National Research Foundation | Mineral Law in Africa | minerals to metals | Development Policy Research Unit | CeBER Centre for Bioprocess Engineering Research | Future Water

POLICY BRIEFS:

Developing a Fibre Micro-industry to Generate Economic Growth from Degraded Land Post-Mining

A Towards Resilient Futures Community of Practice Publication

Policy Implications & Recommendations

Mineral Law in Africa (MLiA)

- To foster the entrepreneurial economy envisaged in the National Development Plan, lawmaking must become more pro-active. Pro-active lawmaking – promoting good behaviour through incentives – may enhance buy-in to achieve behavioural changes.
- Proposed amendments to the environmental regulations should be implemented to change mine rehabilitation goals.
- The legislative provisions should not be restricted to efforts at returning the land to its pre-mining state, as the only acceptable outcome.
- The focus of rehabilitation efforts should rather be on a sustainable end-state. Such a focus will alleviate the impact of legislative restrictions regarding biodiversity, and enable bioremediation using fibrous plants.
- The government should create an enabling environment for environmentally and socio-economically sustainable projects on degraded mining land. This can be achieved by greater efforts at inter-governmental relations and co-ordinated legislation.
- Different government departments should also play a more active role in facilitating agreements between the mining right holder, the landowner and the local community.

MINERAL LAW IN AFRICA

Centre for Bioprocess Engineering Research (CeBER)

The available land associated with abandoned, end-of-life mines, and mines planning for end-of-life in South Africa, provides a valuable base resource for the post-mine economy.

- Owing to the need for robust post-mine economies with potential for sustained wealth generation, agriculturally-based renewable raw materials require potential for value addition and development of economic complexity. Fibre crops deliver this opportunity.
- Fibre-rich plants can be supported by the soil types and climatic conditions in SA's mining regions, and offer potential to create multi-product value chains and a diverse manufacturing sector.
- Further, they offer potential for simultaneous land reclamation through phytoextraction of metals with potential value recovery.
- Meaningful selection of fibre-producing plants requires consideration of soil quality, climate, productivity, potential product range, and phytoextraction potential, with inter-related selection criteria.
- Promising fibre plants include the bamboo B.balcooa, flax, hemp, kenaf and sisal.
- The clear interaction between degree of contamination of the lands, plant performance, climate, fibre quality, and metal location in the plant, needs to be assessed by specific case studies.
- With extreme metal contamination, prior reclamation of the lands using hyperaccumulators should precede fibre crop production.

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Minerals to Metals (MtM)

Fibre-rich plants offer the potential to create multi-product value chains and a diverse manufacturing sector. However, the meaningful selection of viable fibre-producing plants, products and processing methods is not trivial, and is influenced by a number of inter-related factors.

Policy to develop a plant fibre-based economy should thus be:

- Underpinned by a holistic and systemic understanding of the inter-related factors influencing overall performance across different stages of the value chain from a multi-criteria (technical, economic, environment and social) perspective;
- Supported by a sustained program of research to drive technology development and implementation, and build the required expertise and skills.

Plant and Process Specific Recommendations

- The research seems to suggest that the choice of fibrous plants and processing of those plants sets you down certain paths.
- Whilst the selection of plants and processes will be highly dependent on the targeted local and/or export markets, policy makers should consider the bast fibre route if wanting a high degree of flexibility on downstream options, subject to further research and development.

minerals to metals

Development Policy Research Unit (DPRU)

Continuity of supply

- Government should support cultivation of fibrous feedstock at sufficient scale to meet demand, through financial support for produce storage facilities. To build downstream industries, a consistent supply of the correct quality is needed. R&D on farming best-practice is required, in the form of how-to manuals for farmers, rural development workshops, etc.

Input costs

- Setting up processing plants in close proximity to cultivation sites can minimise high transport costs (due to low bulk density of fibrous feedstock). Support for a common storage warehouse supplied by farmers – with careful monitoring – can ensure that feedstock storage is done safely.

Capital outlay

- Buying new machinery or equipment for processing fibrous plants is costly. Participation in existing DTI-driven incentive schemes should be encouraged, and if no subsidy exists, one to support fledgling industries should be created.

Certification

- Capacity constraints at certification authorities stifle product innovation. The South African standards authorities' capacity to allow for testing and certification should be improved, thus facilitating product innovation.

DEVELOPMENT POLICY RESEARCH UNIT

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REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

Policy Brief

MLiA Policy Brief: **DSI-NRF CoP/PB1**
October 2019

From Tailings to Tillings:
Designing the Legal Framework for Mine Wasteland Rehabilitation Through Bioremediation

Prof Hanri Mostert (DST/NRF SARChI: Mineral Law in Africa (MLiA), UCT)
Prof Alexander Paterson (Director: Institute for Marine & Environmental Law, UCT)
Dr Louie van Schalkwyk (Postdoctoral fellow: MLiA, UCT)
Ms Aysha Lotter (Researcher: MLiA, UCT)
Ms Reneilwe Kgosana (Researcher: MLiA, UCT)

Summary

This research evaluated how the law impacts on innovations in mine rehabilitation using fibrous plants. The study examines available legal incentives and sanctions relevant to mine rehabilitation, and concludes that more proactive law-making is required.

The basis of this policy brief is a legal analysis that specifically interrogates the status quo – the currently available remedies and incentives, sanctions and penalties afforded and imposed by the law – to establish the extent to which they will facilitate the envisaged mine rehabilitation proposals. The brief scopes the potential legal issues that may arise in initiating a fibre-farming industry on mine wasteland. A brief discussion of the social and economic context within which the legal research was conducted precedes the explanation of the distinction between proactive and reactive lawmaking. The main questions determining applicable legislation are then laid out. The policy brief concludes by advocating for more proactive laws.

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Introduction

As a country and a society, South Africa is driven by mining. It holds the world's fifth-largest mining sector in terms of GDP value. However, it is vulnerable to the "resource curse" – the "phenomenal dichotomy" between natural resource wealth and socio-economic development. Generating sustainable and inclusive economic growth is an imperative for South Africa in dealing with practically every one of its developmental and societal challenges, aptly summarised as the "evil triplets" of unemployment, poverty and inequality.

Very often, the people most harshly affected by the evil triplets are those living on or close to mine sites. They risk losing their main source of wealth creation – land – to the degradation that follows in the wake of a mining project. In the mining heartland of South Africa, the widespread occurrence of metal pollution of soil and water sources is a particular and extensive challenge.

Bioremediation and restorative agriculture are potential areas of interest for rethinking mine rehabilitation and economic development. They offer the chance to repair degraded land by enhancing its environmental and social value and provides economic value through integrated land development. New economic sectors can be enabled to grow, and new product spaces enabled to emerge as a result, while diverse productive opportunities and economic inclusivity are enhanced. The mine's life cycle may end in the rebirth of a resilient future: a future envisioned as one with a sustainable environment, providing security for the surrounding communities, and actively pursuing skills development and job creation.

If the legal framework is prohibitive, even the best-laid plans will have very little practical value.

However, if the legal framework is prohibitive, even the best-laid plans will have very little practical value. An enabling legal framework is needed to implement the various aspects of the suggested venture of cleaning mine wasteland and simultaneously boosting the agricultural and manufacturing sectors of the economy.

One needs to understand the legal framework to evaluate how well the solutions proposed by the economic, agricultural or scientific perspectives are catered for. Where the legal framework bars the adoption of what seem to be particularly useful and innovative solutions, suggestions for law reform must follow.

Proactive and Reactive Lawmaking

The law fulfils several functions in society that may be relevant to attempted creation of economic complexity and diversification. The range of devices available to law is far wider than just what is on the statute book. They range from measures to remedy grievances or impose penal sanctions, through provisions to achieve distribution or to regulate particular behaviours, to private arrangements.

On the one hand, the law can be reactive: this is the backwards-looking, failure-oriented approach through which errors or injustices are addressed to restore the balance in society or to restore the peace. Some authors refer to this as negative sanctioning in the law and this is seen as a major power of the state: the ability – legitimately endorsed (in statute) – to coerce certain types of behaviour. The strength of this approach lies in the penalties that befall those who do not comply with the expected behaviour: fines or criminalisation with/or without imprisonment, loss of property and/or licences, to name but a few.

On the other hand, the law can also operate proactively to address anticipated future problems, needs or changes. Some authors refer to this as positive sanctioning in the law: good behaviour is rewarded by permitting a say in how scarce resources are to be distributed and used. Government power is not expressed through use of force, but by conferring benefits.

Basic Questions Determining the Applicable Legal Framework

Determining which legislation would apply to a specific project will depend on very specific circumstances present in each case. In general, four basic questions must be answered to determine the legal framework applicable to a proposed bioremediation project:

What is being grown?
Legislation regulating invasive species, water use, use of fertilisers, etc. may be relevant, depending on the crop selection. Complex environmental legal processes, permitting requirements and general obligations may be associated with the cultivation of the proposed plant species.

Where is the site located?
Knowledge about where the crops are to be grown is crucial to identify the relevant spatial planning and land use management laws applicable. The location of the site will determine the applicable zoning requirements, land use restrictions and authorisations needed to proceed with the growing or processing of the selected crop. It is also necessary to determine how the proposed agricultural and processing activities fit in with the municipality's integrated development plan and spatial development framework.

Why are the crops grown?
If the crops are grown mainly to rehabilitate degraded mining land, this bioremediation proposal must be included in, and align with, the mining right holder's rehabilitation plan. Conversely, if the crops are grown largely to provide an alternative economic industry and encourage social development, the project must be included in the mining right holder's social and labour plan. The social and labour plan must align with the municipality's integrated development plan and identify local economic development initiatives supported by the mining right holder.

Who are the stakeholders?
The applicable law will also be determined by who the stakeholders are: those participating, such as the fibre-farmers and the landowners, as well as the persons, neighbours and communities affected. In the case of landowners, for instance, it would make a difference whether the land is under a lease agreement or not and whether the landowner is a natural person, juristic person, or an indigenous community. The applicable laws will determine whether consultation with other parties or consent of those parties are required before bioremediation can commence. Another stakeholder is the state – for example, the ministries dealing with mining, agriculture, land and environment, labour, etc.

Key Policy Implications and Recommendations

To foster the entrepreneurial economy envisaged in the National Development Plan, lawmaking must become more proactive. Proactive lawmaking – promoting good behaviour through incentives – may enhance buy-in to achieve behavioural changes.

Proposed amendments to the environmental regulations should be implemented to change mine rehabilitation goals. The legislative provisions should not be restricted to efforts at returning the land to its pre-mining state as the only acceptable outcome. The focus of rehabilitation efforts should rather be on a sustainable end-state. Such a focus will alleviate the impact of legislative restrictions regarding biodiversity and enable bioremediation using fibrous plants.

The government should create an enabling environment for environmentally and socio-economically sustainable projects on degraded mining land. This can be achieved by greater efforts at intergovernmental relations and co-ordinated legislation. Different government departments should also play a more active role in facilitating agreements between the mining right holder, the landowner and the local community.

Conclusion

The assessment underlying this policy brief concluded that the current legal framework for environmental rehabilitation of mine land, the regulation of land use, the contractual basis of relationships and the protection of communities are largely reactive. It is a framework of sticks, rather than carrots. In legislation dealing with mine land rehabilitation, this is probably to be expected. However, our legal system has not previously catered for innovative methods of mine land rehabilitation such as the one being explored by using fibrous plants.

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Policy Brief

CeBER Policy Brief: **DSI-NRF CoP/PB2**
October 2019

Towards Resilient Futures
Can fibre-rich plants grown on degraded mine land fuel a multi-product value chain?

Sue Harrison (Centre for Bioprocess Engineering Research (CeBER), Future Water Research Institute, & Minerals to Metals (MtM), UCT)
Shilpa Rumjeet (CeBER, UCT)
Xhihluke Mabasa (CeBER, UCT)
Bernelle Verster (Future Water, UCT)

Summary

To stimulate economic growth, post-mining economies could target downstream product diversity based on sustainable and renewable agricultural raw materials such as fibre producing plants. However, without an understanding of the plants that are both best suited to providing the valuable raw material for these products and also for cultivation in the regions of interest for economic development, this cannot be attained. To this end, this brief sets out to identify the fibrous plant species best suited for the recovery of value, including an assessment of the potential of the bast fibre hemp and kenaf plants, and the grass fibre, bamboo. We focus on the conceivable application(s) of these plants as raw materials for post-mining economic activity to counter the impact of mine closure, focussing on the opportunities for these selected plants to thrive in mining regions in South Africa. Finally, the impact of metal contamination on plant production is addressed. This was done through a comprehensive review of the published literature and interviews with relevant experts in South Africa. Based on this research, policy recommendations are then put forward to support the development of a fibre-based micro-industry.

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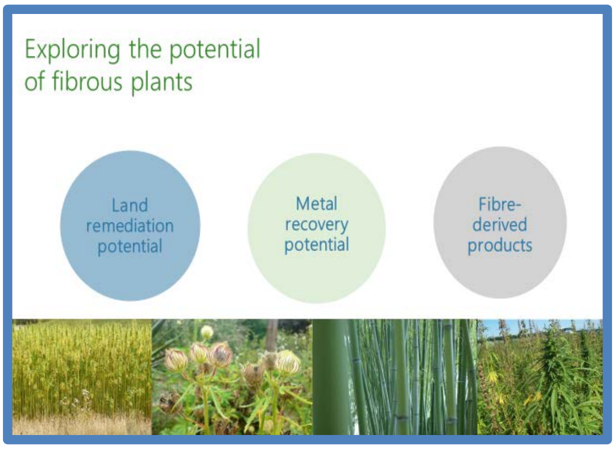
Introduction

The drive to produce bio-based, renewable materials and products requires a sustained source of plant-derived materials. One class of feedstock with potential to yield a diverse grouping of products is fibre crops. These are used in products ranging from wood-like products through to biocomposites and functional materials. Non-fibre components of the plant can be converted into sugars for production of platform chemicals or bioenergy. Further specialty products present in the plant can be extracted. This diverse range of potential products and uses forms the backbone of the concept of using crop fibre production as the raw material for a variety of processing approaches to manufacture a diverse product range as a route to a post-mine economy that is sustainable and has potential to provide economic complexity for both robustness and enhanced quality of life.

On introducing fibre crops as the replacement renewable feedstock for the new fibre economy, awareness of the need to remediate or reclaim the degraded mine land is essential. Further recovery of metals forms a secondary income source for the post-mine community. To achieve this, the role of the fibre crops in phytoextraction needs to be ascertained, along with their growth in (and tolerance of) poor quality soil.

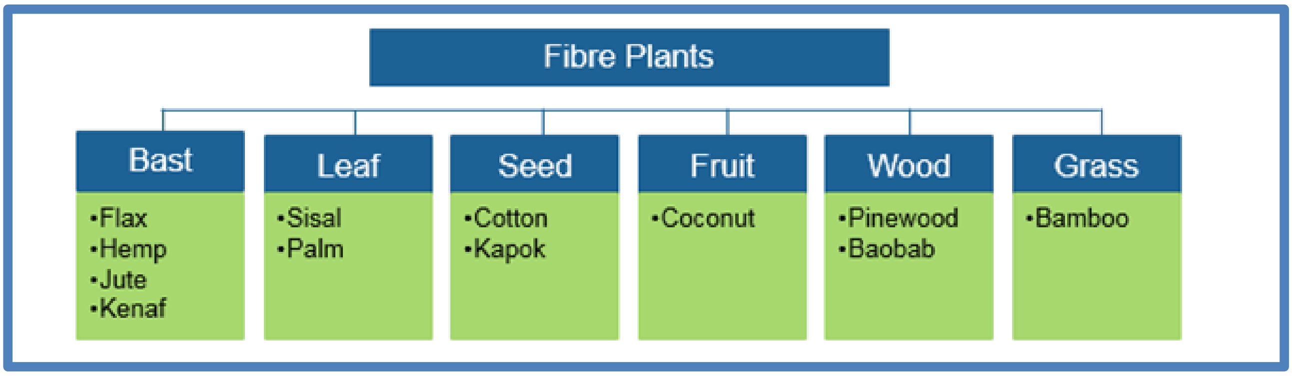


This policy brief considers the potential for production of fibre-based plant crops on degraded mine land. This fibre resource will serve as a renewable raw material and feedstock on which to develop the fibre-based economy as an example of delivering post-mining economic complexity. We identify suitable fibre crops for the environments of the mining regions of interest. We explore the ability to combine remediation and reclamation of this degraded land as an alternative to a two-stage development of remediation and reclamation, followed by agriculture.

Fibre Crops and Their Properties

The fibre crops are classified on the location of their fibres into bast or stem fibres, seed fibres, stalk fibres, grass or reed fibres and wood fibres. These plants produce fibres suited for differing product applications. The fibres are renewable, cheap and biodegradable, fulfilling the requirements for renewable, bio-based raw materials. Common fibre plants are shown in Figure 1.

Figure 1: Classifying Fibre Plants Grown in South Africa

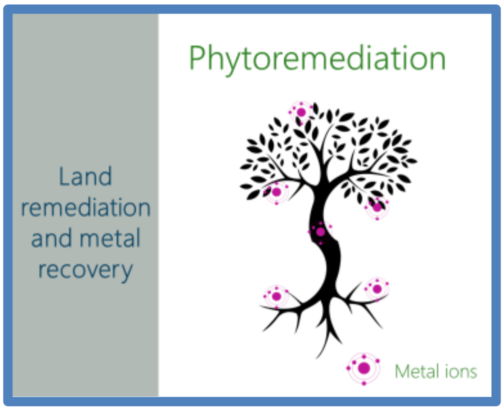


Fibre plants show potential for manufacture into a broad range of products. Products are formed from the fibres themselves. These vary, depending on fibre characteristics (particularly the length of fibre). Products include paper products, textiles, cordage, biocomposites, nanofibers and regenerated cellulose, to name a few. Further products are formed from the woody tissue, leaves and stalks, and other biomass fractions. These include chemical products, composite products and energy products, as shown in Figure 2.

Figure 2: Processing the Fibre Crop into Products Yields a Diverse Product Range

Fibre Crops for Phytoremediation and Phytoextraction

Phytoremediation describes the use of plants to remove metals and other contaminants from the soil, whereas phytomining describes the active concentration of a specific metal into a specific region of the plant e.g. seed or shoot. Both processes can proceed by phytoextraction.



Fibre crops have potential for phytoextraction. For example, bamboo concentrates lead and zinc into shoots and roots at a concentration of 36 mg/kg and 43 mg/kg biomass respectively. Kenaf concentrates nickel and cadmium at a concentration of some 150 mg/kg leaves and copper at 1500 mg/kg leaves, while sisal concentrates cadmium and copper into leaves at some 1500 mg/kg. This metal can be recovered during processing. Where the metals are accumulated into different zones of the plant to the fibre zone, concomitant production of fibre and recovery of metal can be achieved.

Where metal loadings in the soil are very high or rapid remediation of the soil is required, hyperaccumulators may be grown in early years. These plants accumulate specific metals preferably and achieve much higher internal concentrations. For example, the hyperaccumulator *Berkheya coddii* accumulates nickel to levels 100- to 1000-fold that of hemp – however, its biomass is less valuable.

Selecting Fibre Plants for the Post-Mine Economy in South Africa

To select fibre plants for the post-mine economy, the first hurdle is to match the plant requirements (of which a sub-selection are specified in Figure 3) with the growing conditions in the mining regions, while addressing all criteria listed in the pull-out box.

Criteria for plant selection for example sites:
- Non-invasive and/or indigenous
- Preferred soil type
- Temperature tolerance
- pH tolerance
- Multi-product possibility

The climatic and soil conditions in the mining regions of Gauteng, Mpumalanga and Limpopo include soil pHs in the range pH 5.5 to pH 7.2, average rainfalls between 300-500 mm and 600-800 mm with summer rain, and average minimum and maximum temperatures ranging from 5-30 °C to 10-30 °C. The soils are shallow rocky, sandy-clay loams, and loamy topsoil on rocks. Metal contamination is significant and varied. The plants of interest as fibre crops for the South African post-mine fibre economy are: bamboo (*Bambusa balcooa*), flax, hemp, kenaf and sisal.

Figure 3: Plant Growth Requirements and Characteristics of Lead Fibre Crops in South Africa

	Bambusa balcooa	Flax	Hemp	Kenaf	Sisal
Rainfall	400 – 5400 mm	450 – 750 mm	500 – 700 mm	240 – 490 mm	500 – 1500 mm
Temperature	9 – 35 ° C	5 - 30 ° C	6 - 32 ° C	10 - 35° C	10 – 32 ° C
Fibre yield	12 – 18 tons/ha	~ 2 tons/ha	2.2 – 8 tons/ha	5 – 7 tons/ha	1 – 4 tons/ha
Time	5 – 6 years	80 - 100 days	90 -170 days	100 – 240 days	2 – 4 years
M	Pb, Zn, Cr, Fe	Pb, Zn, Cd	Cd, Zn, Fe, Cu, Ni, Pb	Cd, Zn, As, Fe, Pb, Cr	Zn, Cd, Cu

Key Policy Implications and Recommendations

The available mine land associated with abandoned and end-of-life mines as well as mines planning for end-of-life in South Africa provides a valuable base resource for the post-mine economy. Owing to the need for robust post-mine economies with potential for sustained wealth generation, agriculturally-based renewable raw materials require potential for value addition and development of economic complexity. Fibre crops deliver this opportunity.

Fibre-rich plants can be supported by the soil types and climatic conditions in South Africa's mining regions, and offer the potential to create multi-product value chains and a diverse manufacturing sector. Further, they offer potential for simultaneous land reclamation through phytoextraction of metals with potential value recovery.

Meaningful selection of fibre-producing plants requires consideration of soil quality, climate, productivity, potential product range, and phytoextraction potential, with inter-related selection criteria. Promising fibre plants include the bamboo *Bambusa balcooa*, flax, hemp, kenaf and sisal.

The clear interaction between the degree of contamination of the lands, plant performance, climate, fibre quality and metal location in the plant needs to be assessed by specific case studies. With extreme metal contamination, prior reclamation of the lands using hyperaccumulators should precede fibre crop production.

Conclusion

Robust post-mining economies require both reclamation of the mining region to achieve a functioning and stable ecosystem, and the generation of a new economy to sustain livelihood and augment quality of life. The establishment of a fibre-based economy in which fibre crops are cultivated on degraded mine land to produce a sustained, bio-based feedstock for a diverse product range from subsequent processing and manufacture shows potential. Fibre crop cultivation can achieve four goals, potentially simultaneously: land remediation, metal recovery and sustained production of a bio-based feedstock, while also providing livelihoods.

A review of the climatic and soil environment in three mining areas selected based on the presence of mines which have been abandoned and where closures are planned has highlighted the potential for fibre crop plants such as the bamboo *Bambusa balcooa*, hemp, flax, kenaf and sisal. The final selection must be mapped to a specific site, owing to changing conditions. While these plants have phytoextraction potential, it is necessary to establish whether initial phytomining with a hyperaccumulator will be needed for rapid extraction. Similarly, the final selection depends on the product range selected. Based on the potential shown through the desktop study, it is now necessary to explore particular sites and proceed to field trials.

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Policy Brief

MtM Policy Brief: **DSI-NRF CoP/PB3**
October 2019

Multi-Product Potential of Fibre-Rich Plants

Hemp, Kenaf & Bamboo

Jennifer Broadhurst (Minerals to Metals (MtM), UCT)
Tapiwa Chimbganda (MtM, UCT)
Gregory Hangone (Chemical Engineering, CPUT)

Summary

Fibre producing plants have the potential to create multiple products, thus creating jobs and stimulating growth in economically depressed regions. However, without an understanding of the processes by which these plants can or cannot be converted into various other products or uses, this potential will not be effectively exploited. To this end, this brief sets out to identify the downstream options for the recovery of value from hemp, kenaf (both bast fibre plants) and bamboo (a grass fibre plant). This was done through a comprehensive review of the published literature, as well as interviews with relevant experts within South Africa. Based on these insights, multi-product value chains and processing flowsheets have been established and policy recommendations made to support the development of a fibre-based micro-industry.

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Introduction

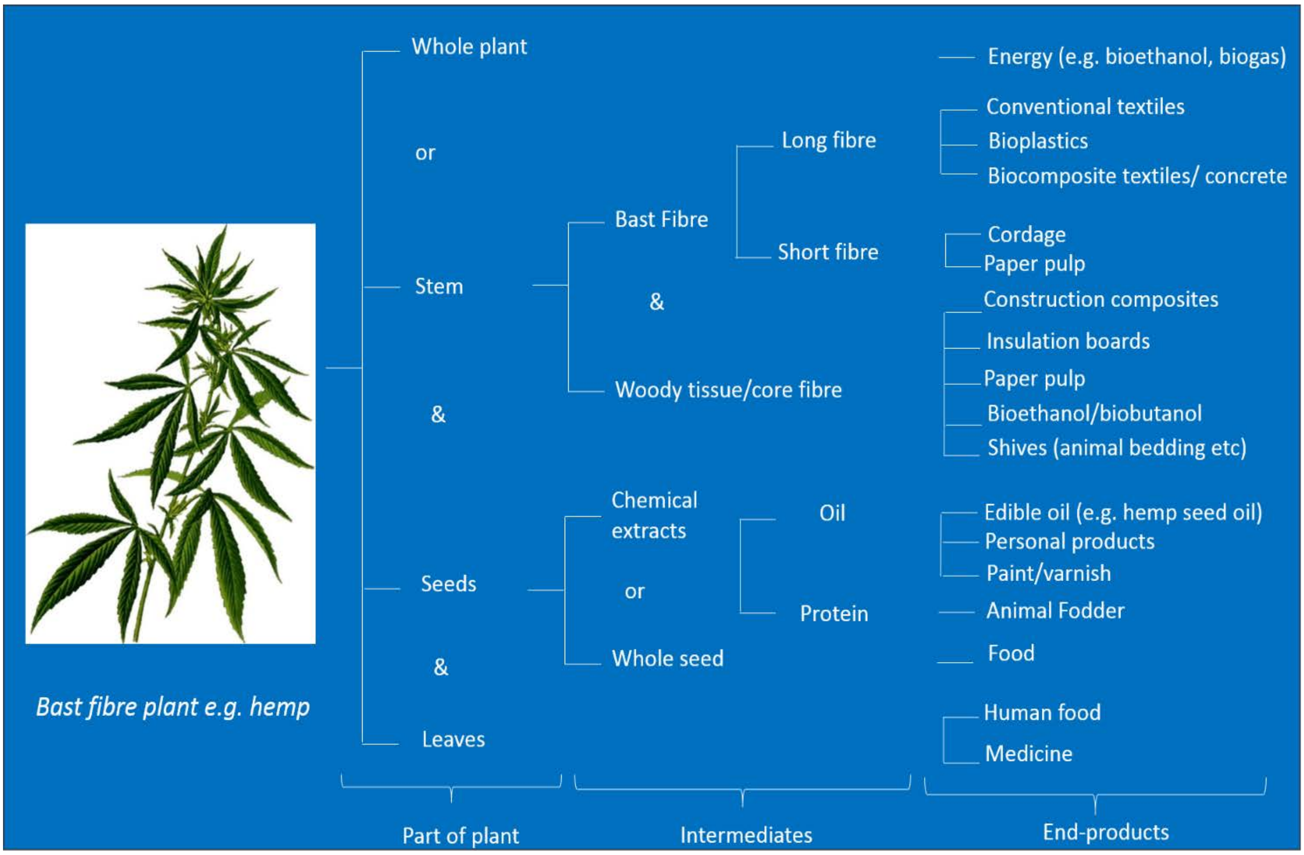
The use of fibre-based plants dates back to the Bronze Age, with plants such as hemp and, in particular, bamboo remaining an important natural resource for traditional applications such as construction and decoration, and even textile and paper production, in many parts of Asia. Over the past 10-15 years, scientific and technological advances have led to the development of more durable products, as well as new high-end applications such as polymer and advanced wood composites. These developments coupled with an enhanced awareness of the need for the development of "greener" materials has resulted in a wide spectrum of niche bamboo, hemp, and even kenaf products in global markets.

This brief provides an overview of the processes and uses of biomass from fibre-based plants, specifically the bast fibres: hemp and kenaf, and the grass fibre, bamboo.

Products and Processes: Bast Fibre Plants

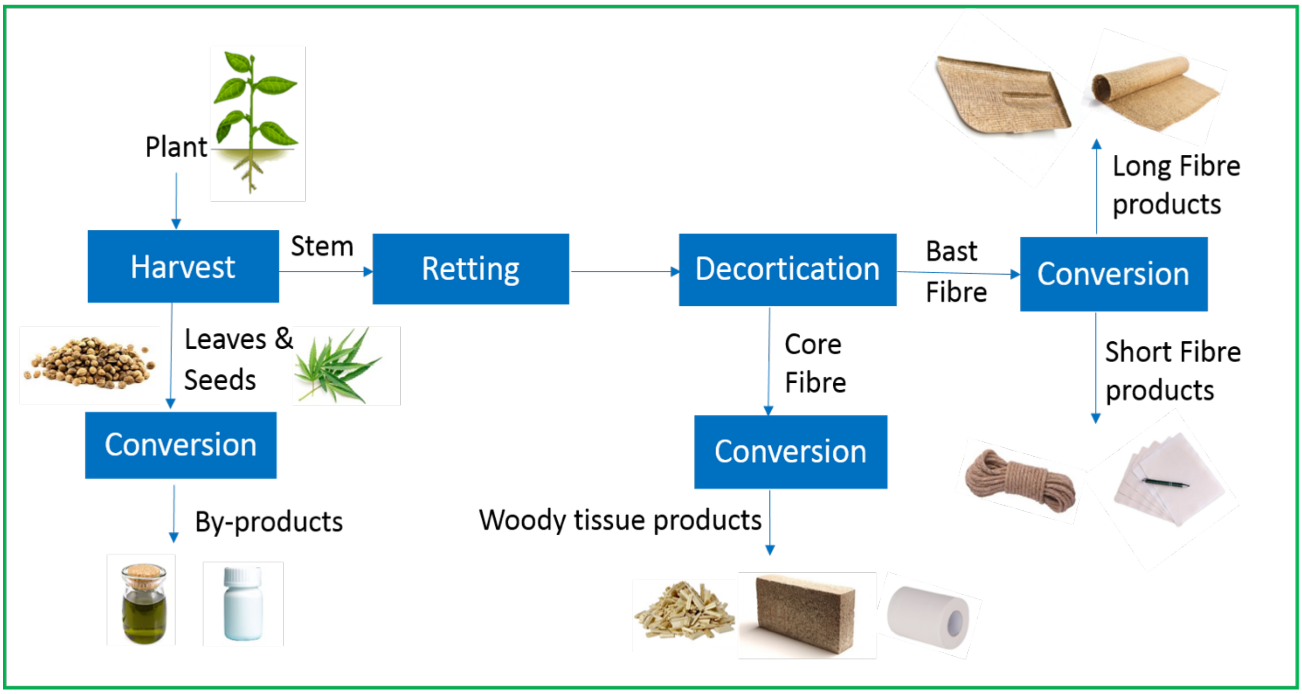
Both hemp and kenaf are dicotyledons, which means that their stems or stalks have an outer bast or fibre and an inner woody core, also known as 'hurd' and sometimes referred to as the core fibre. Although the whole plant can be used for bio-energy production as well as animal fodder in the case of kenaf, processing to separate the bast fibre from the woody tissue and other parts of the bast plant results in multiple products of different levels of complexity (Figure 1).

Figure 1: Multi-Product Value Chains From Bast Fibre Plants



In the case of bast fibres, a single plant can be processed (Figure 2) to simultaneously generate long bast fibres (for the manufacture of high-end materials such as textiles and polymer composites), short bast fibres (for the production of medium-value materials such as paper or cordage), woody tissue or core fibres (for the production of lower-end or bulk materials such as hempcrete, insulation boards, animal bedding and paper), as well as seed oil.

Figure 2: The Main Stages of Bast Fibre Separation and Processing

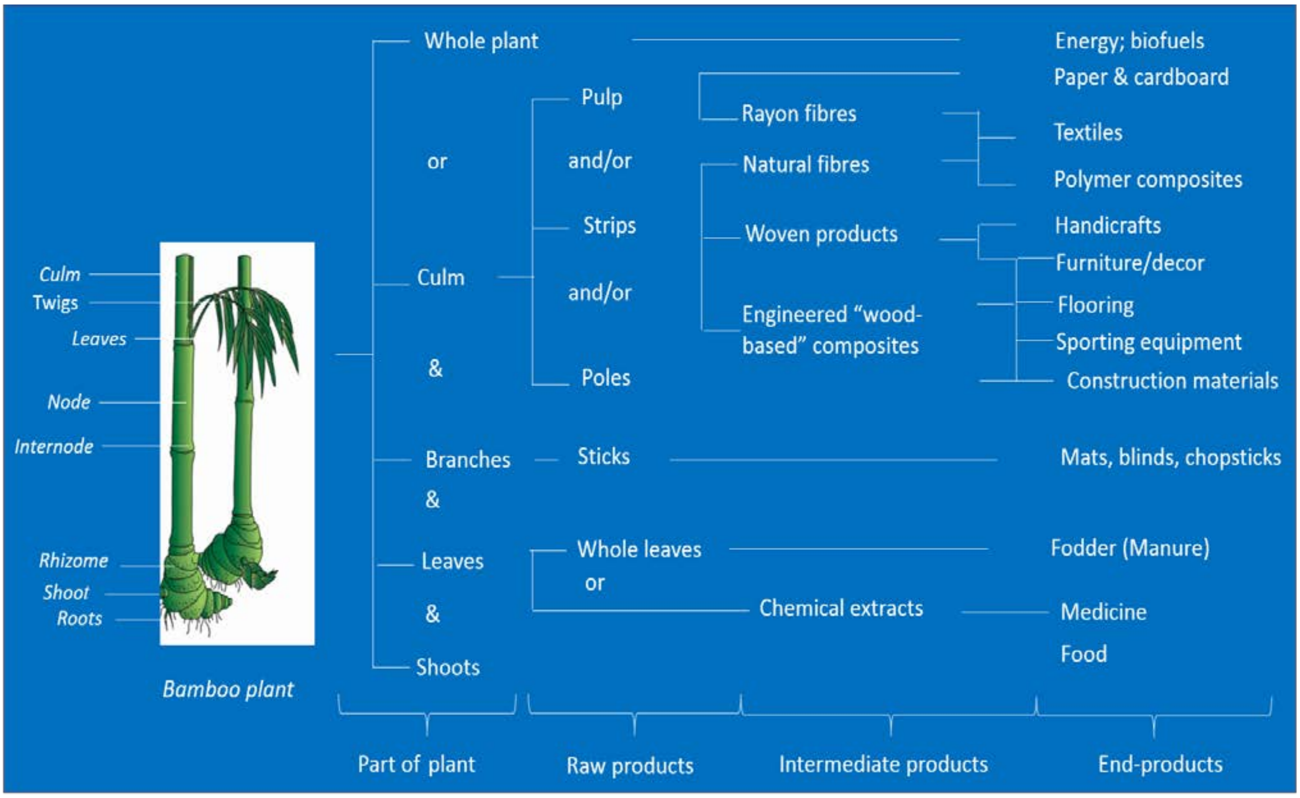


The relative extents to which these different product-types (long bast fibre, short bast fibre, woody tissue or seed oil) are generated and their suitability for final use will, however, be dependent on the methods used to process this biomass, with different processing methods affecting fibre length, colour, quality and strength.

Products and Processes: Bamboo

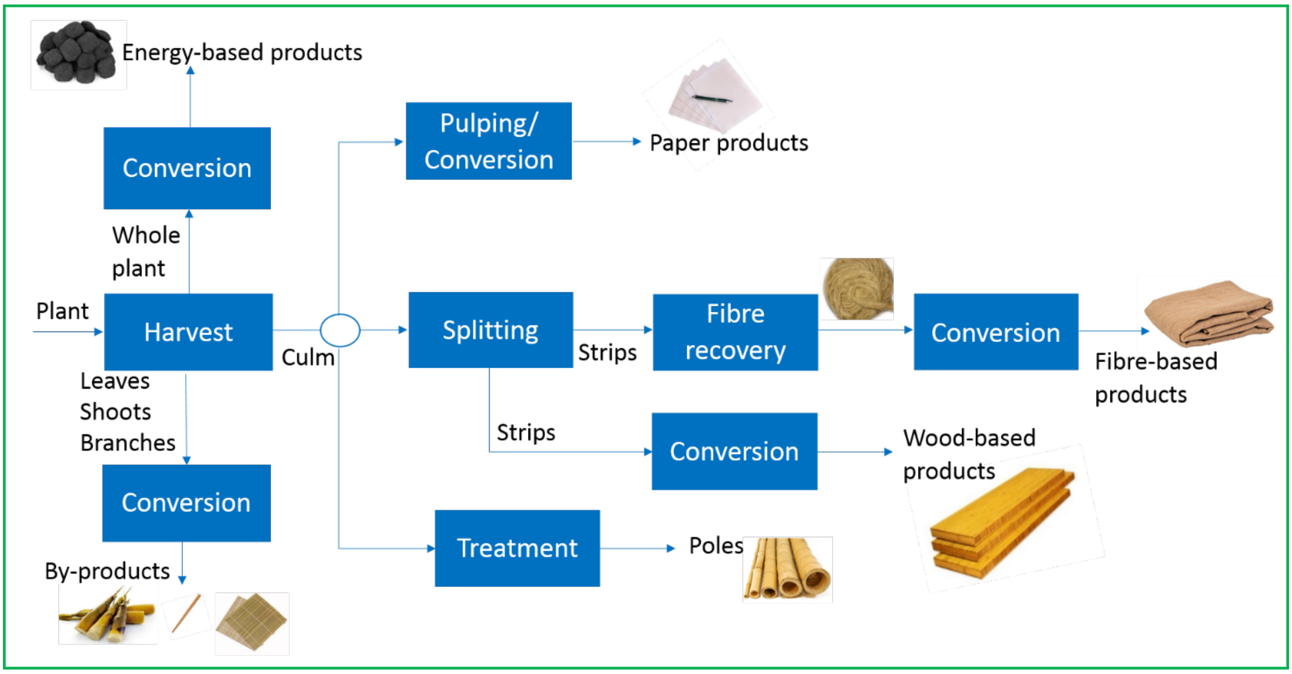
In the case of bamboo, products are mainly generated from the stem or culm, and can be grouped as fibre-based products (including natural and "rayon" or regenerated cellulose fibre products for textiles and polymer composites), wood-based products (including natural wood and engineered wood composite products for construction, furnishings and sporting equipment) and bulk processing products, such as energy and paper (Figure 3).

Figure 3: Bamboo Multi-Product Value Chains



Multi-product opportunities arise through the generation of different products from different parts of the culm, with the higher-quality parts of the stem being used for higher-end products, such as fibre-based products and higher-value wood composites, and by repurposing processing wastes and off-cuts for the manufacture of lower-end and bulk processing products (Figure 4).

Figure 4: The Main Bamboo Processing Stages for Different Product Groupings



As in the case of the bast fibre plants, the methods used for bamboo processing will be highly dependent on the targeted products and associated specifications. Bamboo requires more intensive processing than bast fibre plants for the production of similar products, with the processing of higher-end products being more extensive than that of lower-end products.

Key Policy Implications and Recommendations

General Policy Recommendations
Fibre-rich plants offer the potential to create multi-product value chains and a diverse manufacturing sector. However, the meaningful selection of viable fibre-producing plants, products and processing methods is not trivial, and is influenced by a number of inter-related factors.

Policy to develop a plant fibre-based economy should thus be:

- Underpinned by a holistic and systemic understanding of the inter-related factors influencing overall performance across different stages of the value chain from a multi-criteria (technical, economic, environment and social) perspective;
- Supported by a sustained program of research to drive technology development and implementation, and to build the required expertise and skills.

Plant- and Process-Specific Recommendations
The research seems to suggest that the choice of fibrous plants and processing of those plants sets you down certain paths. Whilst the selection of plants and processes will be highly dependent on the targeted local and/or export markets, policy makers should consider the bast fibre route if wanting a high degree of flexibility on downstream options, subject to further research and development.

Conclusion

Biomass from fibre-producing plants such as bamboo, kenaf and hemp can be converted into various semi-fabricated and higher-value end products. Whilst all fibre plants are capable of generating multiple products from different parts of the plant, the range of possible products and the targeted markets will vary according to the different class of plant. The selection of the plant and the technologies and techniques used to process these plants will depend on the desired products and by-products (and combinations thereof). The bast fibre option appears to be the best of the downstream options for the production of “green” textiles and high-end niche products such as fibre-reinforced composites for the aeronautical and automotive industries, offering more flexibility in terms of processing and product options than bamboo. Although classified as a grass fibre, bamboo is more suitable as a replacement for conventional timber in the production of functional products such as wooden flooring and construction materials and paper.

The effective exploitation of fibre-based plants will also require a comprehensive understanding of the relationship between the properties of the fibre biomass, the required processing methods and the quality of the intermediate and final products. Furthermore, product selection should take into account socio-economic as well as local environmental considerations. To date, however, there appear to be few holistic or systemic studies to facilitate selection of products and processing of biomass from fibre-rich plants. Further studies will also be required to investigate the effect of possible contaminates on the quality of products or the compositions of processing emissions, in the event that fibre plants are cultivated on contaminated land.

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Policy Brief

DPRU Policy Brief: **DSI-NRF CoP/4**
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Developing Capabilities to Build the Complexity of the Fibrous Plant Economy in South Africa

Robert Hill (Development Policy Research Unit (DPRU), UCT)
François Steenkamp (DPRU, UCT)

Summary

With over 6000 abandoned mines and the associated economic vacuum in these mining localities, South Africa has a post-mine economic development problem. Mining land remediation can act as an industrial catalyst through the cultivation of fibrous plants on this land and the processing of these plants to manufacture a diversity of fibrous plant products.

Using the tools of economic complexity and product space network analytics, we identify a set of fibrous plant products that will, firstly, build economic complexity in South Africa and, secondly, be feasible given the country's current productive capabilities. Further, we identify constraints/capabilities that hinder/enable the development of these fibrous plant products, and hence inform micro-industrial policy interventions.

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Introduction

South Africa has seen more than 6000 mines abandoned over the past two decades, and more are set to close in the near future. The operation of a mine provides economic benefit to local economies and thus, without some sort of intervention, mine closure can have debilitating effects on these economies. One form of intervention, which serves the dual purpose of remediating degraded mine land and sustaining these local economies, is the cultivation of fibrous plants as feedstock for downstream industries. In order to determine which downstream industries should be targeted, we employ economic complexity and product space network analytics to develop micro-industrial policy that will drive inclusive economic growth.

This policy brief aims to provide context on South Africa's current fibrous plant economy, as well as the available avenues for diversification which exist to both support local communities post-mining, as well as develop South Africa's economy as a whole. It will conclude with selected policy insights for realising these diversification paths, which are informed by engagement with current industry and firm stakeholders.

What Is Economic Complexity?

The theory of economic complexity explains economic development by focussing on product-level, rather than aggregate, analysis. It suggests that by analysing a country's current productive structure, one is able to determine a country's current productive capabilities, as well as feasible future development paths. The notion of economic complexity hinges crucially on the interplay between two important questions:

1. **How many different products does a country produce?**
2. **How many countries produce a particular product?**

The interplay between these questions provides insight into the overall level of economic complexity of a country, which is summarised by the Economic Complexity Index (ECI). More complex countries will be those that produce a greater diversity of specialised products – i.e. where these products are not produced by many other countries. Countries with low complexity will be those that produce a few relatively common products. Analogously, products that are highly complex are those that require specialised productive capabilities only available to a small number of countries, while less complex products are those that are produced using relatively unadvanced and commonly accessible technologies.

Why Is Economic Complexity Important?

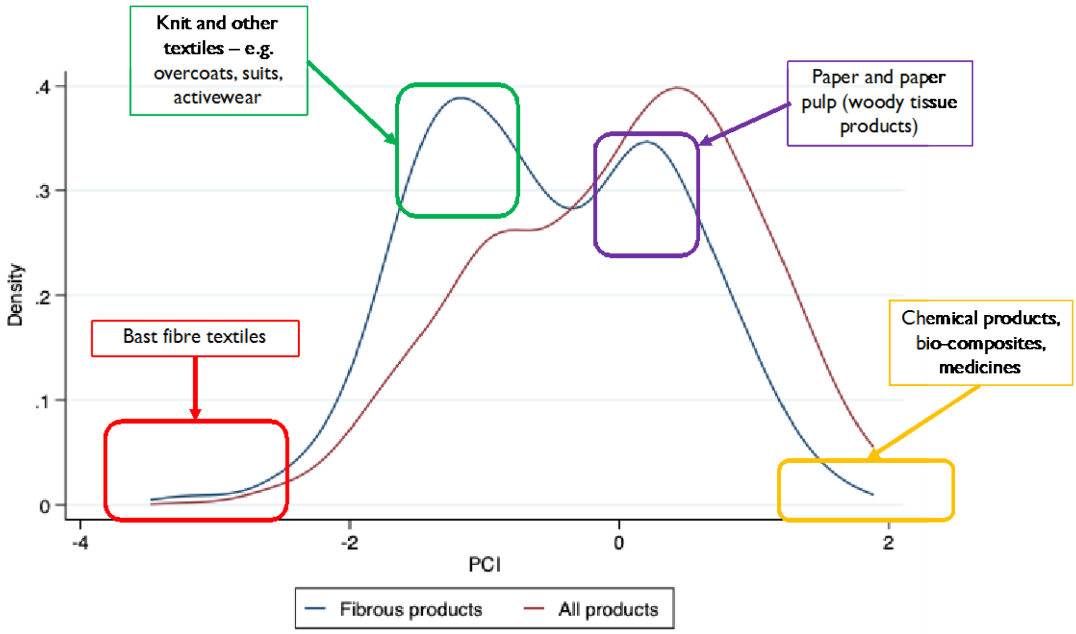
There is a strong positive relationship between economic complexity and economic development: if a country can increase economic complexity, it will very likely lead to increased economic development. The process of increasing economic complexity relies on carefully choosing industries to target with product-level policy interventions. However, which industries to choose in this targeting exercise falls foul of the chicken-and-egg problem: how can you encourage an industry to invest in new production processes for a product that does not necessarily have an established market in the country? At the same time though, how do you establish a market without a manufacturer of the product?

In order to overcome these hurdles while still growing economic complexity, targeted products should be more complex than the country's current product mix, while utilising as many of the existing productive capabilities as possible. For example, a country producing T-shirts may opt to increase complexity by diversifying into blouses before they choose to diversify into jet engines.

Fibrous Products and Economic Complexity

Before identifying which fibrous products South Africa should target to grow economic complexity, it is important to identify and understand fibrous products through a complexity lens. Figure 1 summarises the distribution of fibrous product complexity relative to the complexity of all products. Fibrous products show a bimodal distribution, with low-complexity products such as bast fibre textiles and woven textiles populating the lower end of the spectrum, while high-complexity products such as biocomposites, chemical products and pulp occupy the top end of the distribution. In the case of South Africa, which has an ECI of approximately 0.16, it is clear that the focus should be on identifying products in the latter categorisation for expansion possibilities.

Figure 1: Complexity of Fibrous and Non-Fibrous Products, 2016



Source: Authors' calculations from CID (2019)

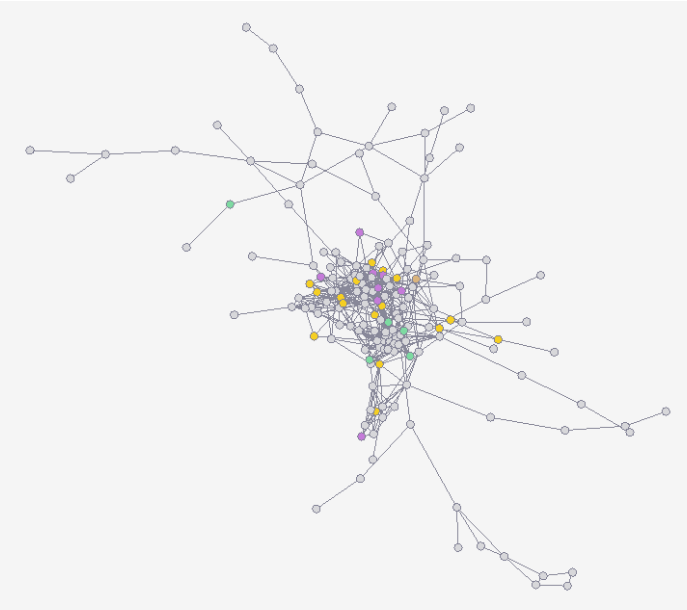
The Fibrous Product Space

The fibrous product space is a network that provides a visual representation of the relationships and synergies between various fibrous products. More related products are clustered more closely together. Figure 2 shows South Africa's fibrous product space, where coloured nodes show the products which South Africa currently produces competitively. Given that these nodes are located in the densely-populated area of the product space, it indicates that South Africa is already well-positioned to diversify its fibrous plant economy. Coupled with the fact that South Africa currently exhibits a fibrous complexity gap, indicating that there may be capabilities available in the economy to develop the fibrous economy, this shows that the establishment of a fibrous post-mining economy is a realistic development goal.

Selected fibrous products, South Africa:

- Seed oils and margarines
- Wood charcoal
- Polishes, soaps and creams
- Paper and paper notebooks
- Footwear and hat shapes

Figure 2: South Africa's Fibrous Product Space



Note: Product groupings or clusters are represented by the following colours: Textiles & Furniture (light green); Vegetables, Foodstuffs & Wood (yellow); Stone & Glass (light brown); Chemicals & Plastics (light purple)

Fibrous Frontier Products

Products which provide diversification opportunities consistent with encouraging economic development are termed frontier products. By determining these frontier products for South Africa and cross-referencing them with the list of fibrous plant products, we identified a list of 50 fibrous frontier products that present potential avenues for diversification. These fibrous frontier products included, among others, paper and pulp products; bioethanol; nonwoven and technical use textiles; and motor vehicle parts. Through the use of semi-structured firm and industry expert interviews, we then narrowed down which products were most viable in the South African context, as well as what policy interventions would be required in order to realise these downstream fibrous diversification

Frontier product characteristics:

1. Not currently exported competitively
2. More complex than current product mix
3. Similar enough to current productive structure to make move feasible
4. Provide future opportunities for diversification into more complex products

opportunities. A summary of the policy issues and their relative priority in each industry is presented in Table 1.

Key points to note are the relatively high barriers to entering the bioethanol and paper and pulp industries, while motor vehicle parts and bamboo flooring seem to offer relatively little in the way of policy-related obstacles. These two industries, being easily accessible, provide South Africa with a two-pronged approach to growing economic complexity through fibrous products: firstly, a more immediate low-complexity approach through bamboo flooring products, and secondly, a more long-term high-complexity approach through nonwoven textiles and biocomposite-based motor vehicle parts.

It should also be noted that there are links between certain of the fibrous frontier products, which may speak to an integrated value chain approach to developing the South African fibrous economy. Nonwoven textiles act as an intermediate input into motor vehicle parts, and as such present an opportunity to boost economic complexity along an entire product value chain.

Table 1: Policy Intervention Priority Rankings for Fibrous Frontier Product Communities

	Bioethanol	Paper & pulp products	Textiles		Wood products		Motor vehicle parts
			Non-woven	Technical use	Fibre & particle boards	Carpentry (flooring)	
Input costs (e.g. transport, safety, storage, water)	Red	Red	Red	Red	Red	Red	Red
Continuity of supply & scale	Red	Red	Red	Red	Red	Red	Red
High capital outlay	Red	Red	Orange	Orange	Red	Yellow	Green
Transferability of machinery	Red	Orange	Green	Orange	Green	Green	Green
Skills constraints	Green	Red	Orange	Green	Green	Green	Yellow
Water permits & scarcity	Red	Red	Green	Green	Green	Green	Green
Research & Development	Green	Green	Orange	Orange	Green	Green	Yellow
Macroeconomic constraints (e.g. exchange rate, demand)	Orange	Green	Green	Green	Orange	Yellow	Green
Fibre not suited to the application	Green	Orange	Green	Orange	Green	Green	Green
Certification	Green	Green	Red	Green	Green	Green	Green
Policy constraints	Red	Green	Green	Green	Green	Green	Green

Key: Red – High Priority; Orange – Medium Priority; Yellow – Low Priority; Green – No Intervention Needed.

Selected Constraints and Related Policy Suggestions

Continuity of supply

Problem: In order to build downstream industries, one needs a consistent and reliable supply of fibrous feedstock of the correct quality. Due to the seasonal nature of fibrous plants, this requires the establishment of upstream supply at scales sufficient to meet downstream demand.

Policy suggestions:

- Government support for cultivation of fibrous feedstock at sufficient scale through financial support to produce storage facilities.
- R&D on farming best-practice in the form of how-to manuals for farmers, rural development workshops to teach farming skills, etc.

Input costs

Problem: Transport, storage and safety all increase input costs due to fibrous feedstock being low in bulk density and dried feedstock posing a fire hazard when stored in large quantities.

Policy suggestions:

- Set up processing plants in close proximity to cultivation sites to decrease transport costs.
- Provide support for a common storage warehouse supplied by farming cooperatives. Make sure this is carefully monitored to ensure that storage of this feedstock is done safely.

Capital outlay

Problem: Buying of new machinery or equipment for processing fibrous plants is costly for the majority of identified industries.

Policy suggestions:

- Encourage participation in existing DTI-driven incentive schemes (e.g. CTCP for textile firms which subsidises upgrading of machinery). If no subsidy exists, consider creating one to support fledgling industries.

Certification

Problem: Capacity constraints at certification authorities stifle product innovation and hamper economic development.

Policy suggestions:

- Improve capacity of the South African standards authorities so as to allow for testing and certification, and thus facilitate product innovation.

Conclusion

Abandonment of mines has created an economic vacuum in parts of South Africa which poses significant socio-economic problems in these mining localities. This policy brief has outlined a method through which the cultivation and processing of fibrous plants can both rehabilitate degraded mine land, as well as develop strong downstream fibrous industries. South Africa is currently experiencing a fibrous complexity gap, which indicates that there may be capabilities available in the economy to develop downstream fibrous industries.

The various fibrous frontier products that were identified as potential diversification opportunities to develop the fibrous plant economy and build economic complexity were interrogated more carefully to determine whether they were economically feasible. The results of this investigation provided a two-pronged approach to growing the fibrous economy: a low-complexity approach through bamboo flooring, and a high-complexity approach through nonwoven textiles and bio-composite panels for motor vehicles. Certain challenges exist in initiating these industries, such as continuity of supply and high input costs. However, these can be overcome with effective and well-targeted micro-industrial policy.

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