POLICY Brief

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Multi-Product Potential of Fibre-Rich Plants

Hemp, Kenaf & Bamboo

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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

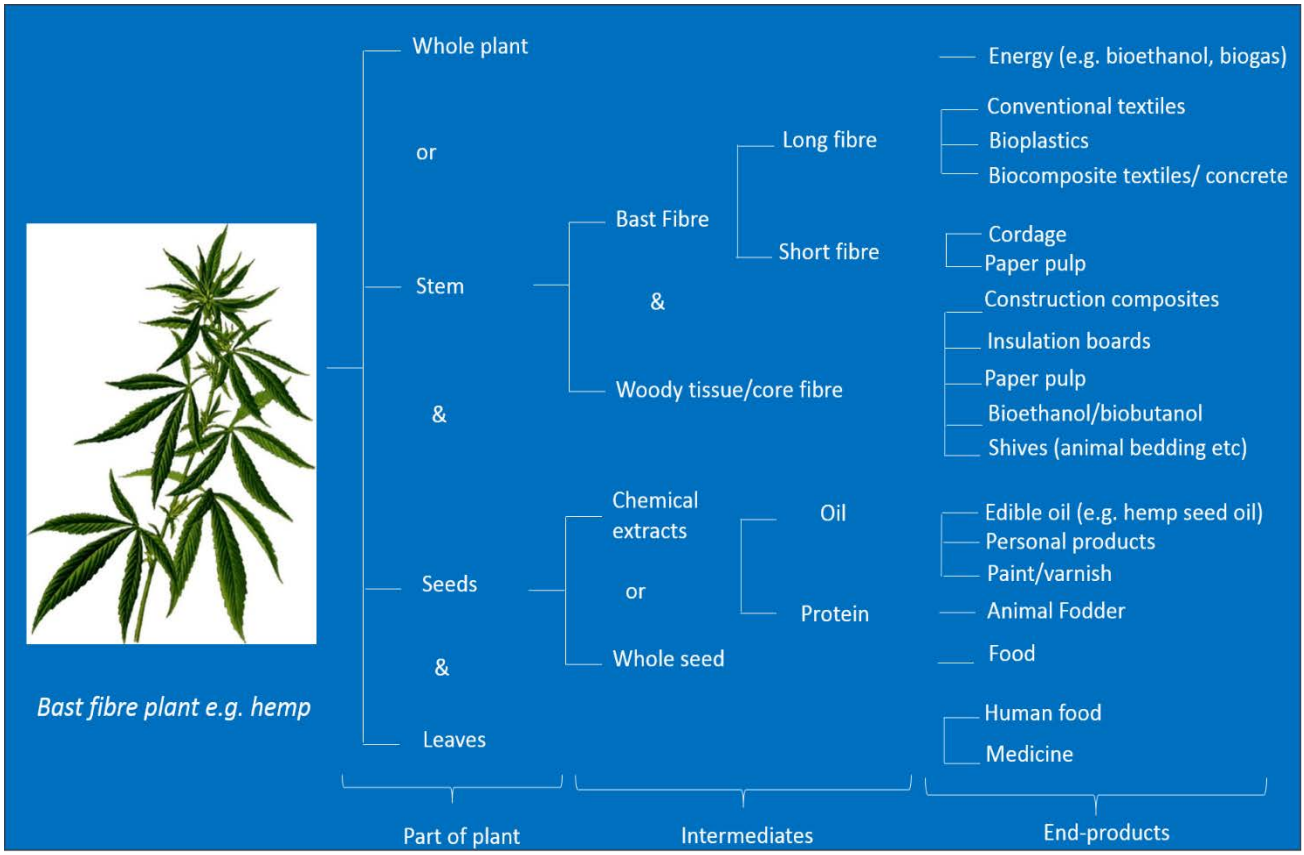
The use of fibre-based plants dates back to the Bronze Age, with plants such as hemp and, in particular, bamboo remaining an important natural resource for traditional applications such as construction and decoration, and even textile and paper production, in many parts of Asia. Over the past 10-15 years, 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

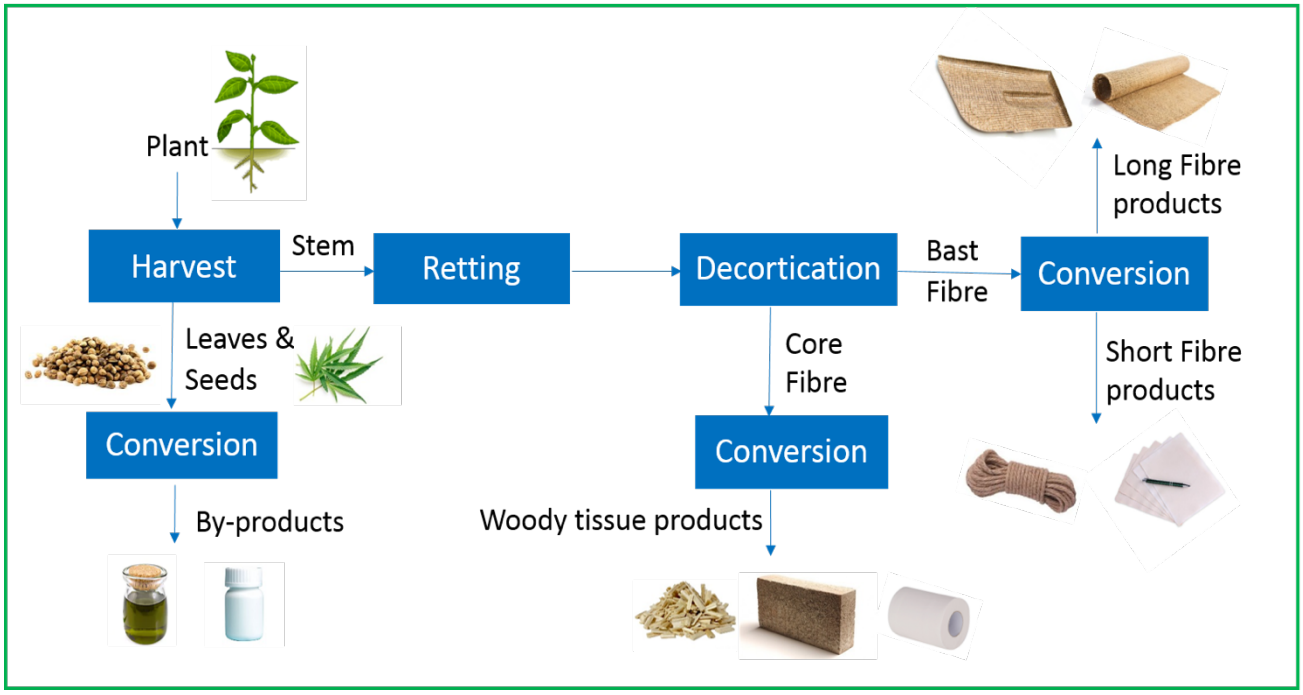
Both hemp and kenaf are dicotyledons, which means that their stems or stalks have an outer bast or fibre and an inner woody core, also known as 'hurd' and sometimes referred to as the core fibre. Although the whole plant can be used for bio-energy production as well as animal fodder in the case of kenaf, 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

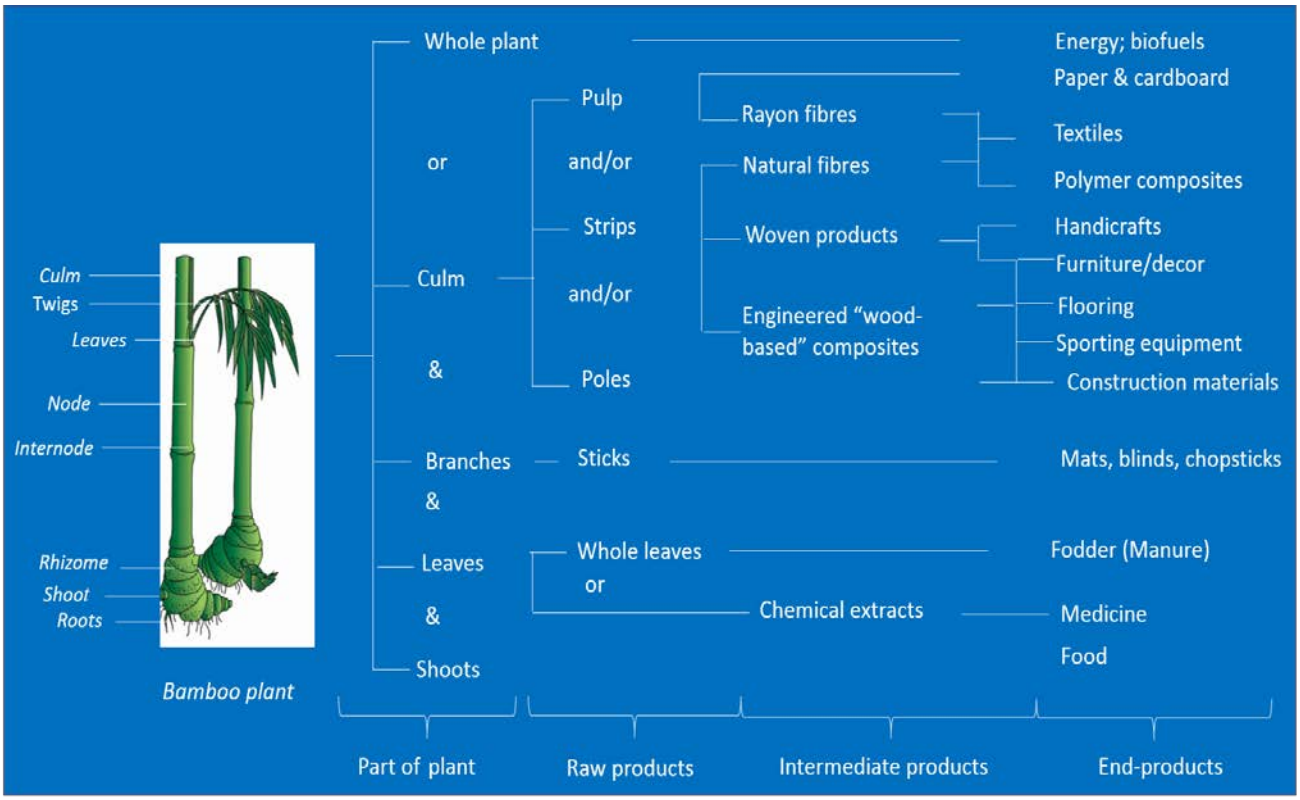


The relative extents to which these different product-types (long bast fibre, short bast fibre, woody tissue or seed oil) are generated and their suitability for final use will, however, be dependent on the methods used to process this biomass, with different processing methods affecting fibre length,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

Products and Processes: Bamboo

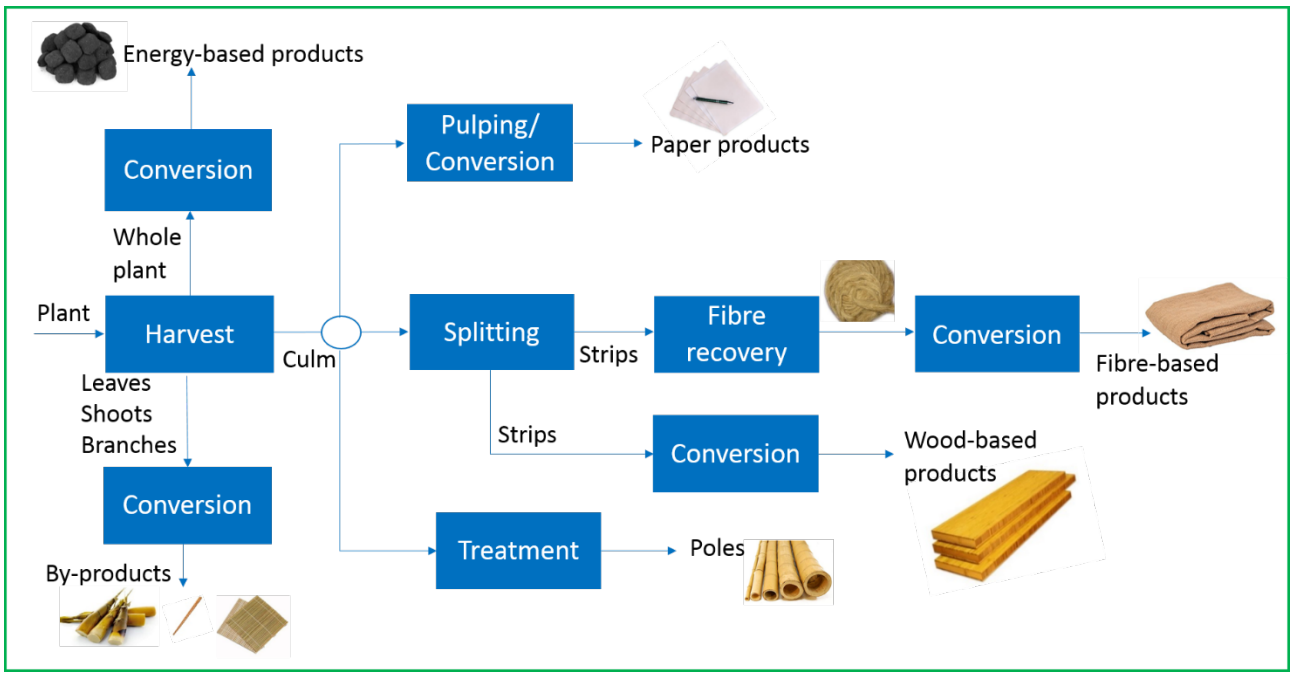
In the case of bamboo, products are mainly generated from the stem or culm, and can be grouped as fibre-based products (including natural and “rayon” or regenerated cellulose fibre products for textiles and polymer composites), wood-based products (including natural wood and engineered wood composite 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.

References and Useful Resources

- Broadhurst, J., Chimbganda, T. and Hangone, G. (2019). Identification and review of downstream options for the recovery of value from fibre producing plants: Hemp, kenaf and bamboo. Working paper commissioned by the "Towards Resilient Futures Community of Practice: Developing a Fibre Micro-Industry to Generate Economic Growth from Degraded Land" on behalf of the South African National Research Foundation.
- Khalil, A., Bhat, I.U.H., Jawaid, M., Zaidon, A., Hermawan, D. and Hadi, Y.S. (2012). Bamboo fibre reinforced biocomposites: A review. *Materials & Design* 42:353-368.
- Papadopoulou, E., Bikiaris, D., Chrysafis, K., Wladyka-Przybylak, M., Wesolek, D., Mankowski, J., Kolodziej, J., Baraniecki, P. et al. (2015). Value-added industrial products from bast fiber crops. *Industrial Crops and Product* 68:116-125.
- Sharma, B., Gatóo, A., Bock, M. and Ramage, M. (2015). Engineered bamboo for structural applications. *Construction and Building Materials* 81:66-73.
- van der Lugt, P., Vogtländer, J., and Brezet, H. (2009). Bamboo, a Sustainable Solution for Western Europe Design Cases, LCAs and Land-use. INBAR Technical Report No. 30, China.

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