UNLOCKING GREEN JOBS IN SOUTH AFRICA: A CATALYTIC INTERVENTION SYNTHESIS REPORT

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Trade & Industrial Policy Strategies (TIPS) is a research organisation that facilitates policy development and dialogue across three focus areas: trade and industrial policy, inequality and economic inclusion, and sustainable growth

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ABOUT THIS PUBLICATION

This document summarises the findings of a two-year initiative and collaboration on *Unlocking Green Jobs: A Catalytic Intervention* between the World Wide Fund for Nature, South Africa (WWF-SA) and Trade & Industrial Policy Strategies (TIPS).

It is complemented by three case studies, namely:

- Essential Amathole A Case Study of Unlocking Green Jobs in the Bioprospecting Sector;
- Protecting and Unlocking Jobs Through Water Stewardship: A Case Study Linked to the Umbogintwini Industrial Complex, ethekwini; and
- Unlocking and Retaining Jobs in the Alien Vegetation Added Value Chain through Industrial Symbiosis: Case Study on Wood Pellets.

This synthesis report and the case studies are based on work and inputs from numerous individuals, including:

- A Project Steering Committee, including Glenda Raven (WWF-SA); Gaylor Montmasson-Clair (TIPS); Eureta Rosenberg (Rhodes University, Environmental Learning Research Centre), and Olivier Grandvoinet (Agence Française de Développement [AFD]);
- A Working Team, including Thabo Thulare (TIPS/Green Cape); Daryl McLean (Rhodes University, Environmental Learning Research Centre); Shakespear Mudombi (TIPS); Mike Ward (Creating Sustainable Value); and Nicola Jenkin (Pinpoint Sustainability); and
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ABBREVIATIONS

AFD	Agence Française de Développement
BBBEE	Broad-Based Black Economic Empowerment
CSI	Corporate Social Investment
CSIR	Council for Scientific and Industrial Research
CSR	Corporate Social Responsibility
DEA	National Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
dti (the)	Department of Trade and Industry
DWAS	Department of Water and Sanitation
EPWP	Expanded Public Works Programme
ETDP	Education, Training and Development Practitioner
Ha	Hectare
HEA	Household Economic Analysis
IAP	Invasive Alien Plants
LGSETA	Local Government Sector Education and Training Authority
MLSTT	Multi-level Socio-Technical Transition framework
NESPF	National Environmental Sector Skills Planning Forum
R&D	Research and Development
SANBI	South African National Biodiversity Institute
SAREBI	South African Renewable Energy Business Incubator
SEIAS	Socio-Economic Impact Assessment System
SETA	Sector Education and Training Authority
SEZ	Special Economic Zone
TIPS	Trade & Industrial Policy Strategies
UNEP	United Nations Environment Programme
WRG	Water Resources Group
WWF-SA	World Wide Fund for Nature, South Africa

1. INTRODUCTION

A series of academic and policy studies over the past 15 years have argued that very large numbers of jobs can be created by greening the economy (e.g. AGAMA, 2003; DEAT, 2008; Maia, et al., 2011; UNEP, 2012; Musango et al., 2013; DEA, 2016; GreenCape, 2016). Such studies have sometimes also argued that many existing jobs should urgently be transformed toward more sustainable development practices.

These "green" jobs are crucial for the restoration and maintenance of South Africa's natural resources, as well as for the transformation of existing patterns of production toward sustainable development. A core contention of sustainable development perspectives is that these interventions can simultaneously alleviate poverty and unemployment.

Various supply-side[1] interventions have aimed to build the human capabilities to achieve the vision. A National Environmental Skills Planning Forum was established to provide coordination and leadership, under the National Department of Environmental Affairs (DEA). The DEA Biodiversity Human Capital Development Strategy and the Environmental Sector Skills Plan provided early policy platforms, and were cascaded up into a priority under the National Skills Development Strategy III. Sector Education and Training Authorities (SETAs) were engaged on building green skills initiatives into their research and plans.[2] Substantial engagement with the Organising Framework for Occupations explored technical challenges of the current qualifications regime in dealing with emergent fields of practice, while the Green Skills Research and Planning programme has generated innovative methodologies, toolkits and human capabilities to undertake green skills and research. Along the skills pipeline, Fundisa for Change informed curriculation in schooling and teacher education, the Environmental Education, Training and Development Practitioner (ETDP) qualifications under the ETDP SETA provided for environmental educator development, the LGSETA (Local Government SETA) Environmental Practitioner qualifications were rolled out to provide entry-level occupational access points, and the South African National Biodiversity Institute (SANBI) Groen Sebenza programme incubated bridging into work capabilities, followed up by the WWF Internship programme. Many public, private and development sector organisations and individuals have also initiated successful local and national interventions (a few of which are detailed in the case studies in Section 4).

During the Groen Sebenza project (a Presidential Jobs Fund initiative), the National Environmental Sector Skills Planning Forum (NESPF) began discussion on the need for more intensive "demand-side conversations". Groen Sebenza mobilised 32 environmental organisations in South Africa to provide two-and-a-half years of intensive top-up training, mentoring and on-the-job experience to 800 young environmental practitioners, based on the logic that these practitioners would be absorbed into organisations (such as local government) where they would be able to help open up the 360 000 jobs which policy studies suggested are possible in the biodiversity sector. Yet this would have required the potential employer organisations to incorporate environmental concerns into their plans; create and fund

[1] The concepts of supply and demand are drawn from traditional labour market economics. "Supply-side interventions" refer to education and training. "Demand" refers to the employment of people who have been educated and trained to do green work, and/or the use of these skills in the workplace.

[2] Important studies were conducted for mining; chemicals; manufacturing; and public sector procurement.

the posts; and actively recruit the environmental practitioners. Such processes take a long time, and presuppose an understanding and commitment from top management.

In response to demand-side challenges in the Groen Sebenza project, the NESPF initiated a proposal for the *Unlocking Green Jobs: A Catalytic Project*, to explore the challenges. The project results were intended to provide a basis for addressing the systemic challenges.

The objectives were to:

- Identify areas of economic or social innovation and government priorities as well as environmental risk that lend themselves to creating green jobs, either as employment or entrepreneurial opportunities, or both; and
- Inform strategic decision-making and broker new partnerships among the key roleplayers in these promising areas, towards unlocking latent green jobs and demonstrating the potential of an inclusive green economy in South Africa.

Planned activities were to:

- Identify promising areas with potential for green jobs;
- Identify challenges/obstacles and leverage points in the system for unlocking and enabling access to these jobs;
- Identify strategic roleplayers in unlocking green jobs;
- Develop key partnerships with strategic roleplayers; and
- Monitor, evaluate and document methodologies applied in unlocking and securing green jobs and key insights and lessons learnt.

The first 18 months involved setting up the project (including staffing), and collecting and analysing baseline information on existing green economy interventions. In the second year, the following categories of intervention were identified as the focus of case studies:

- Water stewardship, based mainly on the current water crisis;
- Value added industries for the beneficiation of alien biomass, and particularly wood pelleting and eco-matting as a complement to the existing Eco-Furniture Project; and
- Bioprospecting (in particular, the production of essential oils), one of the two main thrusts in the National Biodiversity Economy Strategy, due to its ties into water stewardship through the restoration and conservation or productive use of the restored land.

The three case studies provide snapshots across the green economy rather than a comprehensive picture. However, these snapshots illustrate the interdependence of various strategies, and make the case for stronger coordination. Many of the lessons from the case studies are also generalisable across other parts of the green economy.

In addition to these case studies, the incubation of local green technologies and businesses, looking at the business development potential for the localisation of manufacturing and distributing green technologies, was also considered. This focused on the work of the South African Renewable Energy Business Incubator (SAREBI) in Atlantis (see box in Section 4).

Each case study included both quantitative and qualitative analysis. For the quantitative analysis, Vensim models[3] were developed describing the expanded value chain. Available data was collated and used to populate the models. The models can therefore be used to generate estimates of job creation and other impacts at local, provincial or national levels (although there are a few data gaps, as well as data weaknesses in two of the models).

The qualitative component involved interviews, site visits and document analysis in selected sites where the strategies are being implemented. The draft studies were also distributed for comment to experts in the field, and feedback was incorporated.

The case studies are intended to serve as "mirror data", i.e. a basis for discussion in strategic planning and action through multi-stakeholder forums, rather than as definitive. The project is planned to now take forward these processes at national, provincial and local level in selected sites, in which the results will be used to review existing policies and strategies; coordinate efforts and resources; and begin expanding the scope and scale of green job creation.

This report outlines the conceptual and theoretical considerations that informed the case studies (Sections 2 and 3). It then summarises the key findings and recommendations from the four case studies (Section 4) and formulates a strategy to take forward the findings through stakeholder engagement and advocacy processes, partnerships and social dialogue (Section 5).

[3] Vensim models provide graphical representation of stock and flow as well as causal loops. This interacts with a set of data sets and equations. The graphical representation for each Vensim model is presented in the text below, and the data sets and equations are illustrated for wood-pelleting in Annexure B.

2. CONCEPTUAL ISSUES

Three conceptual considerations informed the project and the selection and development of the case studies.

2.1 Reframing the "economy"

First, the project framed the economy more broadly than the market economy. There is increasing recognition in academic literature, donor research and some aspects of state strategy that the market economy "should be seen as one part of a diverse economy, constituted by a host of economic practices articulated with one another in dynamic and complex ways and in multiple sites and spaces" (Smith, 2011). Drawing on Raworth (2016) the economy is framed in this project as including also the state economy; the household or family economy; and the economy of the commons. Each of these are briefly described below.

Globally, the market economy is projected to shed 800 million jobs by 2030 (McKinsey, 2017) purely due to digitisation and automation of business processes. This report also argues that shrinking natural resources (in particular water) places another three million jobs in the market economy in South Africa at risk; yet those currently excluded from the market economy can play a valuable role in saving existing jobs and potentially creating new jobs in the household economy and the economy of the commons. Both depend on strategies within the state economy.

The household economy is a primary site of survival for those excluded from the market economy. Household Economic Analysis (HEA) has developed as a methodology to explore how they do so, and how best to support them.

> *"Central to HEA is an analysis of how people in different circumstances get the food and cash they need, of their assets, the opportunities open to them and the constraints they face, and of the options open to them at times of crisis. It involves the analysis of the connections between different groups and between different areas, providing a picture of how assets are distributed within a community and who gets what from whom" (Save the Children UK 2008: 2).*

The ZANOC project in South Africa (among other projects) has therefore mapped the gender, age and poverty profile of citizens across agro-ecological zones; household resources by way of access to land, livestock and other income streams; trends in water supply (as well as the seasonality of labour patterns); sources of food and access to food; as well as impacts, hazards, vulnerabilities and response strategies. Such information has been used to a limited extent in some of the case studies in this project, but integrating the available data into policy and planning is proposed as one basis for the multi-stakeholder forum dialogues.

The economy of the commons is another site of survival.

> *The commons paradigm is a versatile social form that is reviving ancient forms of shared stewardship for resources and community, often with modern twists and the use of digital technologies.*

> *Contemporary commons can be seen in open source software and Wikipedia, community land trusts and local currencies, seed-sharing cooperatives and co-housing, art collaborations and open textbook projects. What unites countless commons is their attempts to de-commodify resources and mutualize benefits through bottom-up governance systems that are fair and inclusive….*
>
> *Instead of privatizing gains and externalizing costs onto nature and society, commons seek to reinvent the very meaning of "the economy" by re-integrating it with living systems, local community, and social participation.*
>
> *As nonmarket systems, commons provide a regenerative, holistic way of meeting everyday needs and empowering people through self-governance. Because they are appropriately sized and participatory, commons tend to be more democratic, trusted, oriented to the long term, and adaptable to changing circumstances and local knowledge than either markets or the state. (Schumaker Centre for New Economics, n.d.).*

The economy of the commons is of course highly contested.

> *The open access (commons) versus private control debate is raging. The debate takes place in a number of fields, including the intellectual property and cyber law literatures, as well as in broader public debates concerning propertisation, privatisation, deregulation, and commercialisation of areas as diverse as communication networks, government services, national forests, and scientific research…*
>
> *First, infrastructure resources [including the environment] are fundamental resources that generate value when used as inputs into a wide range of productive processes. Second, the outputs from these processes are often public and nonmarket goods that generate positive externalities that benefit society. Third, managing infrastructure resources in an openly accessible manner may be socially desirable when it facilitates these downstream activities (Frischman, B: 2005: 918-221).*

The state economy directly impacts on supporting existing household economies and economies of the commons to achieve sustainability. Integrating the lessons learned from the latter into the former requires methods and tools not yet widely incorporated into state strategy.

The case studies were selected as a spread covering these different economic domains, and the inter-relationships between them. They illustrate the different approaches for anticipating and stimulating demand in each case and highlight the need to articulate green economy interventions across different economic domains.

2.2 Articulating green economic paradigms

A spectrum of paradigms inform approaches to green economic development across all economic domains.[4]

For some, the green economy represents a new phase of capitalism, in which the efficiencies provided by technological progress provide strategies to also allow maximising profits and shedding of labour costs. Water, waste and energy efficiencies are seen as technical responses to production constraints. The challenges represented by a shrinking natural resource base, emerging climate changes and social imperatives (or the associated regulatory compliance conditions, such as carbon taxes and Broad-Based Black Economic Empowerment (BBBEE) scorecards) provide new competitive spaces for capital accumulation within what remains a foundationally extractive paradigm.[5]

At the other end of the spectrum, "sustainable development" paradigms often believe that economic activity should operate between the parameters of biophysical constraints and human well-being; that market economies are a shrinking component of overall economic activity, while economies of the commons and family economies are becoming more important; that some forms of growth are possible or necessary in some contexts, while to achieve sustainability, de-growth may even be necessary in others; that strategies should be intentionally designed to achieve economic, social and environmental justice; and that cooperation rather than competition is the best strategy in a context of growing populations and diminishing natural resources.

These paradigmatic differences are unlikely to be resolved anytime soon. Rather, the "deep conversations" proposed in multi-stakeholder forums are aimed at articulating the different paradigms. Natural resources are input constraints to production. Improving energy, waste and water efficiencies in production within the private sector is intrinsically necessary to alleviate pressure on such resources. However, private sector funding and capabilities can be better coordinated within existing regulatory commitments (BBBEE scorecard funding for supplier development, enterprise development and skills development; social and labour plan funding for "just transitions"; Community Benefit Sharing within the Bioprospecting Strategy; and focusing green technology development more widely than private sector needs).

The case studies have surfaced possibilities for articulating the above paradigms, and the multi-stakeholder forum discussions aims to engage stakeholders in developing strategies to improve coordination.

[4] For a more delicate differentiation of paradigms, see Death 2015: Four Discourses of the Green Economy in the Global South.

[5] In relation to the energy sector for, example, Baker et al (2013) argue that a shift is taking place from "'electric capitalism' – the way in which the current electricity regime in (South) Africa entrenches and embeds existing inequalities through its uneven development and levels of access while locking in a carbon-intensive development path – to a form of 'climate capitalism' in which capitalism's growth imperatives are increasingly served by the creation of new sites of accumulation in a low carbon economy".

2.3 Replacing traditional economic thinking tools with those of green economics

Table 1 summarises differences between traditional approaches to economics and green economic approaches.

Table 1: Comparison of traditional and green economy approaches

Current economy	Green economy
GDP growth: more economic activity as the aim	Beyond GDP: prosperity as the aim
Focus on the near future (short-termism)	Long-termism
Maximisation of return	Safeguarding of long-term incomes
Shareholder value	Stakeholder value: benefit to society
Extraction of natural resources	Management of natural resources
Linear production systems	Circular production systems
Short-life products for sale	Long-life services: the 'performance economy'
Efficiency measured in monetary terms (such as cost-benefit analysis)	Multidimensional efficiency (such as multi-criteria analysis)
Micro- and macro-rationality highly divergent	Micro- and macro-rationality highly congruent

Source: Mistra, 2014

Most current state-led green economy initiatives in South Africa rely on traditional economic approaches. For example, cost-benefit analyses of isolated value chains have been used in developing, funding, implementing and monitoring/reporting on most state green economy interventions. Instead, using multi-criteria analysis of expanded value chains allows economic, social and environmental externalities also to be taken into consideration. The case studies illustrate the use of green economic tools, and make the case for their use more widely.

For example, the Value Added Industries case study demonstrates that wood pellets may not be the most profitable use of alien biomass, on a cost-benefit analysis of the isolated value chain. Yet expanding the production and use of these to replace paraffin in unelectrified households (as part of a more diversified Value Added Industry value chain) mitigates household fires and chemical pneumonia, both of which have significant downstream costs in the fire-fighting or healthcare systems. (The study also suggests that more localised production may enhance viability).

Similarly, the Essential Oils study illustrates that bioprospecting strategies may appear more profitable when incentivised through private sector farming, but that more developmental strategies are more expensive to fund yet have wider benefits in unlocking household economies and economies of the commons to benefit. They also have land restoration benefits.

The case studies therefore highlight limitations in the use of traditional economic thinking in existing state-led strategies; and exemplify the value of green economic principles in mapping circular value chains, using approaches such as multi-criteria analysis, and converging macro- and micro-rationalities.

3. THEORETICAL ISSUES

Two theoretical frameworks have been used in the project, namely the multi-level socio-technical transition framework and the expansive learning process.

3.1 Multi-level socio-technical transitions

A Multi-level Socio-Technical Transition framework (MLSTT), as conceptualised by Geels (2014), has been used to identify obstacles at niche, regime and landscape levels within each case study. As described by Baker et al (2013), "the term 'socio-technical transitions' refers to 'deep structural changes' in systems...which involve long-term and complex reconfigurations of technology, policy, infrastructure, scientific knowledge, and social and cultural practices". Shifts toward a green economy are forms of socio-technical transitions, and require the coordination of multiple factors at different levels to succeed. A "niche" refers to "a protected space at the micro-level", for example the Amathole Essential Oils project described in the Bioprospecting Case Study. A "regime" refers to "patterns of technologically determined behaviour which is shaped by 'cognitive routines' shared by engineers and influenced by policymakers, scientists, energy users, vested interests and other professional groups….". For example, in the Bioprospecting case study, how the state has planned, funded and evaluated the project. A landscape refers to "the external environment or influences at the macro-level [including] 'demographical trends, political ideologies, societal values and macro-economic patterns'". For example, in the Bioprospecting Case Study, the unequal power relationships between producers and traders, or between European countries currently sourcing bio-oils for production in their own countries relative to beneficiation in South Africa. The landscape influences dynamics at the levels of the regime and the niche.

The case studies aimed to identify obstacles at niche, regime and landscape levels, as a basis for illuminating systemic factors beyond the control of individual projects. The theory of change behind the project is that niche-level activity can serve to catalyse important regime and landscape changes.

3.2 Expansive learning: Collectively learning what is not yet known

As proposed by Engestrom (2016), "expansive learning" refers to "learning what is not yet there", and describes a process through which a group of agents collectively examine the "need state" of a problem; analyse the contradictions; design a new model; examine the new model; implement it; reflect on the process; and consolidate the new practice. "Mirror data" (such as problematic cases) are used as key points of dialogue in the process. There are a variety of methods for implementing expansive learning, one of which is known as a "change laboratory". Key features of a change laboratory include the co-creation of new knowledge. "Runaway objects" are dynamics, such as climate change, "so massively distributed in time and space as to transcend localisation". They are "objects poorly under anybody's control, and have far-reaching, unexpected effects". Runaway objects are contested, but "can also be powerful emancipatory objects that open up radically new possibilities for development and well-being" (ibid: 7). For example, the scale and impact of water shortages – illustrated in the water case study – are potentially disastrous yet confronting the challenges collectively may open up new ways of public-private-community collaboration. Expansive learning is proposed as the methodology to inform some of the stakeholder engagement processes. The case studies were designed to provide "mirror data" to inform such collective strategy-making between potentially antagonistic social actors (community, state, private sector and higher education), in co-creating solutions to the obstacles.

4. DIVING INTO THE CASE STUDIES

4.1 Water as a basis for life and jobs

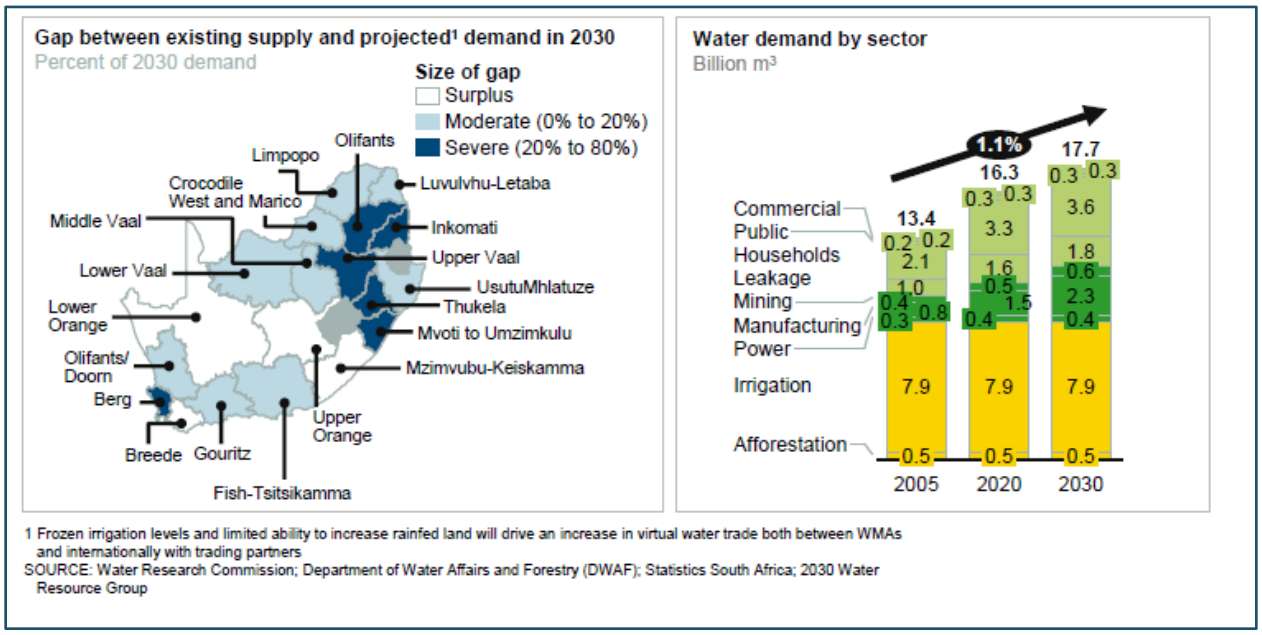
The scale of the socio-economic catastrophe water shortages will cause is rapidly becoming evident across South Africa. In response, the state has declared three provinces as disaster zones; and on 31 March 2018 published the National Water and Sanitation Master Plan (DWAS 2018). The first case study in the Unlocking Green Jobs project (on water stewardship) is the centre-piece of the project. It was completed prior to publication of the Master Plan and raised almost all of the themes also flagged in the Master Plan. However, the case study surfaced a number of other issues that are not considered in the Master Plan, and which may provide valuable input into how the Master Plan is funded, implemented and evaluated.

- The Master Plan is focused on addressing the challenges in supply of and demand for water. It does not describe the new jobs that can be created through this, or the existing jobs that can be saved. The case study provides useful complementary insights about this. Given the enormous budgetary implications of the Master Plan (an additional R533 billion is required over the next 10 years), the job creation/job salvation and poverty alleviation impacts are key multi-criteria considerations informing National Treasury deliberations.
- The Master Plan is understandably focused on water and sanitation. The case studies in the Unlocking Green Jobs project illustrate how water stewardship can springboard wider inclusive socio-economic development through "joined-up" policy and strategy in local development planning. Again, this should be factored into consideration of the Master Plan.
- The Master Plan provides a strategic framework for targeted regulatory reform, capacity-building and coordinated action involving the state and private sector. The case study highlights the crucial roles to be played also by communities (including community-based organisations and non-governmental organisations) and the higher education sector.
- The Master Plan flags a key role for the private sector but perhaps justifiably does not prescribe implementation modalities. The case study illustrates some of the primary revenue bases and organisational capabilities that can be mobilised (e.g. Corporate Social Investment, BBBEE scorecards and Expanded Public Works Programme (EPWP) funding).
- The Master Plan places great emphasis on targeted capacity-building of some state participants. While the envisaged mechanisms for this (such as establishing formal qualification requirements for particular roles, developing and delivering formal learning to access employment in these roles, and improving existing bridging into work interventions) are all important, the case study highlights that much of the learning needed is informal and non-formal; collaborative; and "emergent" (learning what isn't yet known). The model of "expansive learning" through social dialogues proposed by the Unlocking Green Jobs project is an important complement therefore.
- The National Planning Commission has initiated an 18-month national social dialogue on greening the economy. Many of the deadlines in the Master Plan are congruent with this (e.g. the proposed August 2018 mini-Phakisa deadline), however, the impact of water shortages requires far more urgent interventions at local level. The case study provides a mechanism for addressing these
- The case study provides "mirror data" to be used in the local-level multi-stakeholder forum planning processes.

The case study focused on a public-private-community water stewardship programme in the Umbogintwini district in KwaZulu-Natal.

The quantitative modelling for this case study is premised on current (2017) data that water supply in South Africa amounts to 15 billion m^3 and demand is projected to rise to 17.7 billion m^3 by 2030, as illustrated by Figure 1. This will result in a shortfall between water supply and demand of 17% by 2030. Furthermore, "[e]ven though this shortfall is significant, it is likely to be an underestimate as it excludes uncertain impacts of climate change and the declining water quality in the country." (Askham and Van der Poll, 2017)

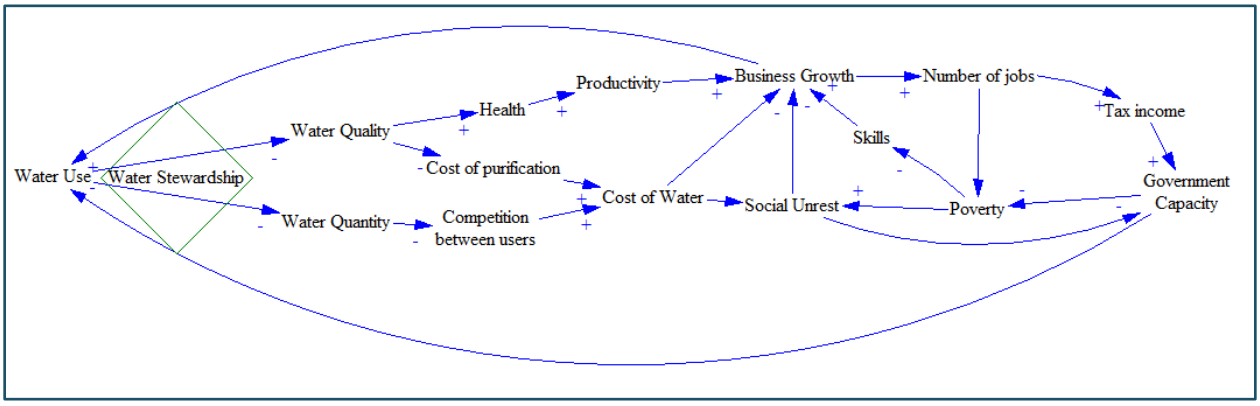
Figure 1: South Africa - Water supply and demand gap



Source: WRG, 2009

Recent estimates (UN, 2016) are that three out of four jobs in the global workforce are heavily or moderately dependant on water. When the occupational composition of these is overlaid on employment statistics in South Africa, a total of 3 057 362 jobs are highly water-dependent. Constrained or expensive water supply is therefore a significant threat to existing jobs. However, managing water resources may also have the potential to create jobs as the value of water increases.

Figure 2: Water system diagram generated from case study



Source: TIPS Water Stewardship Case Study

Note: the + sign means that the change happens in the same direction (a decrease in health will result in a decrease in productivity) while the – sign means that the change will happen in the opposite direction (a decrease in quality will result in an increase in cost of purification)

The quantitative model developed during this case study does consider some aspects that are broadly established through current research. For example, poor water quality also has an impact on health, which exacerbates social protests and lowers productivity. The data for these and other aspects are not yet sufficiently extensive to permit their inclusion in the model, hence the model is illustrative only.

Based on this high-level model of the key components and dynamics of water management, and the possibilities for water stewardship to impact on these (illustrated in Figure 2), water stewardship has significant potential to increase water efficiency (essentially increasing the quantity available) and water quality in catchments. These two impacts can increase people's health, reduce the cost of purification, reduce competition between users and, ultimately, slow the rising cost of water. These are slower processes but, if not addressed, socio-economic dynamics (the right-hand side of the system diagram) will ultimately succumb to the forces at play within the water system (the left-hand side of the diagram).

Building on the formulation on different, possible strategic responses (formulated as scenarios) in water catchment areas, a number of obstacles to job creation in the context of water stewardship were identified:

a) Government is still mainly working on the assumption that water supply is not a limiting factor on employment growth since supply can be guaranteed through investment in infrastructure, such as dams.
b) Supply enhancement through catchment management is mainly being conducted, in this case study, through the Expanded Public Works Programmes and corporate social investment (CSI) programmes, therefore resulting in the jobs being temporary and uncertain. In fact, the assumption is that jobs are short term and that participants should become self-financing or externally employed in a relatively short time frame, usually one to two years.
c) The lack of financial instruments to pay for water supply measures, such as catchment management, means there is no financial incentive for business or communities to become involved in catchment management.

d) The low price of water means that internal efficiency interventions in agriculture, industry and the domestic sector is seeing diminishing returns with many of the financially viable options having already been implemented.
e) The state owns all water (under the National Water Act), and allocates the water through licensing. Water use licences still appear to be allocated on a first-come, first-serve basis rather than careful consideration of the most beneficial use of the water.
f) Complex modelling on the socio-economic-ecological implications of water allocations is hampered by outdated and incompatible data. This is also identified as a factor in the Master Plan, and constrained the Vensim modelling for the case study.

Based on these identified obstacles to decision-making and the ability of decision-makers to understand the implications of these decisions on jobs, a number of possible interventions have been identified:

a) Highlight the potential implications of a 17% water deficit by 2030 through direct links to the impact that this deficit is likely to have on jobs, a key challenge the country faces at present. This includes developing both systemic representations and scenarios around which to engage key roleplayers in dialogue.
b) Advocate for a longer-term view of water stewardship work that occurs in catchments and that contributes to water supply. For decent jobs to be created, water stewardship should be viewed as permanent employment beyond the short-term EPWP and corporate social responsibility (CSR) project cycles.
c) The need to develop financial mechanisms for paying for ecosystem services and water in ways that reflect the value created by these activities is evident. This work urgently needs to be developed further and implemented.
d) An increase in the price of water will be required to make ongoing investment in water efficiency more attractive to water users. As feature of the Master Plan, this will require highly contested decisions over who will pay how much for what water use purposes.
e) The allocation of water needs should be done based on a more careful consideration of the socio-economic-ecological implications of this allocation. The case study has provided scenarios for more nuanced discussions to refine decision-making processes and outcomes.
f) Developing the data sets required to make more informed decisions about water management and allocation is an urgent priority. This is needed directly to better plan and implement national, provincial and local level projects.

In terms of job creation, it is evident that as water becomes a limiting factor within South Africa there are likely to be a number of implications.

First, it is extremely likely that, given the very high percentage of water that irrigated agriculture uses relative to the GDP and job creation per unit of water, further limitations are likely to be placed on the amount of water allocated to this sector. This is likely to result in job losses in this sector. This in turn will require reskilling to support a just transformation as this occurs.

Second, at a global level, it is also likely that companies requiring highly water dependent inputs into their supply chains will look to reduce costs and risks by sourcing these inputs from countries that have higher

levels of water security. Again, it is important to start to identify these sectors and plan to make them more competitive and efficient or start a process of supporting a just transition into other sectors for vulnerable workers.

Third, existing EPWP and CSR programmes provide the basis from which to build longer-term career paths in catchment and water management. If and when financial mechanisms are put in place to support this work, the skills need to be developed to fill the emerging job opportunities. There is significant job creation potential if financial mechanisms recognise the value of water.

Fourth, water efficiency work within agriculture, industry or the domestic sector is unlikely to create significant job opportunities in the market economy (but may provide these downstream, e.g. in household and commons economies). However, it is likely that existing farmers, plumbers, process engineers, artisans, etc. will require upskilling in identifying and responding to water inefficiencies within these sectors and addressing them through implementing new techniques and technologies.

Last but not least, by enhancing supply through the better management of catchments and reducing demand through efficiency and better allocation of water use, it would be possible to avoid water becoming a limiting factor in South Africa's development.

The case study represents a 'first pass' at developing a framework for understanding the potential, blockages and possible approaches to protecting, creating and transitioning jobs that are highly or moderately dependent on water. Through a process of engagement and consultation with experts and key roleplayers from the government, business, academia and civil society sectors, the insights developed so far should be refined, notably to bridge the data gaps.

4.2 Beneficiating alien biomass to further incentivise clearing

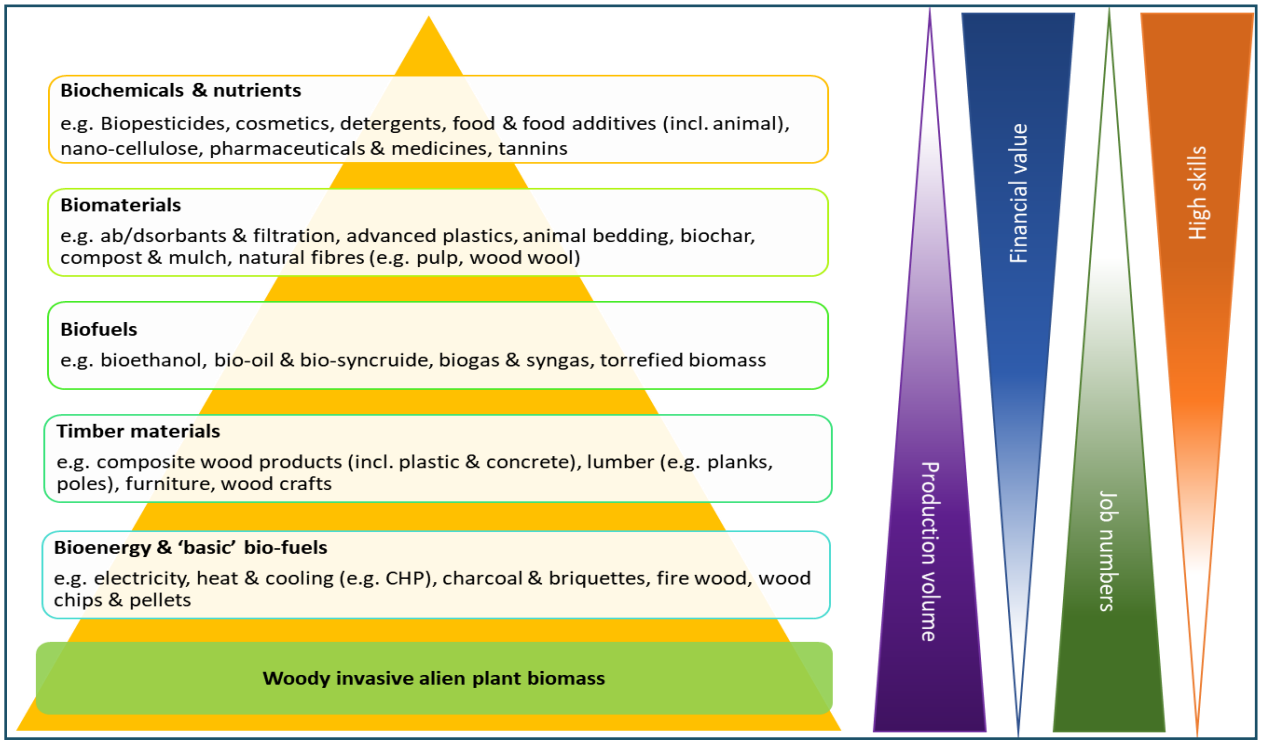
One element of water stewardship strategies is clearing water catchment areas of invasive alien plants (IAPs).

IAPs consume an estimated 4.7% of annual mean water runoff, which represents significant potential for addressing water shortages. Once cleared, the biomass from IAPs can be beneficiated in a range of ways, included in what state strategy currently describes as the Value Added Industries.

For the purpose of assessing value add opportunities for IAPs, Figure 3 proposes a diversified bioproduct value hierarchical framework. The five main categories of bioproducts are listed hierarchically in terms of the complexity and/or simplicity of production or manufacturing.

Other factors relevant to decisions are listed in the adjacent arrows. For example, some products may generate higher profits but create fewer jobs; or some jobs may be better paid but require higher skills levels and are likely to require imported labour.

Figure 3: Invasive alien plant bioproduct value hierarchy



Source: TIPS, derived from Lee, 2015; Mugido et al., 2014; Stafford et al., 2016; Toma-Now, 2016; Vundla et al., 2016

While South Africa's government has spearheaded several large-scale initiatives to unlock green jobs in the alien vegetation value chain, the public sector is not the sole purveyors of such activities, with several private and non-governmental entities also active (or attempting to be) in this space, for example in the manufacture of compost, biochar and briquettes, and medicinal treatments and cosmetics.

Emergent opportunities and more frequent research and development (R&D) activity is occurring on biofuels (torrefied biomass), biomaterials (biochar, filtration, absorbents), and biochemicals and nutrients (tannins, cosmetics and chemicals).

This points to the range of policy choices facing the state regarding beneficiation of biomass from IAPs. Using a multi-criteria analysis, the implications of including wood pellets as an important component of a diversified Value Added Industries strategy are evaluated.

If the manufacturing of wood pellets from IAPs could be realised, and households adopted their use at an incremental rate of 5% a year, this could result in the clearance of an estimated 2.3 million ha of IAPs, which in turn would generate about 1 480 000 direct person day jobs until 2028.

The unlocking of the wood pellet value chain could create green job opportunities for those employed in the fossil fuel sector, paving the way for people to move horizontally into the renewable energy sector, thereby increasing their long-term job security. This may depend on regional matches between such employment opportunities and skills development/work experience.

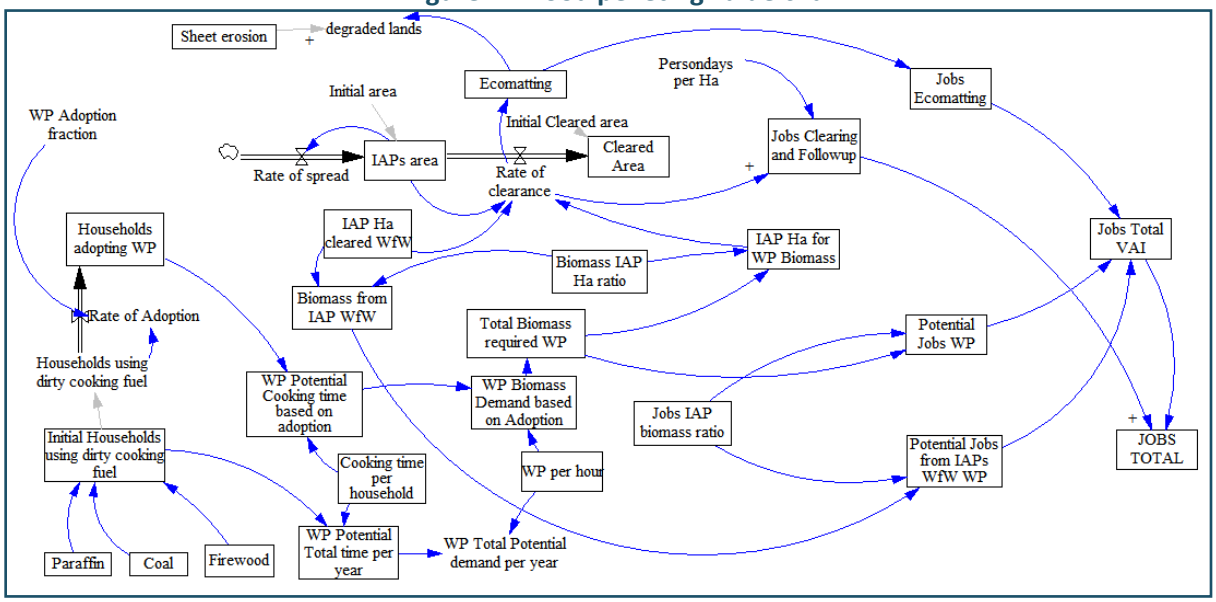
Strong social benefits would also stem from the rollout of wood pellets, with the conversion of 1 060 000 non-electrified households from 'dirty' fuel use to wood pellets. Of the 3.4 million non-electrified households in South Africa, 68% use paraffin for lighting, cooking and heating and 74% use firewood for cooking (Diederichs, McKenzie and Knox, 2014). The side effects of this high usage of paraffin and firewood (from cooking smoke and fumes) contributes to lung diseases, such as cancer, pneumonia and acute lower respiratory infection, and cataracts (ACE, 2017). In addition, cooking on open fires and paraffin usage increase the risk of house fires, with an estimated 45 000 house fires and 3 000 deaths caused annually due to the use of paraffin in South Africa (ACE, 2017). Even focusing purely on the financial implications, a strategy to roll out wood pellets as an alternative could result in significant downstream savings in the healthcare system and more widely.[6]

Yet, despite these strong arguments, and an initial surge of activity in relation to wood pellet manufacturing, the production of wood pellets in South Africa has suffered major setbacks, with many facilities being mothballed as of February 2018.

While the industry has focused on large-scale production for the export market, a more decentralised and localised business model would be relevant to combat some of the barriers associated with large-scale production, such as transport costs. Such a proposition supports the need for localised economies, which encourage entrepreneurialism and, in this case, the creation of a localised industry of wood pellet production, and associated products or distribution networks to service surrounding towns and households.

Figure 4 depicts the wood pelleting value chain, notably the circularised production systems and associated benefits.

Figure 4: Wood pelleting value chain



Source: TIPS Wood Pelleting Case Study

[6] A full analysis of this aspect has not yet been conducted.

Some of the barriers and systemic issues that hinder the production and use of wood pellets produced from IAPs in South African households, are:

a) Large-scale capacity exists, but a localised model would require investment in small-scale (possibly mobile) capabilities.
b) Inadequate and misaligned government policy, which does not encourage the use of IAPs as a biomass feedstock. Policies tend to focus on biomass fuel generated from sources, such as sugar cane or agricultural waste.
c) A poor local market due to the domination of and access to paraffin, which has an embedded network of easily accessible outlets.
d) The cost of production is inhibited by access to feedstock and transport costs associated with feedstock delivery to the manufacturing facility, and distribution for retail and use.
e) A lack of suitable IAPs (an estimated 32% of IAP volume is suitable for wood fuel) and consistent supply for manufacturing plants (large and small) to operate at capacity and respond to potential increased demand.
f) The absence of small-scale technologies and entrepreneurs, especially in the cooking stove sector. These solutions do not have to be large-scale, and ideally not reliant on overseas expertise or manufactured machinery. Solutions may need to involve capitalisation of localised development and distribution, articulated with rollout of wood pellet production.

Over the past 15-20 years, investment has been made in South Africa in the manufacturing of wood pellets (albeit large-scale) and technologies that can use wood pellets, such as cook stoves. However, there appears to be a disconnect between government, not-for-profit and private entities, which has prevented a collaborative approach to effectively introduce wood pellets into the South African market. Malawi provides examples of how it is possible to do this differently.

4.3 Restoring and using land for agricultural development and bioprospecting

Where land is cleared from alien vegetation, it is either restored to sustain biodiversity, or sometimes restored and used for productive purposes in growing more sustainable and profitable crops. (Of course, not only land cleared of alien vegetation can be used for these purposes – the case study illustrates this). The Bioprospecting Strategy aims to grow the bioprospecting industry by 10% a year, off a 2014 baseline of R1.5 billion. The job creation potential is not estimated in the strategy, but the aggregate target for the Biodiversity Economy as a whole is 300 000 jobs. This strategy interfaces with the agricultural and rural development strategies, including the recent 1 Household 1 Hectare project.

The Essential Amathole business plan was developed using a basic analysis of household economies and economies of the commons. The project originators based their plan on an assessment that what local communities and households have available to them is land, water and labour. The project aimed to provide an interface between these production input factors, local higher education capabilities and private sector market access.

The Essential Amathole case study can be used to estimate the land that would need to be cleared of IAPs, restored, and planted, harvested and beneficiated through the extraction of essential oils (a highly

profitable and labour-intensive strategy) in order to create these jobs. (The Vensim model data for this case study is interfaced with the landmass/invasive alien biomass to extrapolate job creation potential through Value Added Industries. However, interfacing the model with the current Department of Agriculture and Land Reform One Hectare project also provides a highly viable workstream to the latter, should the Essential Amathole project be replicated more widely).

Table 2: Job creation estimates per hectare of land in the Essential Amathole Project

	2017	2018	2019	2020	2021	Total jobs over 5 years
Essential Amathole (Pty) Ltd (Ha)	40	68	96	132	132	
Job coefficient: Permanent jobs per Ha		0.66	0.66	0.66	0.66	
Jobs coefficient: Seasonal jobs per Ha	1	1	1	1	1	
Permanent jobs	39	45	63	87	87	**87**
Seasonal jobs	40	68	96	132	132	**468**
Total Essential Amathole jobs	**79**	**113**	**159**	**219**	**219**	**555**
Out growers (Ha)	0.5	45	80	120	168	
Jobs per Ha (Permanent)	0.66	0.66	0.66	0.66	0.66	
Jobs per Ha (Seasonal)	1	1	1	1	1	
Permanent jobs	0	30	53	79	111	**111**
Seasonal jobs	1	45	80	120	168	**414**
Total out grower jobs	**1**	**75**	**133**	**199**	**279**	**524**
Total permanent jobs	**39**	**75**	**116**	**166**	**198**	**198**
Total seasonal jobs	**41**	**113**	**176**	**252**	**300**	**882**
Total Jobs	**80**	**188**	**292**	**418**	**498**	**1080**
Total Ha	**40.5**	**113**	**176**	**252**	**300**	

Source: Essential Amathole Project Proposal, 2017

Essential Amathole in the Eastern Cape was one of several essential oils projects initiated in line with the Bioprospecting Strategy (part of the national Biodiversity Economy Strategy) and the Agricultural Development Strategy.[7]

Essential Amathole represents a partnership between the state; private sector; rural communities in the Amathole district; and staff and students at the University of Fort Hare. The private sector acts as a hub, with centralised capabilities for cultivating and supplying seedstock; distillation; retail; administration, management and marketing.

Businesses also grow their own crops, leasing land from the university, a local agricultural college and the state. The community participates through cooperative "outgrower" relationships, using private or

[7] Many of these projects are in "hibernation" or have collapsed completely due to the challenges reported in this study.

communal land. The university provides testing and monitoring of soil, crops and other key production factors.

The project has to date cleared 40 hectares of IAPs; restored the land through composting; planted; harvested; distilled; and sold essential oil. Other than as outgrowers, the community owns 25% shares in Essential Amathole, as the community benefit sharing component. A total of 68 different community groups registered as potential beneficiaries of the Trust, including old age homes, gospel groups, youth sports clubs and cooperatives wanting to play an extended role in the project as opportunities open up.

However, the project went into hibernation just as it was beginning to reach sustainability. This was due to an unfortunate confluence of factors. The time taken to build community involvement initially drew project resources away from production; and the time taken to restore land before planting also slowed things down. The Minister of Agriculture, Forestry and Fisheries, in response to protests nationally, issued a determination raising the minimum wage for agricultural workers higher than the contracted project budgets. While intrinsically a good thing, a nimbler state response should have facilitated the adjustment of the project funding, which did not take place. As a result, the project was forced to retrench. Project reports were submitted but allegedly not forwarded by the state to the donor, resulting in project funding being cut off. Traders in the market sensed vulnerability and reportedly used this to negotiate down prices.

The project has achieved some significant gains in the short space of three years. Central capabilities have been built; partnerships have been established; skills have been developed; hectares have been cleared and planted; the Essential Amathole brand has been established; and the project retains some capacity and momentum. Essential Amathole is in the final stages of negotiating a new contract with the provincial Department of Rural Development and Agriculture.

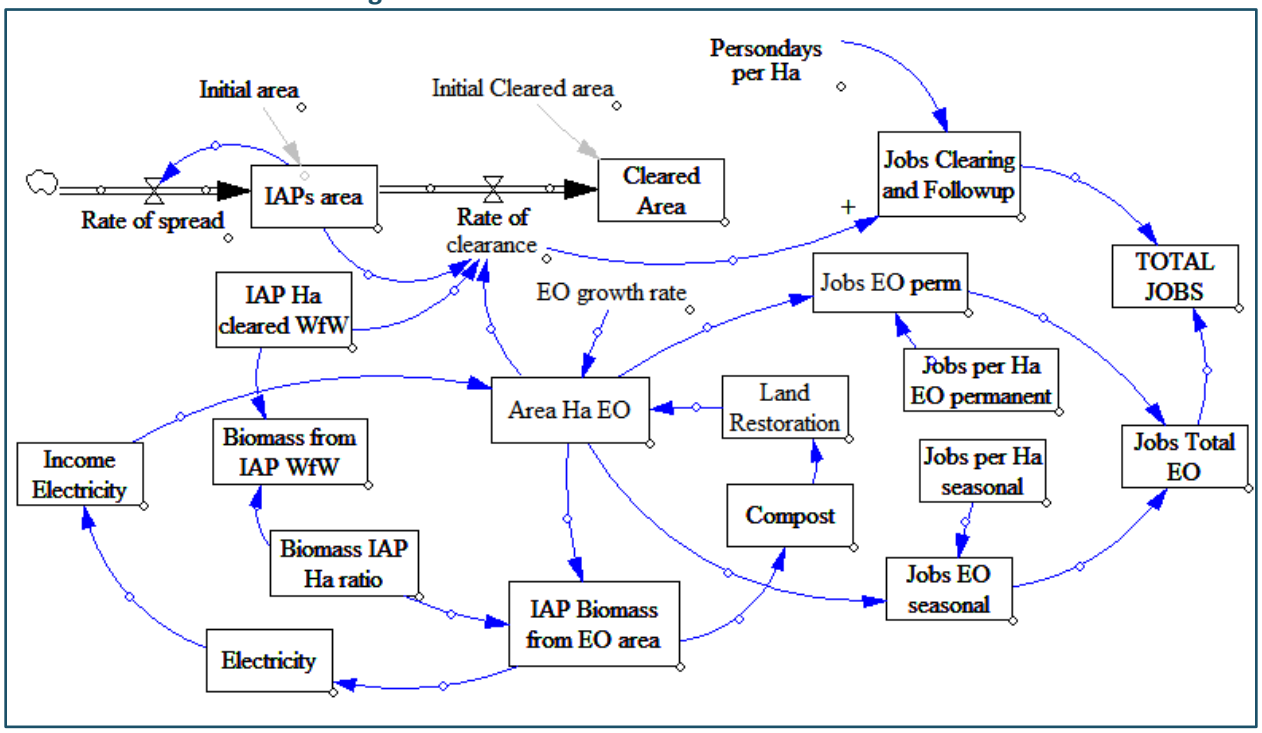
However, important lessons from the initiative may avoid a similar meltdown; and could also inform a review of the bioprospecting strategy (and implementation modalities) to take forward the job growth, social development and environmental restoration agenda.

Essential Amathole appears to be typical of many essential oil projects that have collapsed around the country. To achieve the policy vision set in the National Bioeconomy Strategy, government should provide long-range planning and funding; monitoring and evaluation criteria that balance the economic, environmental and social impacts; economies of scale and market access to mitigate the power of traders; coordination of research and development capabilities with such developmental agendas; and much better management of the strategy on the part of the state.

Most importantly, projects, such as essential oils, work best within an overall industrial symbiosis at local level. Where alien vegetation is cleared, water quantity and quality is improved, which impacts on the sustainability of industries that use the water. The biomass generated can be further beneficiated and used in energy supply or in compost for land restoration. In addition, the cleared and restored land can be productively used in farming for the production of essential oils. This is at the heart of any industrial symbiosis argument.

Based on EA's experience, Figure 4 illustrates the circularities, and the value of integrated environmental planning in local economic development. The diagram also illustrates the value of shifting from cost-benefit analyses of linear and isolated value chains toward multi-criteria analyses of expanded and circularised value chains.

Figure 4: Essential oils circularised value chain



Source: TIPS Essential Oils Case Study

Challenges and associated recommendations in relation to bioprospecting include the following:

- Some state policies (including the Bioprospecting Strategy itself) should be reviewed; policy coordination is important across the relevant regulatory frameworks; and the strategy should be taken through the Socio-Economic Impact Assessment System (SEIAS) analysis.
- During the review, the tools of green economic thinking (such as extending and circularising value chains, using multi-criteria analysis rather than cost-benefit analysis) should be used. This should inform planning, budgeting, management and monitoring/reporting of bioprospecting projects. It is particularly important to distinguish between commercial farming initiatives and developmental projects, such as Essential Amathole.
- State capabilities to implement the strategy should be strengthened.
- Market access: the domestic market is very small. While using the BEE scorecard funding for enterprise development and supplier development may be helpful for developmental projects, accessing international markets is, however, key to growing the industry as a whole. South Africa is highly quality-competitive and price-competitive in essential oils (and have unique species currently being sought by international traders). Yet South Africa is one of very few countries that

fails to provide “pavilions” for domestic retailers at international trade fairs. Some local producers now access these markets under other expensive (About R200 000 for a small stall) schemes. The support of the Department of Trade and Industry (the dti) to open access to international markets is key to growing demand side. If the industry could double sales, employers project they could almost double employment in the sector.

- Knowledge and skills building to access international markets: CBI (an initiative led by England, Switzerland and Netherlands) ran a very helpful programme educating South African producers on accessing international markets. A strategically-led and ongoing follow-up programme spearheaded by the dti to build these skills/capabilities would support the industry to do this more independently, both individually and sectorally.
- Packaging essential oil products for export purposes: given the hazards associated with essential oils, South African regulations appear appropriate. However, hazardous packaging absorbs as much as 5/6ths of the costs of exporting, an unprecedented case in bioprospecting internationally. Further investigation is required, but a partnership with the packaging industry may assist in resolving the challenges.
- Bioprospecting licences for indigenous plants: there is a need to optimise the business processes for issuing bioprospecting licences; and for strengthening the oversight once licences are issued. Some employers report having not received any response over more than two years after application, despite follow ups. Others report receiving the licence but having had no monitoring ever since. This factor constrains the production of indigenous essential oils, for which there is a growing demand. Appropriate responses may include a review of the Bioprospecting Strategy itself.
- Managing water issues: the multiyear drought cycle in South Africa is affecting production in some areas. Some employers report having moved operations to other countries as a result. Water efficiency strategies and water stewardship need to be integrated into industrial development for essential oils. Grey water recycling may also be an appropriate response in some context.
- Clarifying the role of technical and scientific support agencies in stimulating industrial growth. Some agencies have entered the market (due to income-generation needs) as producers and bio-traders, in ways that compete with and undercut local enterprise development. There is widespread industry discontent with this.
- Obtaining organic certification and the subsidisation thereof internationally. Organic certification is required to access international markets. The dti has an incentive scheme in place for this, which should be rolled out more intensively in the essential oils sector.

Incubating local green technologies and businesses: The South African Renewable Energy Business Incubator

The South African Renewable Energy Business Incubator (SAREBI), provides a classic market economy focus (but with an argument for focusing green technology production also on needs in household economies and economies of the commons).

The SAREBI incubator aims to stimulate the development of small enterprises in the green technology space, with its designated Special Economic Zone (SEZ) status (SEZ status provides a battery of state incentives for private sector investment). The research explored the potential of SEZs to support scientific and technical innovation, and roll out business development to support the development and supply of these in response to green economy needs in South Africa.

Many green technologies and materials (e.g. in construction) are currently imported, and greening the industry potentially results in an export of jobs. This demonstrates the importance of an economic greening strategy being linked to a "localisation" of product innovation and manufacturing strategies.

The SAREBI incubator is located within the Atlantis SEZ, which brought to bear a full range of incentives* and allowed for significant fast-tracking of the SAREBI project. The City of Cape Town initially donated 60ha of land to be used to set up the SEZ.

As of 2017, the zone has attracted a total of R680 million worth of investment. In addition to Gestamp Renewable Industry's R450 million initial and subsequent R150 million additional investment, other companies invested the balance of the R680 million. Skyward Windows invested R50 million to manufacture double glazed windows, Kaytech invested R130 million (for geotextile expansion) and Resolux invested R25 million to house wind tower internals (GreenCape, 2016).

The SEZ is projected to attract more than R3.7 billion worth of foreign direct investment and create 1 200 jobs over the 2017-2022 period in waste, energy efficiency, solar, wind and through other components. The downstream impact of these manufacturing jobs (installation and maintenance of the manufactured products) has not been estimated.

However, important lessons from the project include:

- The need to align strategy and policy across different tiers of government;
- Such strategies should be located within strong institutions, and institutional capabilities should be built (as well as relationships between different institutional capabilities);
- SEZ status should be informed by a sound economic analysis;
- Investment support needs to be actively leveraged;
- Skills development and organisational capability-building is crucial to success (TIPS, 2015).

While the SAREBI focus has been on renewable energy, the lessons are relevant also to possible enterprise development for water efficiency, biotechnology or waste.

** These incentives include Vat and Custom Relief for SEZs, which will have a custom controlled area for companies to qualify for import duty rebate and VAT exemption. Employment Tax Incentive will be offered to all employers of low-salaried employees below R60 000 a year. The Building Allowance is for companies operating in a SEZ and will be eligible for an accelerated depreciation allowance on capital structures (buildings). The Reduced Corporate Income Tax Rate is for certain companies located in an SEZ and will qualify for a reduced corporate income tax rate of 15% instead of the current 28% headlines rate.*

5. CONCLUSIONS

This report provides only a synthesis of some aspects of a two-year project. The key project findings summarised above illustrate some key aspects of the possibilities for green job creation; the potential scope and scale of this (variable across policy choices and environmental challenges in different contexts); current obstacles; and potential solutions.

At the heart of the way forward lies a proposed process of:

- Using the quantitative and qualitative data as a basis for achieving buy-in from policy owners at national and provincial level (as well as a review of the polices and strategies themselves);
- Convening and supporting multi-stakeholder dialogues at local level in at least three provinces, focussed on collective problem-solving and action; and
- Expanding the scope and scale of potential green job creation, in ways that are relevant to local economic development planning across selected sites.

Key findings from the project that are also relevant to other parts of the green economy were tabled and discussed at the National Environmental Skills Summit 2018[8]. Agreement on the findings and the way forward include:

- Available data is sometimes sketchy, incoherent or inadequate for purposes of modelling. Stronger coordination of data collection and analysis is important, possibly by bringing the different agencies who have such mandates into a process where a coordination strategy is agreed;
- Many policies should be reviewed, based on the findings of research and the experience of those implementing the policies. Further, coordination of such policy reviews should take place using the SEIAS.
- Adaptive monitoring and evaluation strategies are important, accompanied by adaptive management strategies, to ensure nimbler responses to policy implementation challenges.
- All the above presuppose capacity-building, which may include individual skills development which should be embedded within organisational capacity-building efforts, focused on service delivery priorities; and
- The analysis achieved through the initial case studies should probably be extended also to other parts of the green economy. Suggestions for other priorities discussed at the National Environmental Skills Summit were for mine rehabilitation and waste.

[8] Recommendations specific to individual interventions are detailed in the relevant sub-sections of the report above and the case studies.

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ANNEXURE A: EXPERTS CONSULTATION

During the review process, key experts in each sub-sector were consulted on the research findings and report. Those whose feedback was solicited and/or who provided feedback are detailed below.

Consultations for Water Stewardship	Institution and Designation
Dr Mark Dent	International Water Stewardship Alliance; South Africa Manager
Dr Mark Graham	GroundTruth: Owner and Director
Nicole Solomon	AECI; Group Community Development Programmes
Nomali Msomi	Umbogintwini Industrial Association; Community Liaison Officer
Nick Tandi	Strategic Water Partners Network (SWPN)
Christine Colvin	WWF-SA; Water Programme Manager

Consultations for Essential Oils	Institution and Designation
Ian Weir	CEO Amathole Essential
Karen Swanepoel	South African Essential Oils Producers Association
Sandra Kruger	Sandra Kruger and Associates
Flip and Riana Minnaar	Highland Essential Oils
Dr Marthinus Horak	CSIR
Dr Crispen Olver	Former Director General for Department of Environmental Affairs and Tourism
Dr Boitumelo Semete	Council for Scientific and Industrial Research
Akho Skenjana	Department of Trade and Industry, Eastern Cape
Dr Christopher Morris	International researcher in the bioprospecting field
Natalie Feltman	Department of Environmental Affairs

Consultations for Wood Pelleting	Institution and Designation
Jarred Lyons	Western Cape Industrial Symbiosis Program Western Cape
David Lello	Ekasi Energy
Grant Trebble	Director of Wood@Heart
Jasper Cloete	Director, Viking Energy

Consultations for SAREBI Business Incubator	Institution and Designation
Maloba Tshehla	Innovation Hub, Energy
Gracia Munganga	Innovation Hub, Waste and Energy
Rethabile Melamu	Innovation Hub, Green Economy and Energy
Nkosazana Masiza	Strategic Water Partners Network Researcher
Selwyn Jacobs	South African Reserve Bank Economist
Dr. Maserumule	Department of Science and Technology (Energy Division)
Dr Najma Mohamed	ILO, Green Jobs and Green Economy
Annelize van der Merwe	Department of Trade and Industry: Director Green Economy

ANNEXURE B: DATASETS FOR VENSIM MODELLING (WOOD PELLETING)

The Vensim diagrams summarised in this report are fully complete only for wood pellets. For water and essential oils, the models lack a few data sets (or the data sets available are highly contested). The incomplete models can still be adjusted to generate employment estimates, but a complete model for wood pellets is summarised below to provide an illustration of the data modelling behind each Vensim diagram.

Biomass calculations

Variable	Value	Source
IAPs area	over 10 million hectares 1 736 438 condensed hectares	Stafford, 2017
Biomass	The woody biomass of dense plant invasions varies from 32 to 198 t/ha (dry biomass), and we have estimated the total woody biomass to be 167 million tonnes from the NIAPS conducted in 2010 (Le Maitre and Forsyth, unpublished).	Stafford, 2017
IAPs spreading rate	5–10% per annum	Stafford, 2017
	7.4% and 15.6% (depending upon species)	DEA, 2015b
Working for Water activities clearing	169 086 ha per annum	Stafford, 2017
	Average cost of R9000/ha (condensed or 100% invaded)	
	35-person days to clear one hectare Total cost of R15.3 billion for alien plant clearing.	Stafford, 2017
Cost of controlling IAPs	R600 million a year over 20 years	
IAP suitability for wood pellets	Only a portion of the harvestable woody IAP biomass is available for bioenergy, since some of the biomass will be used for higher-value uses. Applying the suitability ratios for Pinus, Acacia and Eucalyptus IAP biomass for VAI wood products, for Agulhas it was estimated that: • 53% (338 995 tonnes) is available for bioenergy (heat and electricity). • 32% (207850 tonnes) is suitable for wood-fuels (firewood, charcoal, wood pellets, woodchips, torrefied wood-chips and torrefied pellets), engineered wood and wood composites (wood-wool, fibre-board and wood-cement and wood-plastic composites). • 1.5% is available for lumber, large poles (>5cm diameter). • 3% is available for small poles and droppers (droppers=3–5cm diameter and slats=1–3cm	Stafford, 2017

	diameter). • 10% of the woody biomass (twigs) is left in-field after harvesting as residue.			
Water impact - IAPs waste	7% of our water resources			Barnes, Ebright, Gaskin and Strain, 2015
Current IAP clearing rate	6.7% reduction in MAR			Versfeld et al., 1998
	1,444 million m3/annum or 2.9% of the country's MAR			Le Maitre et al. 2013
	Assumed an average of 200000 ha per year are cleared in the short-term 560000 ha in the medium term 1450000 ha in the long-term			Maia et al., 2011
	2.8 million hectares cleared			DEA, 2015b
	1 person can clear 13.8 ha (Dependent on density) The number of jobs required for the 100 000 t/a wood production is 121 (based on 1,667 hectares to be cleared at a rate of 13.8 hectares per person).			DWAF, n.d.
Total available IAP biomass	Total invasive alien plant biomass is estimated to be about 165 million Mg. Spread over about 44 million ha, giving a mean IAP biomass standing stock of about 3.7 Mg/ha with a range from 0-228 Mg per ha.			Le Maitre and Forsyth, 2011
Estimated areas that can be cleared daily per person and per 12-member team	Control method	Extent (m2) cleared by 1 person per day	Extent (m2) cleared by 12-member team per day	eThekwini Municipality, n.d., 59
	Light (mechanical & chemical)	850 – 900	10,800	
	Medium (mechanical & chemical)	550 – 650	7,800	
	Heavy (mechanical & chemical)	250 – 350	4,200	
	Extra heavy (mechanical & chemical)	100 – 150	1,800	
	Special weeds (e.g Pereskia)	As required		
Wood pellets				
Average hours spent cooking per week	9.5 hours			Stats SA, 2017

Jobs (person days) per cleared area

	Average 2005-2010
Person days/Area cleared (Ha)	11.0
Area cleared (Ha)/Person days	0.1
Person days/Area cleared + Follow up (Ha)	2.3
Area cleared + Follow up (Ha)/Person days	0.4

Source: Author's calculations based on DWAF (2017)

Estimated areas that can be cleared daily per person and per 12-member team

Control method	Extent (m2) cleared by 1 person per day	Extent (m2) cleared by 12-member team per day
Light (mechanical & chemical)	850 – 900	10,800
Medium (mechanical & chemical)	550 – 650	7,800
Heavy (mechanical & chemical)	250 – 350	4,200
Extra heavy (mechanical & chemical)	100 – 150	1,800
Special weeds (e.g. Pereskia)	As required	

Source: eThekwini Municipality (n.d., 59)

Household energy use for cooking

Energy for cooking	Number (thousands)
Electricity from mains	12 597
Electricity from generator	394
Gas	560
Paraffin	867
Wood	1 505
Coal	80
Candles	20
Animal dung	14
Solar energy	27
Other	36
None	23
Total	**16 122**

Source: Stats SA (2016)