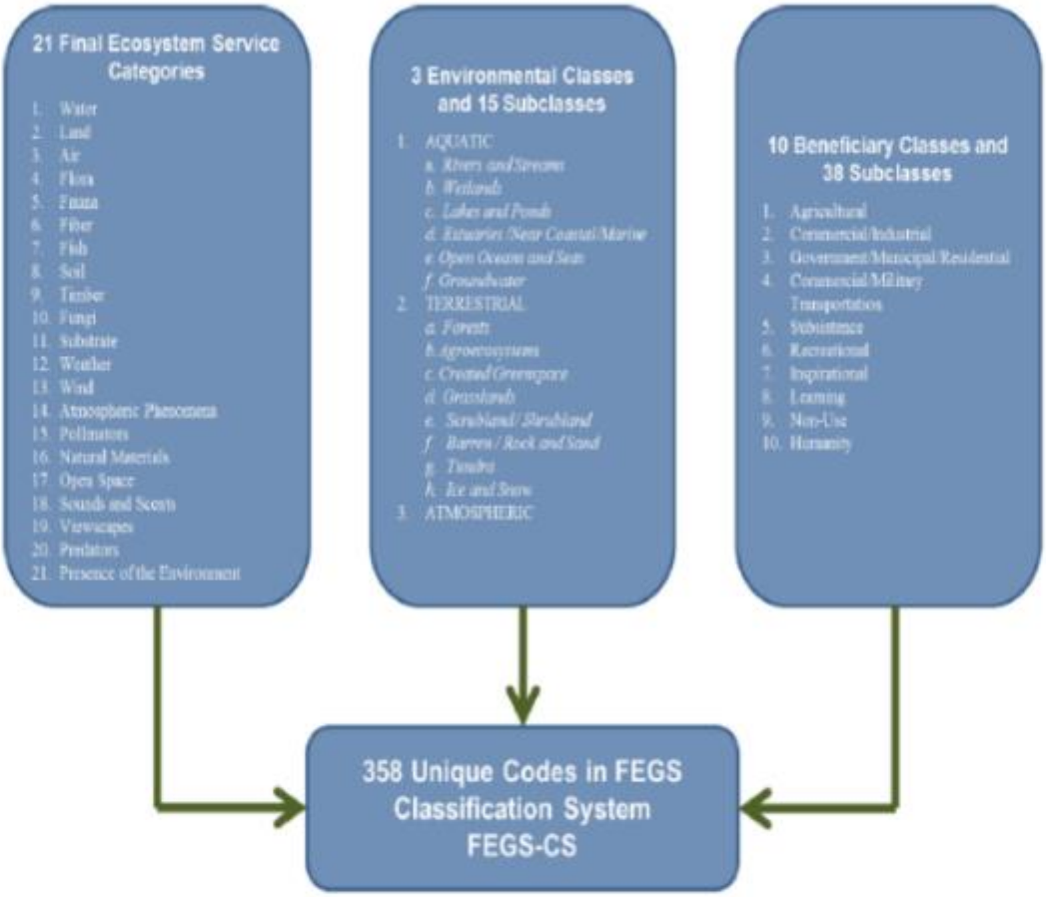

Figure 10-10: Final Ecosystem Goods and Services Classification System (FEGS-CS) (Landers and Nahlik 2013)

10.2.2.2 Ecosystem Services in the Karatara and Keurbooms Catchments

The presence of ecosystem services were identified for the Keurbooms and Karatara catchments. This identification was made possible through the catchment classification process conducted in previous steps. A 'high-level' ecosystem service framework was developed that describes the ecosystem services present in the study area (Table 10-5).

Table 10-5: Ecosystem Services provided by ecological infrastructure in the Karatara and Keurbooms Catchments (Adapted from MEA 2010 and TEEB 2013)

Service Type	Ecosystem Service	Description	Karatara Catchment	Keurbooms Catchment
Provisioning Service	Fresh water provisioning	Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water and provide fresh water for use. Vegetative cover influences the quantity of water available locally.	x-The region is a strategic water source area-The fresh water provisioning is greatly impacted by alien invasive plants	
	Livestock Grazing	Grazing and posturizing of livestock to receive products including: beef, goat, poultry, milk, eggs etc.	x	x-Relatively higher water use for Livestock Watering
	Harvesting	Sustainably produced/harvested crops	x-Cultivated Land, Plantations, Undeveloped communities	
	Raw Materials (Timber and fuelwood)	Sustainably produced/ harvested wool, skins, leather, firewood, etc.	x-Rural communities utilize resources to construct traditional dwellings and for fuel.	
	Other Products	Game meat, and other products like fertilizers, construction material, handcraft material and oils and waxes.	x	
	Genetic materials (Medicinal, genetic stock)	The high biodiversity in ecological systems provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources	x-Natural distribution for numerous species valuable in bioprospecting market	
Regulating Service	Carbon Sequestration	Carbon sequestration, maintaining and controlling temperature and precipitation	X- Prevalence of natural forests, woodlands, thicket and alien-species stands provide a carbon sink	
	Water regulation (hydrological flows)	Regulating surface water runoff, aquifer recharge, river and stream recharge etc.	x-Water regulation is a key service provided in this catchment however is greatly impacted by the status of alien invasive plants	
	Water purification and waste assimilation	The physical flow of water through ecosystems and biological activity of microorganisms provides a filter service of waste, acting as a natural buffer to the surrounding environment. Through this process water is purified and waste is either eliminated or attenuated. Additionally, pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.	X- Natural ecosystems provide a valuable water purification and waste assimilation service.	

Service Type	Ecosystem Service	Description	Karatara Catchment	Keurbooms Catchment
	Biological Control	Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.	x	x
	Natural Disaster Regulation	Resilience to natural disasters such as droughts, floods and fires	x-As water regulation and fire intensity influenced by alien vegetation- there is a reduction in this service	
	Erosion regulation	Maintenance of nutrients and soil cover and preventing negative effects of erosion (e.g. impoverishing of soil, reduced dune integrity)	x- Shallow roots and fire prone characteristics of IAP species negatively influence soil stability.	
Cultural Service	Recreational and tourism	Recreational activities such as Hunting, hiking, photography, camping, nature walks, jogging, animal watching etc.	x-Tourism is a key economic driver in the region.	
	Spiritual and inspirational	Amenity of the ecosystem, cultural diversity and identity, spiritual values, cultural heritage values etc.	x- No clear data	
	Educational	Education, art and research	x- Educational institutions are present, however are not directly attributed to the presence of ecological infrastructure	
Supporting Service	Habitat Support (Species and Biodiversity)	Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements. Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'	x- High extent of protected areas (25%) and high proportion of priority biodiversity areas (58%) indicate that there is biodiversity value	

The high-level ecosystem service identification exercise allowed for a framework by which each management unit was subject to a regionally specific ecosystem service mapping exercise. This exercise utilised the regionally specific extent and type of ecological infrastructure to link to the classification of beneficiaries present in the sub-catchment to output a management unit specific preliminary description of the environmental value chain. Please see Table 10-6 through to Table 10-16. Please note, the ecosystem Mapping exercise was not done for the Palmiet River Sub-Catchment.

Table 10-6: Preliminary ecosystem service mapping of 8947 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow (m3/Day)	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage Catchment Reclaimable
8947 (Keurbooms)	20,027	Natural Forest	0%	13,362	26,790	Fresh water provisioning	Population	876	Dams (Capacity m3)	90,000	Degraded Natural (Ha) SANParks	1,585	1,985	10%
		Woodland	12%			Livestock Grazing	Population Density (Ha/Capita)	23	Plantations (Ha) SANParks	0	Alien Transformed (Ha) SANParks	65		
						Harvesting								
						Raw Materials - Timber and fuelwood-								
		Thicket	21%			Other Products	Unemployed	243	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	335		
						Genetic materials - Medicinal, genetic stock-								
		Shrub/ Fynbos	59%			Carbon Sequestration	No Income (Households)	10	Protected Areas (Ha)	57				
		Grassland	7%			Water regulation - hydrological flows-	Source Water from River /Stream /Spring (Households)	35	Total CBA and ESA (Ha)	14,164				
						Water purification and waste assimilation								
						Biological Control								
						Natural Disaster Regulation								
						Erosion regulation								
						Recreational and tourism								
						Spiritual and inspirational								

						Educational Habitat Support - Species and Biodiversity							

Table 10-7: Preliminary ecosystem service mapping of 8969 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
8969 (Keurbooms)	4,421	Natural Forest	0%	2,951	No Data	Fresh water provisioning	Population	187	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	1,432	1,432	32%
						Livestock Grazing								
						Harvesting								
		Woodland	15 %			Raw Materials - Timber and fuelwood-	Population Density (Ha/Capita)	24	Plantations (Ha) SANParks	-	Alien Transformed (Ha) SANParks	-		
						Other Products								
		Thicket	30 %			Genetic materials - Medicinal, genetic stock-	Unemployed	51	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	0		
						Carbon Sequestration								
						Water regulation - hydrological flows-								
		Shrub/ Fynbos	51 %			Water purification and waste assimilation	No Income (Households)	2	Protected Areas (Ha)	6				
		Grassland	4%			Biological Control	Source Water from River /Stream /Spring (Households)	8	Total CBA and ESA (Ha)	4,122				
						Natural Disaster Regulation								
						Erosion regulation								
						Recreational and tourism								
						Spiritual and inspirational								
						Educational								
						Habitat Support - Species and Biodiversity								

Table 10-8: Preliminary ecosystem service mapping of 8992 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomonmic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
8992 (Keurbooms)	22,582	Natural Forest	3%	12,094	253,100	Fresh water provisioning	Population	1,681	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	4,507	6,886	30%
						Livestock Grazing								
						Harvesting								
		Woodland	6%			Raw Materials - Timber and fuelwood-	Population Density (Ha/Capita)	13	Plantations (Ha) SANParks	2,163	Alien Transformed (Ha) SANParks	944		
		Thicket	54%			Other Products	Unemployed	589	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	1,435		
						Genetic materials - Medicinal, genetic stock-								
		Shrub/ Fynbos	32%			Carbon Sequestration	No Income (Households)	71	Protected Areas (Ha)	6,048				
		Grassland	4%			Water regulation - hydrological flows-	Source Water from River /Stream /Spring (Households)	30	Total CBA and ESA (Ha)	14,949				
						Water purification and waste assimilation								
						Biological Control								
						Natural Disaster Regulation								
						Erosion regulation								
						Recreational and tourism								

						Spiritual and inspirational Educational Habitat Support - Species and Biodiversity								

Table 10-9: Preliminary ecosystem service mapping of 9085 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9085 (Keurbooms)	2,602	Natural Forest	25%	1,412	No Data	Fresh water provisioning Livestock Grazing Harvesting	Population	265	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	170	202	8%
		Woodland	3%			Raw Materials -Timber and fuelwood- Other Products	Population Density (Ha/Capita)	10	Plantations (Ha) SANParks	946	Alien Transformed (Ha) SANParks	-		
		Thicket	44%			Genetic materials - Medicinal, genetic stock- Carbon Sequestration	Unemployed	95	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	32		
		Shrub /Fynbos	23%			Water regulation - hydrological flows-	No Income (Households)	12	Protected Areas (Ha)	1,815				
		Grassland	2%			Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational	Source Water from River /Stream /Spring (Households)	3	Total CBA and ESA (Ha)	1,141				

						Habitat Support - Species and Biodiversity						

Table 10-10: Preliminary ecosystem service mapping of 9097 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9097 (Keurbooms)	6,502	Natural Forest	25 %	3,081	No Data	Fresh water provisioning	Population	833	Dams (Capacity m3)	180 000	Degraded Natural (Ha) SANParks	379	984	15%
		Woodland	3%			Livestock Grazing	Population Density (Ha/Capita)	8	Plantations (Ha) SANParks	436	Alien Transformed (Ha) SANParks	135		
						Harvesting								
						Raw Materials - Timber and fuelwood-								
		Thicket	50 %			Other Products	Unemployed	285	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	470		
						Genetic materials - Medicinal, genetic stock-								
		Shrub/ Fynbos	19 %			Carbon Sequestration	No Income (Households)	43	Protected Areas (Ha)	2,900				
		Grassland	1%			Water regulation - hydrological flows-	Source Water from River /Stream /Spring (Households)	7	Total CBA and ESA (Ha)	2,328				
						Water purification and waste assimilation								
						Biological Control								
						Natural Disaster Regulation								
						Erosion regulation								
						Recreational and tourism								

						Spiritual and inspirational Educational Habitat Support - Species and Biodiversity								

Table 10-11: Preliminary ecosystem service mapping of 9114 management unit in the Keurbooms catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9114 (Keurbooms)	1,210	Natural Forest	48%	808	No Data	Fresh water provisioning Livestock Grazing Harvesting	Population	123	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	62	110	9%
		Woodland	4%			Raw Materials - Timber and fuelwood- Other Products	Population Density (Ha/Capita)	10	Plantations (Ha) SANParks	61	Alien Transformed (Ha) SANParks	-		
		Thicket	36%			Genetic materials - Medicinal, genetic stock- Carbon Sequestration	Unemployed	44	Wholesale, Retail, Catering and Acc 29% Finance, Real Estate and Business Services 23%		Heavy Alien Degradation (Ha) SANParks	47		
		Shrub/ Fynbos	9%			Water regulation - hydrological flows-	No Income (Households)	6	Protected Areas (Ha)	783				
		Grassland	2%			Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational	Source Water from River /Stream /Spring (Households)	1	Total CBA and ESA (Ha)	395				

						Habitat Support - Species and Biodiversity								

Table 10-12: Preliminary ecosystem service mapping of 9036 management unit in the Karatara catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9036 (Karatara)	6,842	Natural Forest	28 %	2,409	28,353	Fresh water provisioning Livestock Grazing Harvesting Raw Materials - Timber and fuelwood- Other Products Genetic materials - Medicinal, genetic stock-	Population	1,262	Dams (Capacity m3)	200 000	Degraded Natural (Ha) SANParks	1,104	1,303	19%
		Woodland	7%				Population Density (Ha/Capita)	5	Plantations (Ha) SANParks	2,269	Alien Transformed (Ha) SANParks	58		
		Thicket	39 %				Unemployed	367	Wholesale, Retail, Catering and Acc 18% Finance, Real Estate and Business Services 28%		Heavy Alien Degradation (Ha) SANParks	142		
		Shrub/ Fynbos	24 %				No Income (Households)	61	Protected Areas (Ha)	5,067				

		Grassland	1%			Carbon Sequestration Water regulation - hydrological flows- Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational Habitat Support - Species and Biodiversity	Source Water from River /Stream /Spring (Households)	14	Total CBA and ESA (Ha)	1,083				

Table 10-13: Preliminary ecosystem service mapping of 9095 management unit in the Karatara catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecmonomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9095 (Karatara)	1,176	Natural Forest	53%	110	No Data	Fresh water provisioning Livestock Grazing	Population	219	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	-	162	14%
		Woodland	0%			Harvesting Raw Materials - Timber and fuelwood- Other Products	Population Density (Ha/Capita)	5	Plantations (Ha) SANParks	81	Alien Transformed (Ha) SANParks	33		
		Thicket	35%			Genetic materials - Medicinal, genetic stock- Carbon Sequestration	Unemployed	63	Wholesale, Retail, Catering and Acc 18% Finance, Real Estate and Business Services 28%		Heavy Alien Degradation (Ha) SANParks	129		
		Shrub/ Fynbos	6%			Water regulation - hydrological flows-	No Income (Households)	11	Protected Areas (Ha)	72				
		Grassland	1%			Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational Habitat Support -	Source Water from River /Stream /Spring (Households)	2	Total CBA and ESA (Ha)	329				

						Species and Biodiversity							

Table 10-14: Preliminary ecosystem service mapping of 9140 management unit in the Karatara catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9140 (Karatara)	4,825	Natural Forest	32%	503	28,353	Fresh water provisioning Livestock Grazing	Population	901	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	127	517	11%
		Woodland	5%			Harvesting Raw Materials -Timber and fuelwood-	Population Density (Ha/Capita)	5	Plantations (Ha) SANParks	687	Alien Transformed (Ha) SANParks	268		
		Thicket	44%			Other Products Genetic materials - Medicinal, genetic stock-	Unemployed	261	Wholesale, Retail, Catering and Acc 18% Finance, Real Estate and Business Services 28%		Heavy Alien Degradation (Ha) SANParks	122		
		Shrub/ Fynbos	6%			Carbon Sequestration	No Income (Households)	44	Protected Areas (Ha)	107				
		Grassland	1%			Water regulation - hydrological flows- Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational	Source Water from River /Stream /Spring (Households)	10	Total CBA and ESA (Ha)	4,101				

						Habitat Support - Species and Biodiversity							

Table 10-15: Preliminary ecosystem service mapping of 9179 management unit in the Sedgefield catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9179 (Sedgefield)	5,015	Natural Forest	0%	No Data	**No Data**	Fresh water provisioning Livestock Grazing	Population	1,892	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	No Data	No Data	No Data
		Woodland	2%			Harvesting Raw Materials - Timber and fuelwood-	Population Density (Ha/Capita)	3	Plantations (Ha) SANParks	No Data	Alien Transformed (Ha) SANParks	No Data		
		Thicket	65 %			Other Products Genetic materials - Medicinal, genetic stock-	Unemployed	601	Wholesale, Retail, Catering and Acc 18% Finance, Real Estate and Business Services 28%		Heavy Alien Degradation (Ha) SANParks	No Data		
		Shrub/ Fynbos	12 %			Carbon Sequestration	No Income (Households)	117	Protected Areas (Ha)	1,869				
		Grassland	2%			Water regulation - hydrological flows- Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism	Source Water from River /Stream /Spring (Households)	8	Total CBA and ESA (Ha)	1,511				

						Spiritual and inspirational Educational Habitat Support - Species and Biodiversity								

Table 10-16: Preliminary ecosystem service mapping of 9170 management unit in the Sedgefield catchment

Catchment	Area (Ha)	Ecological Infrastructure		Natural (Ha) SANParks	Average Flow	Ecosystem Services	Beneficiaries		Key Ecomnomic features		Extent of Impact on Undeveloped Land		Total Reclaimable Land (Ha)	Total Percentage of Catchment Reclaimable
9170 (Sedgefield)	686	Natural Forest	0%	No Data	**No Data**	Fresh water provisioning Livestock Grazing Harvesting Raw Materials - Timber and fuelwood- Other Products Genetic materials - Medicinal, genetic stock-	Population	504	Dams (Capacity)	-	Degraded Natural (Ha) SANParks	No Data	No Data	No Data
		Woodland	2%				Population Density (Ha/Capita)	1	Plantations (Ha) SANParks	-No Data	Alien Transformed (Ha) SANParks	No Data		
		Thicket	33%				Unemployed	163	Wholesale, Retail, Catering and Acc 18% Finance, Real Estate and Business Services 28%		Heavy Alien Degradation (Ha) SANParks	No Data		
		Shrub/ Fynbos	5%				No Income (Households)	34	Protected Areas (Ha)	261				

		Grassland	0%			Carbon Sequestration Water regulation - hydrological flows- Water purification and waste assimilation Biological Control Natural Disaster Regulation Erosion regulation Recreational and tourism Spiritual and inspirational Educational Habitat Support - Species and Biodiversity	Source Water from River /Stream /Spring (Households)	0	Total CBA and ESA (Ha)	397				

10.2.3 Comparative Risk Assessment

10.2.3.1 Methodology

A Comparative Risk Assessment (CRA) is a methodology used to determine the risk posed to ecosystem services. CRA serves to rate the consequences associated with the subsequent environmental effects and its uncertainty.

Various scenarios (such as in this study, the spread of alien invasive plants) could pose a variety of threats to the ecosystem services. For each scenario-asset combination, the ecosystem services identified are assessed. The question asked is 'What is the likelihood that this ecosystem service in this significant ecological infrastructure will be affected under this scenario? What would be the consequences of this scenario in this significant ecological infrastructure to the delivery of this ecosystem service?'. In the case described in this report, the scenario is IAP clearing programmes and which ecosystem services will be most likely and result in the greatest consequence due to ecological restoration.

The likelihood is the probability of the scenario having an effect on the asset. Likelihood takes into account an element of uncertainty, in that the likelihood that an ecosystem service will be affected under the scenario in question over a specified time frame is rated. Uncertainty with regards to the knowledge upon which the statements or connections between scenario-asset-service linkages are made, is also stated explicitly for each CRA. This level of certainty (e.g. high, medium or low) is a statement based on the judgement of the certainty of and confidence in the risk assessment (Table 10-17). For example, a low level of certainty indicates that evidence to bear out the assessment is weak or lacking.

Table 10-17: Qualitative and quantitative classes of likelihood of a scenario (environmental effect, or resultant change in the flow of an ecosystem service) eventuating from a management decision and of having an environmental consequence to a service from an environmental asset in the ecosystem adapted from the classification adopted by the IPCC (2007)

Likelihood rating	Assessed probability of occurrence	Description
Almost certain	> 90%	Extremely or very likely, or virtually certain. Is expected to occur.
Likely	> 66%	Will probably occur
Possible	> 50%	Might occur; more likely than not
Unlikely	< 50%	May occur
Very unlikely	< 10%	Could occur
Extremely unlikely	< 5%	May occur only in exceptional circumstances

The consequence is the change in the service from the environmental effect of the scenario on the exposed asset. The assessment of consequences can follow, or adapt in an appropriate manner, the severity ratings (Table 10-18).

Table 10-18: Qualitative measures of consequence to environmental services in an ecosystem arising from the hazards linked to a scenario. Please note the matrix utilised below was altered to identify the consequence of an ecosystem service returning to the landscape. Therefore a "Severe" consequence represented- Substantial permanent restoration of environmental service.

Consequence rating	Level of consequence	Environmental effect
Severe	1	Substantial permanent loss of environmental service, requiring mitigation or offset.
Major	2	Major effect on the asset or service that will require several years to recover, and substantial mitigation.
Moderate	3	Serious effect on the asset or service, that will take a few years to recover, but with no or little mitigation.
Minor	4	Discernible effect on the asset or service, but with rapid recovery, not requiring mitigation.
Insignificant	5	A negligible effect on the asset or service.

The level of risk is the product of likelihood and consequence in the event of an environmental effect on an asset. Table 10-19 combines the likelihood and consequence rating to determine risk as:

- Low (L) requiring no to little response;
- Medium (M) requiring local level response;
- High (H) requiring regional level response; or
- Extreme (E) requiring national level response.

Table 10-19: Levels of risk, assessed as the product of likelihood and consequence in the event of an environmental effect on an ecosystem asset (Adapted from Australian/New Zealand Standard on Risk Management (2004)).

Likelihood Rating	Consequence Rating				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	High	High	Extreme
Unlikely	Low	Low	Medium	High	Extreme
Very unlikely	Low	Low	Low	High	Extreme
Extremely unlikely	Low	Low	Low	Medium	High

The outcome of the CRA will include a table of ecosystem services with the likelihood and consequence of environmental effect, and the level of risk.

10.2.3.2 Results

Ecosystem Service	Likelihood of Impact										
	8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	Keurbooms			Kara	Keur	Kara	Keur		Kara	Sedge	
Fresh water provisioning	Almost Certain	Likely	Almost Certain	Almost Certain	Possible	Likely	Almost Certain	Possible	Almost Certain	Almost Certain	Almost Certain
Livestock Grazing	Possible	Unlikely	Possible	Possible	Very Unlikely	Unlikely	Possible	Very Unlikely	Possible	Extremely Unlikely	Extremely Unlikely
Harvesting	Likely	Possible	Likely	Likely	Unlikely	Possible	Likely	Unlikely	Likely	Very Unlikely	Very Unlikely
Raw Materials -Timber and fuelwood-	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely
Other Products	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely
Genetic materials -Medicinal, genetic stock-	Likely	Possible	Likely	Likely	Unlikely	Possible	Likely	Unlikely	Likely	Very Unlikely	Very Unlikely
Carbon Sequestration	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely
Water regulation -hydrological flows-	Almost Certain	Likely	Almost Certain	Almost Certain	Possible	Likely	Almost Certain	Possible	Almost Certain	Almost Certain	Almost Certain
Water purification and waste assimilation	Unlikely	Very Unlikely	Unlikely	Unlikely	Very Unlikely	Very Unlikely	Unlikely	Very Unlikely	Unlikely	Extremely Unlikely	Extremely Unlikely
Biological Control	Possible	Unlikely	Possible	Possible	Very Unlikely	Unlikely	Possible	Very Unlikely	Possible	Extremely Unlikely	Extremely Unlikely
Natural Disaster Regulation	Almost Certain	Possible	Almost Certain	Almost Certain	Possible	Almost Certain	Almost Certain	Possible	Almost Certain	Almost Certain	Almost Certain
Erosion regulation	Possible	Unlikely	Possible	Possible	Very Unlikely	Unlikely	Possible	Very Unlikely	Possible	Extremely Unlikely	Extremely Unlikely
Recreational and tourism	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Very Unlikely	Possible	Possible
Spiritual and inspirational	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely
Educational	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely	Extremely Unlikely
Habitat Support -Species and Biodiversity	Almost Certain	Likely	Almost Certain	Almost Certain	Possible	Likely	Almost Certain	Possible	Almost Certain	Possible	Possible

Ecosystem Service	Consequence of Impact										
	8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	Keur			Kara	Keur	Kara	Keur		Kara	Sedge	
Fresh water provisioning	Major	Moderate	Major	Major	Moderate	Moderate	Major	Moderate	Major	Major	Major
Livestock Grazing	Moderate	Minor	Moderate	Moderate	Minor	Minor	Moderate	Minor	Moderate	Insignificant	Insignificant
Harvesting	Major	Moderate	Major	Major	Moderate	Moderate	Major	Moderate	Major	Insignificant	Insignificant
Raw Materials -Timber and fuelwood-	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Other Products	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Genetic materials -Medicinal, genetic stock-	Major	Moderate	Major	Major	Moderate	Moderate	Major	Moderate	Major	Insignificant	Insignificant
Carbon Sequestration	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Water regulation -hydrological flows-	Major	Moderate	Major	Major	Moderate	Moderate	Major	Moderate	Major	Major	Major
Water purification and waste assimilation	Minor	Insignificant	Minor	Minor	Insignificant	Insignificant	Minor	Insignificant	Minor	Insignificant	Insignificant
Biological Control	Moderate	Minor	Moderate	Moderate	Minor	Minor	Moderate	Minor	Moderate	Insignificant	Insignificant
Natural Disaster Regulation	Major	Major	Major	Major	Major	Major	Major	Major	Major	Major	Major
Erosion regulation	Moderate	Minor	Moderate	Moderate	Minor	Minor	Moderate	Minor	Moderate	Insignificant	Insignificant
Recreational and tourism	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Moderate	Moderate
Spiritual and inspirational	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Educational	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Habitat Support -Species and Biodiversity	Major	Moderate	Major	Major	Moderate	Moderate	Major	Moderate	Major	Moderate	Moderate

Ecosystem Services	Comparative Risk of Impact											Cumulative Impact Score
	8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179	
Fresh water provisioning	Extreme	High	Extreme	Extreme	High	High	Extreme	High	Extreme	Extreme	Extreme	40
Livestock Grazing	High	Low	High	High	Low	Low	High	Low	High	Low	Low	21
Harvesting	High	High	Extreme	Extreme	Medium	High	Extreme	Medium	Extreme	Low	Low	31
Raw Materials -Timber and fuelwood-	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Other Products	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Genetic materials -Medicinal, genetic stock-	Extreme	High	Extreme	Extreme	Medium	High	Extreme	Medium	Extreme	Low	Low	32
Carbon Sequestration	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Water regulation -hydrological flows-	Extreme	High	Extreme	Extreme	High	High	Extreme	High	Extreme	Extreme	Extreme	40
Water purification and waste assimilation	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Biological Control	High	Low	High	High	Low	Low	High	Low	High	Low	Low	21
Natural Disaster Regulation	Extreme	High	Extreme	Extreme	High	Extreme	Extreme	High	Extreme	Extreme	Extreme	41
Erosion regulation	High	Low	High	High	Low	Low	High	Low	High	Low	Low	21
Recreational and tourism	Low	Low	Low	Low	Low	Low	Low	Low	Low	High	High	15
Spiritual and inspirational	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Educational	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	11
Habitat Support -Species and Biodiversity	Extreme	High	Extreme	Extreme	High	High	Extreme	High	Extreme	High	High	38

10.2.4 Ecosystem Service Valuation

Ecosystem service valuation is a process that attempts to quantify the benefits that are provided by natural ecological infrastructure. In this case the approach was assigned to valuing services (identified in the CRA) that would be restored as a result of IAP clearing. It has been illustrated above that ecosystems provide communities with a range of benefits and services of which play a large role in influencing their socio-economic well-being. The valuation of ecosystems is thus performed at this socio-economic scale, demonstrating the magnitude of benefits using a common financial currency. This common currency allows for the identification and quantification of relationships between impacts on ecological infrastructure and the resulting impacts on the ability to provide natural socio-economic benefits. This financial platform provides a valuable tool for valuing ecosystem services in the areas, allowing these relationships to better be understood, thus informing sustainable ecologically, economically and socially inclusive decision making.

It is important to note however that the results of this study, which are presented financially, are only done so to provide insights into the relationships between natural systems and the well-being of beneficiaries. Caution must be taken when likening the results as financial values on these systems in terms of pricing of the ecological infrastructure.

Ecological infrastructure provides a range of services including intermediate (supporting and regulating) and final (provisioning and cultural) services. The intermediate services provide the support and maintenance processes necessary for the final services to be provided to beneficiaries. These services are thus embedded within the ecosystem services value chain and cannot be valued in isolation. The valuation tools used below were limited to methods using available secondary data sources and benefit transfer studies. A limitation of resulting from a relatively low availability of area specific data for the Karatara and Keurbooms catchments, meant that average values had to be inferred across space utilizing the most appropriate indicators. The analysis nonetheless provides information on spatial variation in the potential value that can be reclaimed due to land rehabilitation.

There is consensus among the professional community of resource economists that the production function approach is therefore best suited as a valuation method for intermediate ecosystem services.

Such an approach employs what is known as ecological-economic production functions to apply knowledge of ecosystem functioning and processes to derive the marginal value of supporting and regulating ecosystem services as intermediate inputs into goods and services that are produced and consumed by economic agents (Loreau *et.al.* 2002; MEA 2005; Perrings 2006; Simonit, Perrings 2011).The use of production-functions fell outside the scope of this study however for context it is important to understand the role they play in the valuation process. The first step in such a valuation is to value the final consumption services. Thereafter chains of causality are quantified through the production functions, effectively linking the attributes of biodiversity (components, structure and processes).Intermediate services valuation then would take the form of a risk analysis requiring assessment of both the mean effect of a change to an ecosystem (the first moment of the distribution of possible outcomes), and the probability of an outcome (i.e. risk effects) that depends on higher moments of the distribution (e.g. dispersion and spread) (Mäler 2005).Assessing the "insurance value" of regulating services is one method for such an evaluation.

The approach to valuation was therefore by means of assessing the key ecosystem services prioritised in the CRA by means of final ecosystem services and the insurance value provided by ecological infrastructure.

Ecosystem services assessed to display the greatest response or level of restoration post alien clearing and rehabilitation included the following:

Ecosystem Service	Category	Approach to Valuation
Fresh Water Provisioning	Provisioning Service	Final benefits value
Hydrological Regulation	Regulating Service	Not valued-This will be captured through the valuation process
Habitat Support	Supporting Service	Ecological value (Quantified using hectare equivalence)
Natural Disaster (Fire prevalence)	Regulating service	Insurance value (Insurance premium)

10.2.4.1 Fresh Water Provisioning

The approach to valuation of the water provisioning service was one whereby the marginal value of additional water to the catchment due to IAP clearing was calculated. This approach was largely driven by availability and reliability of available data conducted at a desktop level. Based on an extensive data and mining process, the resulting methodology was to understand the difference in evapotranspiration (ET) between IAPs and natural vegetation. This allowed an understanding of variation in water use, post and prior to IAP clearing. The various spatial densities of IAPs (provided by SANParks 2013) were condensed to provide a condensed footprint of IAPs in the catchment. The difference between the ET for all current IAPs and the extent of fynbos that would potentially replace it was calculated to result in the total additional water available. Results of which can be found in Table 10-20.

The marginal cost of supply approach was utilised to identify a proxy for the value of water. An example of the steep curve

The water crisis in the Western Cape has resulted in discussions on the utilisation of reverse osmosis plants to utilise desalination technology as an option for additional fresh water. The cost of desalination at R15/l was thus utilised as a maximum amount. The minimum value of water was calculated through determining the cost of IAP clearing and related back to the volume of additional water provided. In other words the volume of water restored per ha was divided by cost per ha of which resulted in R1/l. It is noted that both of these values are extreme (high and low) however for the purposes of the demonstration they were seen as fit.

Table 10-20: Raw data utilised to calculate the value of the water provisioning service that would be restored through IAP clearing programmes

Quinary	Catchment	Area (Ha)	Ave Evapotranspiration (ET) for aliens (mm/a)	Ave ET for aliens (m3/ha/a)	Total ET by aliens (m3/a)	Ave ET for fynbos (mm/a)	Ave ET for fynbos (m3/ha/a)	Total ET by Fynbos (m3/a)	Water Available due to fynbos rehabilitation (m3/a)	Value of water Min (Mil R/a)	Value of water Max (mil R/a)
8947	Keurbooms	20,027	904	9,038	5,683,758	520	5200	3,270,323	2,413,435	2.40	36.20153
8969	Keurbooms	4,421	904	9,038	3,235,039	520	5200	1,861,378	1,373,661	1.37	20.60491
8992	Keurbooms	22,582	904	9,038	25,198,365	520	5200	14,498,644	10,699,721	10.64	160.4958
9036	Karatara	6,842	904	9,038	3,654,390	520	5200	2,102,664	1,551,726	1.54	23.27589
9085	Keurbooms	2,602	904	9,038	528,756	520	5200	304,236	224,520	0.22	3.3678
9095	Karatara	1,176	904	9,038	876,709	520	5200	504,441	372,268	0.37	5.584021
9097	Keurbooms	6,502	904	9,038	4,199,684	520	5200	2,416,415	1,783,268	1.77	26.74902
9114	Keurbooms	1,210	904	9,038	354,586	520	5200	204,022	150,564	0.15	2.258466
9140	Karatara	4,825	904	9,038	3,261,656	520	5200	1,876,693	1,384,963	1.38	20.77445
9170	Sedgefield	686	904	9,038	-	520	5200	-	-	-	0
9179	Sedgefield	5,015	904	9,038	-	520	5200	-	-	-	0

8994	Keurbo oms	5,807	904	9,038	1,214,700	520	5200	698,915	515,786	0.51	6.275321
8996	Keurbo oms	16,050	904	9,038	11,183,968	520	5200	6,435,036	4,748,933	4.72	57.77803
9017	Keurbo oms	7,290	904	9,038	93,466	520	5200	53,779	39,688	0.04	0.482861
									25,258,532	25.13	307.3087

10.2.4.2 Habitat Support

The relative conservation importance of vegetation types present in the study area that are currently impacted by IAPs was assessed. This was done through the use of the SANBI Wetland Offset Guidelines (SANBI 2014) of which attribute a specific vegetation type with a Ha equivalent multiplier of which is based on the relative conservation ratio of that vegetation type. The conservation ratio considers the threat status and level of protection of vegetation types.

Various limitations were identified through the use of this method, however the opportunity to quantify the relative conservation importance of a region by ha utilising a published guideline provided a valuable approach. The offset calculator typically identifies offset targets in terms of ha equivalents due to residual negative impacts and then allows for an assessment of suitability of potential receiving sites to achieve the identified targets. A key input into the calculator to identify targets is an indicator of health prior to development and an indicator post development. Thus, a change in condition or conservation value can be seen over the span of a development. Typically, this change in condition is negative and results in the requirement for an offset of specific magnitude to be undertaken.

The approach taken here was that if an operator were to remove all IAPs at a site, what sort of credit the operator would receive in terms of biodiversity gains. It is noted that this is a contentious approach however the use of threat and protection ratios provided for a measure of relative conservation importance and thus a measure of biodiversity value. An example of this measure of relative conservation importance would be, if 1ha of highly endangered vegetation were to be restored through IAP clearing, would it be more valuable from a conservation perspective to if 1ha of savannah were restored?

The calculator takes various indicators into account:

1) The area to be restored;
2) The change in condition before and after the activity (in this case a positive change);
3) The relative conservation importance multiplier-Status Multiplier (in this case the wetland vegetation map was utilised);
4) The regional conservation importance-regional context (High, Moderate and Low were used that corresponded with the site falling within a protected area, Critical Biodiversity Area, Ecological Support Area or an area with no regional significance)
5) The Local context- of which was kept constant throughout the calculator

The output of the calculator was a ha equivalent per vegetation group of which was summed to get a total ha equivalent of the conservation importance of natural vegetation currently degraded by IAPs. Various vegetation types contributed more to the total ha equivalent than others. The difference between the condensed area of IAPs and the ha equivalents of the conservation value represented the marginal ha equivalent value provided by conservation importance.

The proxy utilised for valuation was current undeveloped land price in the George area (Maximum price R59 395 (51-300 ha) and Minimum price R31 692 (>300ha)). The land prices were adjusted to 2017 values by use of 5% inflation.

Table 10-21: Raw data utilised to calculate the value of biodiversity that would be restored through IAP clearing programmes

	Eastern Fynbos-Renosterveld Sand Fynbos			Eastern Fynbos-Renosterveld Sandstone Fynbos			Eastern Fynbos-Renosterveld Shale Band Vegetation	Eastern Fynbos-Renosterveld Shale Fynbos			Eastern Fynbos-Renosterveld Shale Renosterveld			Grand Total
Row Labels	**High (CBA+prot)**	**Mod (ESA)**	**Low (None)**	**High (CBA+prot)**	**Mod (ESA)**	**Low (None)**	**High**	**High (CBA+prot)**	**Mod (ESA)**	**Low (None)**	**High (CBA+prot)**	**Mod (ESA)**	**Low (None)**	
8,947				125	45						71	14		254
8,969					80						1			81
8,992				640	7			152			192	1		993
9,036	21	1		292	25		0	9	2					350
9,085				1	17									18
9,095				6	21			20	17					63
9,097				10	3			44	3					61
9,114				13	8									21
9,140	0	21		17	30			40	7					115
8,994				134										134
8,996				1,066	91						1			1,158

9,017				10	0									10
Not specified			149			2,728				107			167	3,150
Grand Total	21	22	149	2,314	327	2,728	0	266	28	107	266	15	167	6,410
Hab bef	13	33	58	13	33	58	13	13	33	58	13	33	58	
Hab after	88	88	88	88	88	88	88	88	88	88	88	88	88	
Change in Habitat	75	55	30	75	55	30	75	75	55	30	75	55	30	
Grand Total condensed IAPArea (ha)	16	12	45	1,735	180	818	0	200	15	32	199	8	50	
Status Multiplier	15	15	15	0	0	0	30	4	4	4	30	30	30	
Regional context	1	1	1	1	1	1	1	1	1	1	1	1	1	
Local Context	1	1	1	1	1	1	1	1	1	1	1	1	1	
MULTIPLIER	12	9	6	0	0	0	12	3	2	2	24	18	12	
8,947	-	-	-	19	4	-	-	-	-	-	1,280	137	-	1,440
8,969	-	-	-	-	7	-	-	-	-	-	23	-	-	29
8,992	-	-	-	96	1	-	-	343	-	-	3,462	14	-	3,915

9,036	193	4	-	44	2	-	0	20	2	-	-	-	-	265
9,085	-	-	-	0	1	-	-	-	-	-	-	-	-	2
9,095	-	-	-	1	2	-	-	45	20	-	-	-	-	68
9,097	-	-	-	2	0	-	-	100	4	-	-	-	-	106
9,114	-	-	-	2	1	-	-	-	-	-	-	-	-	3
9,140	0	104	-	3	2	-	-	91	8	-	-	-	-	208
8,994		-	-	20	-			-	-	-	-	-	-	20
8,996		-	-	160	7			-	-	-	22	-	-	189
9,017		-	-	2	0			-	-	-	-	-	-	2
Not specified	-	-	268	-	-	82	-	-	-	48	-	-	601	999
Total	193	108	268	347	27	82	0	599	35	48	4,787	151	601	
Ha eq CREDITS	193	108	268	347	27	82	0	599	35	48	4,787	151	601	7,245

	2014	2017 (5% inflation)
Min Land Value/Ha	31,692	36,687
Max Land Value/ Ha	59,000	68,300

10.2.4.3 Natural Disaster Regulation (Fire Regulation)

To carry out the premium calculation, the data of the fires which occurred in the Western Cape Province since the year 2008 were mined from the internet. This data included the year and month which the fire occurred, the reported expected recovery cost to reach basic operational condition for the region, the region which the fire occurred. The cost of recovery was adjusted for inflation using 6% inflation rate. The number of fires occurring in a single year where counted and the average over ten years was adopted as a better representation of how many fires are expected in a single year. The recovery cost which had been adjusted for inflation was summed for each year and the average was taken to represent the cost which would be needed should the expected claims occur.

Where data availability is not a limitation, a full insurance model would be constructed using a Poisson distribution on Number of Claims and the Bayesian probability on the probability of a fire occurrence. In this case, classical probability will be applied where:

Probability =Average number of fire events per year over 10 years (Period investigated (i.e. 10 years) (P=N/T) is used and it is assumed that the number of claims follow a Poisson distribution with only with N average number of claims per year is made. We further assumed that there are only N events that could potentially result in an immediate insurance payment due to fire and also that since there were only N potential events which could give rise to a claim, the claims would occur at the end of the year.

The basic Insurance risk model formula used is adopted from Actuarial Statistical Models and uses the following formulae to calculate a basic premium over ten years.

Premium for entire duration= $P\ (1 + \Theta)\ \lambda\ E(X)$

Where:

- P is the probability of a claim occurring in a year
- Θ represent a percentage of insurer's profit (mark-up value)
- λ represent the expected number of claims, which is a varying N in this case.
- E(X) represent the expected aggregate claim, the amount of claim.

To calculate the premium which should be paid to insurance company per year or set aside annually as protection against the fire damage is calculated using the following formulae:

Premium per year= $\frac{i * Premium\ over\ the\ entire\ duration}{1-(1+i)^{-n}}$

10.2.5 Cost Related Data

10.2.5.1 Costs

Alien plant removal data was obtained from Working for Water (WfW) for 45 contractors. After the removal of outliers, 39 contractors were included in the analysis of which shows the average costs involved in alien plant removal. The data was temporal ranging from 2005 to 2014 of which inflation was utilised to estimate the average costs per ha and per day for each contractor.

The data unfortunately did not indicate the following factors of which all play a role in influencing these costs:

- Slope (Steeper the higher costs);
- Density of plant species;
- Species removed;
- Age and size of species;
- Rates of specific contractor.

To account for this variation and knowledgeable of the high ranges of costs between contractors, an upper and lower range of 30% of the average costs was utilised in the analysis. Results are present in Table 10-22.

Table 10-22: Average costs involved in Alien Removal Programmes

Activity	Average Cost (R in 2018)			Source
	Lower	Average	Upper	
Average Alien Removal Per Ha	2,672	3,817	4,963	Adapted for inflation from WfW 2015 (30% above and below)
Per employee per day	121	137	154	Adapted for inflation from WfW 2015- Upper and lower are maximum and minimum records
Acacia species Per Ha	1,794	2,563	3,332	Adapted from Le Maitre *et al.* 2002, at an average of 5.1% inflation over the past 10 years
Eucalyptus per Ha	3,073	4,390	5,707	Adapted from Le Maitre *et al.* 2002, at an average of 5.1% inflation over the past 10 years
Pine per Ha	2,998	4,283	5,568	Adapted from Le Maitre *et al.* 2002, at an average of 5.1% inflation over the past 10 years
Hakea per Ha	1,707	2,439	3,171	Adapted from Le Maitre *et al.* 2002, at an average of 5.1% inflation over the past 10 years

Additional cost data was obtained from a study conducted by Mugido and others (2014) of which indicated a range (min and max) for harvesting, chipping and transportation of various species in the Olifants catchment (Table 10-23). The results of the study indicate the costs for species similar to that in the study area and vary based on varying proportions of each. A minimum and maximum total clearing cost per ha was calculated based on the total average costs identified this way. The total costs utilised in the analysis were the results of R21 000 and R79 000 per ha for full removal, chipping and transportation.

Table 10-23: The costs of harvesting, chipping and transporting IAP biomass (Mugido et al 2014)

	Clearing R/Ha		Chipping R/Ha		Transport R/Ha	
IAP Species	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Acacia-eucalypt-pine	13 800	21 500	10 900	11 200	6,597	6,900
Eucalypt-Acacia-Pine	19 700	23 000	19 900	43 300	10 700	12 700

10.2.5.2 Benefits

The sustainable removal of invasive alien species requires a long-term rehabilitation management strategy of which the removal plot must be revisited each year. The average person days per ha for each year of rehabilitation were estimated by Nel *et al.* 2008 and are shown in Table 10-24.

Table 10-24: Average person days required per ha when removing alien vegetation (Nel at al 2008)

Year	Average cost of Alien Removal (Person Days/ Ha)
1 (initial site visit)	28.92
2	7.09
3	3.78
4	0.46
5	0.32

Based on analysis of WfW data on clearing of invasive alien species, assuming that variation in cost/ha is due to ease of operation (slope, density, species), the following table (Table 10-25) identifies the range of employees required to clear a Ha and furthermore continued management for 5 years.

Table 10-25: Employment data per ha for 5 years (WfW data)

Relative removal difficulty	Low	Average	High
Employees per Ha (Y1)	19.5	27.9	36.2
Employees per Ha (Y2)	4.782214	6.831734	8.881254

Employees per Ha (Y3)	2.549615	3.642307	4.734999
Employees per Ha (Y4)	0.310271	0.443244	0.576217
Employees per Ha (Y5)	0.21584	0.308343	0.400846

Please note that the average number of employees required corresponds to that identified by Nel *et al.* 2008.

Value of IAP biomass was determined through a study done by Mugido and others (2014). The results, after being corrected for at 5% inflation, indicated the value of biomass to be used as fuel to range between R610 and R826 per wet tonne.

Please note although the specific use of biomass as fuel is an extreme simplification of the variety of uses for removed IAP biomass, it has been used here as an indicator of the potential magnitude of value received. There are a range of additional uses for removed biomass such as charcoal, biochar, tannins, fuel or building materials as well as opportunities for additional job creation and livelihood options associated with each of these micro economies of which have not been explored here but are nonetheless relevant.

The average biomass of represented by IAP species of similar species to those in the study area (Acacia-Eucalyptus-Pine) at high density was indicated to range between 56 and 86 tonnes/ha (Mugido *et al*. 2014).

10.2.6 SWOT Analysis

A SWOT analysis was conducted to explore Economic Policy Instruments (EPI) that could serve as mechanisms to internalise ecosystem services into economic decision making. Table 10-26 explores various approaches to the proposal of economic instruments towards driving implementation of IAP clearing programmes.

Table 10-26: Strengths, weaknesses, opportunities and threats of various approaches that economic instruments may take to incentivise IAP clearing programmes.

Key Question	Possible Solution	Strength	Weakness	Opportunities	Threats
Who will finance initial IAP clearing programmes	The Land Owner	- Land owners already possess a duty of care to clear IAP from land; - Land owners can ensure ongoing management of rehabilitated land;	- A concern that land owners do not possess financial capital or resources required for IAP clearing programmes; - Require institutional auditors to monitor and evaluate to ensure ongoing management;	- Possible development of pre- removal funding mechanism - Establish an institutional body (perhaps through BioFin) that provides independent auditors	- WfW provides a finding mechanism, however only operates on public land as revenue received is obtained via municipalities
	Government	- Government already have organisations and capacity to undertake the task (DEA, WfW); - Municipal government is mandated to conduct IAP	- The ongoing management of rehabilitated land is often not maintained; - Budget cuts reduce financial capacity; - National government is not mandated to conduct IAP clearing	- Provide incentives to land owners to maintain rehabilitated land and implement reactive instruments (penalties).	-

Key Question	Possible Solution	Strength	Weakness	Opportunities	Threats
		clearing programmes on both private and public land;	programmes on private land;		
If government is to clear, how will they receive revenue?	Environmental Tax	- The mechanism for collection already exists through the Biodiversity Stewardship Programme	- An environmental tax will place pressure on existing tax contributions - Environmental tax will draw revenue from tax payers at a national level and not from the beneficiaries of Ecosystem Services	-	-
	Penalties to non-compliance	- The mechanism for collection already exists	- Aggressive invasion of IAP has resulted in extensive non-compliance in the catchments and thus accountability is challenging; - The approach is reactive and does not promote a self-regulating system (Requires auditing of all land);	-	-
If land owner is to clear, how will they be	Tax/ Rate breaks/ water pricing strategy	- A tax or rate break may possible provide incentive for ongoing	- The financial resources required for IAP clearing far outweigh the possibility of receiving a tax or rate break;	- An incentive of this magnitude may be applied to a portion of the requirements for	

Key Question	Possible Solution	Strength	Weakness	Opportunities	Threats
financially incentivised?		management of rehabilitated land	- Water pricing currently only finds WfW and other government run management initiatives	compliance (Water Tariff/Charge); - Water pricing may provide direct PES opportunities	
	Increased price incentive	- An increased price incentive could be placed on products produced due to evidence of sustainable land use practices.	- Requires the development of a certification or branding scheme; - The production outputs of much of the land in the study area is relatively low and therefore may not drive IAP clearing;	- Establish a certification scheme for sustainable land management - Integrate the cost of additional water into existing pricing strategies	- Certification does not always change behaviour and require significant initial financial investment. May only be appropriate for industrial land owners
	Tradeable Permits	- Tradeable permits or credits received through IAP clearing initiatives may produce a market of which would drive ongoing clearing	- The appropriate quantification of tradeable permits can be challenging; - A tradeable permit system requires development - Tradeable permits could be utilised to drive inappropriate offset banking;	- Establish a tradeable permit system. This may not be appropriate for all landowners but perhaps targeted at industrial sector. - Develop an alien clearing incentive credit of which operates through current EIA requirements	- Requires national buy in (DEA and DWS).
	Increased land value	- Structures already exist to some degree	- Increased land value will only be realised by the	- Establish a mechanism to integrate and inform land	-

Key Question	Possible Solution	Strength	Weakness	Opportunities	Threats
			land owner once the land is sold; - This incentive already exists and has seemingly limited influence (SPLUMA); - There is no mechanism for integrating historical efforts in IAP clearing programmes into land value;	price based on IAP clearance - SPLUMA may provide a mechanism	
	- Reduced insurance premium	-	- IAP reduction would be required at a regional level to influence premiums	- This would need to be applied at a regional level and therefore would promote pressure by adjacent land owners to comply; - Need to develop a regional land owners association.	- Regional buy in from land owners is required

10.3 Annexure C: Ecosystem Service Mapping

Service Type	Ecosystem Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
Provisioning Service	Fresh water provisioning	Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water and provide fresh water for use. Vegetative cover influences the quantity of water	High (High proportion of population source directly from natural sources)	Low (lowest population)	High (Kruisvallei and High proportion of population source directly from natural sources)	Medium (Some Irrigation)	Low (low population)	High (Pivot irrigation-Karatara)	Medium	High (Pivot irrigation)	Medium	Medium	High (Sedgefield)

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
		available locally.											
	Livestock Grazing	Grazing and pasturising of livestock to receive products including: beef, goat, poultry, milk, eggs etc.	Medium (Water allocation)	Low	Medium (Water allocation)	Low	High	Low	HIGH- Highest proportion of smallholdings	High	Low	Low	Low
	Harvesting	Sustainably produced/harvested crops	Medium- Informal sector is relatively high proportion	Medium- Informal sector is relatively high	High (High proportion not employed and no income)	Medium- Informal sector is relatively high proportion	Low- Informal sector is low proportion	Medium- Informal sector is relatively high	High (High proportion not employed and no income-	Low- Informal sector is low proportion	Low- Informal sector is low proportion	Low- Informal sector is low proportion	High (Groenvlei and Swartvlei- Highest proportion

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
				proportion				proportion	Includes Keurbooms Estuary)				not employed and no income)
	Raw Materials (Timber and fuelwood)	Sustainably produced/harvested wool, skins, leather, firewood, etc.	Low	Low	High (High proportion not employed and no income)	High (High proportion of plantations)	Medium	Medium	Medium	Medium	High (High proportion of plantations)	Medium	High (Groenvlei and Swartvlei- Highest proportion not employed and no income)

Service Type	Ecosystem Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	Other Products	Game meat, and other products like fertilizers, construction material, handcraft material and oils and waxes.	Medium-Informal sector is relatively high proportion	Medium-Informal sector is relatively high proportion	High (High proportion not employed and no income)	Medium-Informal sector is relatively high proportion	Low-Informal sector is low proportion	Medium-Informal sector is relatively high proportion	High (High proportion not employed and no income)	Low-Informal sector is low proportion	Low-Informal sector is low proportion	Low-Informal sector is low proportion	High (Groenvlei and Swartvlei-Highest proportion not employed and no income)
	Genetic materials (Medicinal,		HIGH (Within natural range of numerous	HIGH (Within natural range of numerous	HIGH (Within natural range of numerous	HIGH (Within natural range of numerous	HIGH (Within natural range of	HIGH (Within natural range of numerous	HIGH (Within natural range of numerous	HIGH (Within natural range of numerous	HIGH (Within natural range of	HIGH (Within natural range of numerous	HIGH (Within natural range of numerous

Service Type	Ecosystem Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	genetic stock)		valuable bioprospected plants)	valuable bioprospected plants)	valuable bioprospected plants)	valuable bioprospected plants)	numerous valuable bioprospected plants)	valuable bioprospected plants)	valuable bioprospected plants)	valuable bioprospected plants)	numerous valuable bioprospected plants)	valuable bioprospected plants)	valuable bioprospected plants)
Regulating Service	Carbon Sequestration	Carbon sequestration, maintaining and controlling temperature and precipitation	Medium (Woodland)	Medium (Woodland)	Medium (Woodland)	High (High prop Natural Forests and Plantations)	High (High prop Natural Forests and Plantations)	High (High prop Natural Forests and Plantations)	High (High prop Natural Forests and Plantations)	High (High prop Natural Forests and Plantations)	High (High prop Natural Forests and Plantations)	Medium (Natural Forest)	Medium (Natural Forest)
	Water regulation (hydrol	Regulating surface water runoff,	High	High	Medium (high prop of	High	High	Medium (high prop of	Medium (high prop of	High	Medium (high prop	HIGH	High

Servi ce Type	Ecosyst em Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbo oms	Keurbo oms	Keurbo oms	Karatar a	Keurb ooms	Karata ra	Keurbo oms	Keurbo oms	Karat ara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	ogical flows)	aquifer recharge, river and stream recharge etc.			alien plants)			alien plants)	alien plants)		of alien plants)		

	Water purification and waste assimilation	The physical flow of water through ecosystems and biological activity of microorganisms provides a filter service of waste, acting as a natural buffer to the surrounding environment. Through this process water is purified and waste is either eliminated or attenuated. Additionally, pathogens (disease causing	High	High	High	High	High	High	High	High	High	High	High

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
		microbes) are eliminated, and the level of nutrients and pollution is reduced.											
	Biological Control	Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.											

			K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
Service Type	Ecosystem Service	Description	8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	Natural Disaster Regulation	Resilience to natural disasters such as droughts, floods and fires	HIGH	HIGH	Low (high prop of aliens)	HIGH	HIGH	Low (high prop of aliens)	Low (high prop of aliens)	HIGH	Low (high prop of aliens)	HIGH	HIGH
	Erosion regulation	Maintenance of nutrients and soil cover and preventing negative effects of erosion (e.g. impoverishing of soil, reduced dune integrity)	High	High	High	High	High	High	High	High	High	High	High

Service Type	Ecosystem Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
Cultural Service	Recreational and tourism	Recreational activities such as Hunting, hiking, photography, camping, nature walks, jogging, animal watching etc.	MEDIUM	MEDIUM	MEDIUM	High	MEDIUM	High	MEDIUM	MEDIUM	MEDIUM	High	High

Service Type	Ecosystem Service	Description	K60A	K60B	K60C	K40C	K60E	K40C	K60E	K60E	K40C	K40D	K40D
			Keurbooms	Keurbooms	Keurbooms	Karatara	Keurbooms	Karatara	Keurbooms	Keurbooms	Karatara	Sedge	Sedge
			8947	8969	8992	9036	9085	9095	9097	9114	9140	9170	9179
	Spiritual and inspirational	Amenity of the ecosystem, cultural diversity and identity, spiritual values, cultural heritage values etc.	Low/ Unknown	Low/ Unknown	Low/ Unknown	Low (Karatara Gold Fields)	Low/ Unknown	Low (Karatara Gold Fields)	Low/ Unknown	Low/ Unknown	Low (Karatara Gold Fields)	Low/ Unknown	Low/ Unknown
	Educational	Education, art and research	-	-	-	Medium	-	Medium	-	-	-	Medium	Medium

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
Supporting Service	Habitat Support (Species and Biodiversity)	Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish,	HIGH 92% Natural 0.29% Protected 2% Aliens 7.9% Degraded	LOW-MEDIUM 98% Natural 0.15% Protected 0% Aliens 32.38% Degraded	LOW_MEDIUM 94% Natural 26.78% Protected 10.54% Alien 19.96% Degraded	MEDIUM 63% Natural 74% Protected 2.9% Aliens 16.1% Degraded	HIGH 63% Natural 69.8% Protected 1.23% Alien 6.54% Degraded	LOW 36% Natural 6.13% Protected 13.73% Alien 0 Degraded	MEDIUM 73% Natural 44.6% Protected 9.3% Alien 5.83% Degraded	HIGH 77% Natural 64.73% Protected 3.91% Alien 5.15% Degraded	MEDIUM 40% Natural 2.23% Protected 8% Alien 2.6 Degraded	Unknown 30% Natural 38% Protected	Unknown 72% Natural 37% Protected

Servi ce Type	Ecosyst em Service	Description	K60A Keurbo oms 8947	K60B Keurbo oms 8969	K60C Keurbo oms 8992	K40C Karatar a 9036	K60E Keurb ooms 9085	K40C Karata ra 9095	K60E Keurbo oms 9097	K60E Keurbo oms 9114	K40C Karat ara 9140	K40D Sedge 9170	K40D Sedge 9179
		mammals and insects all depend upon different ecosystems during their movements. Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing											

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
		the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known											

Service Type	Ecosystem Service	Description	K60A Keurbooms 8947	K60B Keurbooms 8969	K60C Keurbooms 8992	K40C Karatara 9036	K60E Keurbooms 9085	K40C Karatara 9095	K60E Keurbooms 9097	K60E Keurbooms 9114	K40C Karatara 9140	K40D Sedge 9170	K40D Sedge 9179
		as 'biodiversity hotspots'											

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