A case study addressing the economic and operational feasibility of establishing Biohubs in the Private Native Forests of SouthEast Queensland

IEA Bioenergy: Task 43

October 2022

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Published by IEA Bioenergy

USC
Forest Industries Research Centre

A case study addressing the economic and operational feasibility of establishing Biohubs in the Private Native Forests of SouthEast Queensland

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Executive Summary

Research was conducted to evaluate biomass availability and the feasibility of biohubs (local and region) related to biomass utilisation for product generation from forest management in the Private Native Forests (PNF) of Southeast Queensland. Biomass estimates were developed from four different coups to understand the complexity of the resource; this data was then connected to supply chain operational costs to perform an economic analysis of two different types of proposed biohubs (producing biochar and pellets respectively). An analysis of the resulting biomass and biohub operational costs was conducted in the context of regional product markets and feasibility.

Introduction

A sustainable bio economy optimizes the sourcing, processing, transportation and marketing of material to end users, this needs to be done economically to be viable. A bio hub requires the prerequisite conditions of supply and market demand. It is believed that the private hardwood resource (PNF) in Southeast Queensland is strategically positioned (geographically, resource abundance and markets) to establish a sequence of viable biohubs with variable feedstock supply (industry, growers, small farms, etc.) and ample local markets (existing and proposed pellet mills, energy fuel, etc.). As a frame of reference, there are nearly 2.6 million hectares of PNF in SEQLD currently supplying more than 200,000m3 of hardwood to local markets with no biomass currently being extracted, this biohub project explores the prospect of using material currently seen as a waste product as well as other supplemental sources due to altered land management schemes support a bioenonomy infrastructure with high quality supply demands in excess of 400,000 tonnes per year.

This case study connects the potential supply options, processing technologies and market demands to evaluate financial and operational viability of biohubs. This project primarily focuses on financial feasibility of localized hubs. These hubs would amalgamate existing supply from private native harvest sites that have a residue by-product from harvesting operations (non-commercial logging byproducts tree tops, branches, etc.) and supplemental supply from proposed thinning operations for biomass generation, fire hazard reduction and productive land management. This local-hub would serve as a locality for supply amalgamation, product processing (debarking, chipping, grinding, etc.), sorting (e.g. high-grade material for pellets and low grade for energy fuel or char), upgrading (moisture content, chemical and physical contaminates), and transport to final market (different commodity classes or niche markets). Additionally a regional hub pathway including the raw transport of material to regional mega-hubs which could further combine forestry stocks with other supply to access greater processing, upgrading, infrastructure and transportation efficiencies is explored.

GMT Logging and Private Forest Service Queensland (PFSQ) with support from USC FIRC and QDAF collaborated to execute the initial biomass harvesting analysis of this project (Berry 2021a). This project report further analyses the biomass availability from this site, leverages the estimated cost of felling and extraction developed while further evaluating the regional supply chain costs to support local and regional biohubs.

Motivation for this project were to first gauge the regional and landscape variations associated biomass availably and to evaluate the commercial viability of local and regional biohubs to support broader regional investment into the sector.

The USC Forest Industries Research Centre (FIRC) assisted with data collection to complete an analysis of the biomass availability, operational productivity and economics associated with biohub configurations.

Study Area

The regional study area was located in Southest Queensland, Australia with biomass values from Mt. Urah in Southeast Queensland (the hinterland between Gympie and Maryborough) (**Figure 1**). Four 2ha sites were used in this study along with regional assumptions.

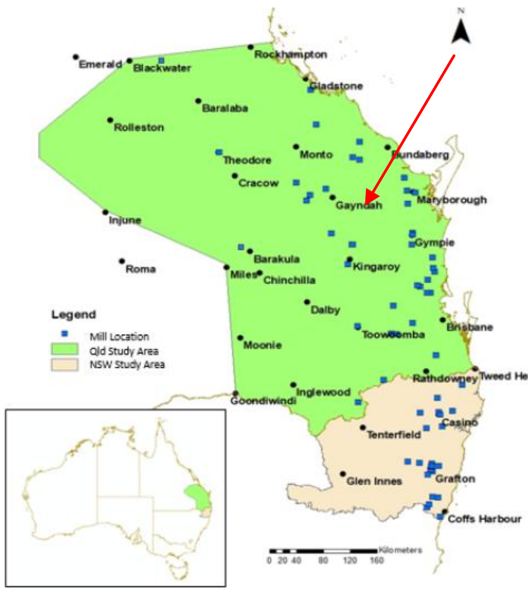

Figure 1. Australian context of regional case study. Biomass values from Mt. Urah Trial location south-west of Maryborough, Queensland.

Four 2ha sites with different characteristics (stand densities, diameter classes, species composition and expected quality) were chosen (**Table 1**). Each of the 4 sites were paired with a different operational biomass harvesting treatment for evaluation and review (see Berry 2021a) which then fed into the resulting biohub analysis.

Table 1. Study Site Characteristics and Biomass assumptions for plots (from Berry 2021a)

	Plot				
Site Characteristic	**1**	**2**	**3**	**4**	**Source**
Area (ha)	2	2	2	2	
Dominate Species	GBX	SPG	ACA/SPG	SPG/MIX	PFSQ
Original stems per hectare (sph)	618	743	891	806	PFSQ
Retained stems per hectare (sph)	72	110	91	135	PFSQ
Mean DBHOB (cm) (Treat & >10cm)	18.63	15.68	13.09	16.55	PFSQ+
% of Stems treated & > 10cm	51%	33%	49%	64%	PFSQ+
Retained Mean Tree Height (m)	30.91	26.84		28.63	USC
Mean Tree Volume (m3)	0.226	0.132	0.083	0.194	[1]
Mean Tree Mass (tonnes)	0.256	0.150	0.094	0.219	[1]

[1] Paul et. al. 2016
Above-ground biomass:(ABG(kg)) = EXP{(-2.016 + 2.375LN(DBH)} x 1.067
Note: Dry Biomass convered to Volume based on 30% MC and dry density of 790kg/m3
Note: Stems <10cm not included in volume analysis

Plots were characteristic of the private native forest resource with a variety of species, diameter classes and quality depending on site location and historic interventions. For context in the original study, ~~for~~ biomass harvesting plot 1 was harvested via shear head harvester and grapple skidder while Plots 2-3 were harvested using a Harvester-Forwarder and all plots used a Feller Buncher to harvest saw logs. All material was collected and analysed for biomass availability and its relation to hub design in this study.

Research Methods

Biomass Evaluation

Volumetric values were calculated based on inventory data supplied by PFSQ (10% area sample pre-harvest) with a representative biomass equation as per Paul et al. 2016. Stems with diameter less than 10cm were omitted from the analysis, as they are generally either left standing or are destroyed during the mechanical harvesting process and not recovered, furthermore their cumulative biomass potential is generally less than 5 tonnes/ha in most operational conditions. Biomass availability was then analysed based on theoretical and observed values to determine average profiles anticipated for regional recovery to support local and regional biohubs.

Biohub Evaluation

Biomass quantity and quality data from the sample plots were amalgamated to produce average quantities of the regional resource which then fed an analysis of Biohubs and specific technologies as detailed in **Table 2 and Figure 2.**

Table 2. Biohub Technology Summary

	Local Biohub	Regional Biohub
Biomass Extraction	In-Field Felling & Extraction	In-Field Felling & Extraction
Biochar	In-Field Carbonator with support equipment	Raw material transported to centralized faclity housing Carbonator with support equipment
Pellet	In-Field Mobile Debarking, Drying, Chipping, Pelletizing along with support equipment	Raw material transported to Combined semi-permanenant Facility with Debarking, Drying, Chipping, Pelletizing along with support equipment
Area Supported	50 ha	250ha

* Assumed distance between local and regional hub (50km) and distance to market (100km)

Figure 2. Tigercat Carbonator for Biochar (left) and Typical Pellet Plant (right)

This analysis uses Tigercat's Carbonator which is an all-in-one unit design to produce biochar at scale (~10tonnes/hour), track mounted and able to be utilized in-field at local hubs and on site at regional hubs. Pellet production assumed highly mobile pellet equipment (including debarking, drying, chipping, etc.) in local hubs and in quasi permanent facilities in the regional hub scenario.

Specifically, costs and operational efficiencies for felling and extraction was based off Berry 2021a, chipping productivity and costs were based off in-field data samples and the CRC for Forestry Chipping Model, typical values for excavator and support equipment, regional and international studies for debarking, drying based on cost per evaporative ton, carbonator values per industry reps (personal communication), and pelletizing per global norms as per generalised table below (**Table 3**).

Table 3. Key Biohub Technology Economic Assumptions

	Metric	Source
Felling & Extract	$40/ t	Berry 2021a
Mobilisation	Calculated based on equipment/ number of trips (1000/trip)	
Debarking	$6-10/t	McEwan et al. 2017; Ghaffariyan et al. 2012/2013
Chipping	$15-$20/t	CRC for Foresry Model
Drying	$150/Evaporative Ton	Berry et al. 2018
Pellets	$100-150/t	Visser et al. 2020
Carbonator	$25/tonne Input @ 10% Recovery = $250/t of Biochar Produced	Industry Representative

Results and Discussion

Results are first presented for estimated biomass availability and trial biomass recovery (m3 and tonnes). This is followed by an analysis of local and regional biohubs based on operational assumptions and machine rates. An economic analysis around the biohub (local and regional) along with a comparison (technologies), breakeven analysis (market viability and market distance) and sensitivity analysis towards biomass availability in each hub design is developed. Results are presented in $/GMT of feedstock and/or $/t of product produced (Char/Pellets).

Moisture Content

As noted, this study presents biomass results in volume (m3) as well as green metric tonnes (tonnes). Estimated green tonnes of material depends on an appropriate moisture content and bulk material density. Furthermore, moisture content is affected by relative humidity, temperature and environmental conditions and will fluctuate seasonally. It is also largely dependent on how much time has elapsed since the harvest – in this study biomass from the sites was collected to a centralized point around 2-3 weeks after harvest with associated weights with respect to that point in time and moisture content. Random samples of biomass were tested for moisture content with an average moisture content of 30.3% on a green basis (44% dry basis) determined. These samples were taken on the same day forwarding operations occurred (e.g. weights were measured at the same time for a direct correlation). The dry density of the characteristic resource was assumed to be the same as Spotted Gum (SPG) at 790kg/m3 (FPC 2020) resulting in a green density of 1134kg/m3 with the assumed moisture content, where:

$$Moisture\ Content_{green} = \frac{Mass_{green} - Mass_{dry}}{Mass_{green}}$$

$$Density_{green} = \frac{Mass_{green}}{Volume_{green}}$$

This is a very important assumption; as moisture content increases so does green tonnes and vice versa. In the field this will vary depending on how fresh the material is when collected and the regional weather conditions. Figures are presented here based on volume (m3) and green tonnes as appropriate, for reference conversion from m3 to tonnes equates to a factor of 1.13 and tonnes to m3 equates to a factor of 0.88 for the species and moisture assumptions in this report.

Furthermore, for products it is assumed that 10% of mass is retained with biochar production and 80% with pellets largely due to the removal of moisture and combustion.

Analysis of Biomass Availability and Extractability

Biomass Harvest

Data from the forwarder's on-board scale was used determine total biomass recovered (plots 2-4) while the skidded material from plot was roughly estimated. These figures paired with PFSQ's inventory data and the stem count from the feller-buncher was used to generate the following biomass (theoretical and harvested values) (**Tables 4,5,6**).

Table 4. Estimated Biomass Availability and Recovery per plot.

Value	1	2	3	4
Original stems per hectare (sph)	618	743	891	806
Retained stems per hectare (sph)	72	110	91	135
Mean DBHOB (cm) (Treat & >10cm	18.63	15.68	13.09	16.55
% of Stems treated & > 10cm	51%	33%	49%	64%
Mean Tree Volume (m3)	0.226	0.132	0.083	0.194
Mean Tree Mass (tonnes)	0.256	0.150	0.094	0.219
Stems Harvested (sph)	28	11	12	33
Biomass_Theory (tonnes/ha)	**68.08**	**30.29**	**36.51**	**89.40**
Biomass_Theory (m3/ha)	**60.04**	**26.71**	**32.20**	**78.84**
Recovered (tonnes/ha)	**45.00**	**18.76**	**17.50**	**31.75**
Recovered (m3/ha)	**39.68**	**16.54**	**15.43**	**28.00**
% Recovery	66%	62%	48%	36%

NOTE: Plot 1 Biomass Recovery = Estimated Guess

Observed Recovery from the sites ranged from 17-45 tonnes/ha (15-40 m3/ha).

Percent recovery was found to be highest in plot 1 as expected, given the whole-tree skidding operation, however the other values are hard to rationalize and plot 4 may assume an artificially high % of stems >10cm and could have inflated the anticipated volumes. This is uncertain and is reflective of pre-survey data. Further sensitivity is required for a more robust analysis.

Commercial Log Harvest (Saw Logs, Poles, Peelers)

PFSQ provided the following commercial harvest values (**Table 5**). Commercial log harvests are not analysed within this report though should be a reviewed for long-term value ramifications for sustainable harvest as part of a more comprehensive study. This said, the average diameters for this harvest where a key assumption for estimating sawlog top volume available as part of the broader biomass harvest. The average DBH of the sawlog harvest per plot was used for subsequent volumetric and mass calculations for resultant non-commercial biomass spec tree heads available for biomass recovery (see next section and **Table 6**).

Table 5. Estimated commercial log harvest volumes per plot.

Plot #	Count	Volume (m3)	Average Diamter (cm)
1	46	22.24	35.76
2	12	3.71	24.83
3	22	9.34	34.60
4	59	19.26	30.96

Uncommercial Sawlog Stem Head and Top Biomass

A survey was completed to estimate the approximate volume of head material remaining in field. Top material is highly correlated to stump diameter (DBH) and was approximated to be 40% of theoretical stem biomass volume and mass which is a slightly more than the theoretical estimate of crown volume being around 30% of an overall tree biomass profile (Ximenes et. al 2016). The full amount of this material that is recoverable in a biomass harvest is yet to be determined and analysis herein is best available estimate.

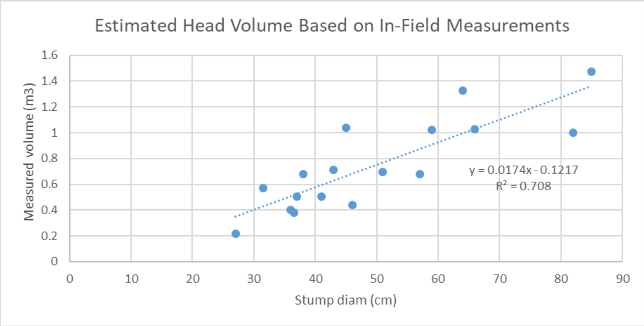

Figure 3. Estimated Head Volume associated with standing tree stump diameter

Based on this assumption and average diameter as per sawlog harvest, as discussed above, the following was estimated for head/ top volume likely remaining in the field (**Table 6**).

Table 6. Estimated Biomass Availability from Uncommercial Sawlog and Pole Stems (Heads and Tops)

	Plot			
Value	**1**	**2**	**3**	**4**
Harvest Count	46	12	22	59
Mean Tree Diamter (cm)	35.76	24.83	34.60	30.96
Avg Tree_Volume (m3)	0.998	0.420	0.922	0.708
Avg Tree_Mass (tonnes)	0.880	0.370	0.813	0.625
Assumed Top Left Over	40%	40%	40%	40%
Head Mass (tonnes/ha)	10.41	1.14	4.60	9.48
Head Volume (m3/ha)	9.18	1.01	4.06	8.36

Note: Only a fraction of the Head volume would be suitable for chips

As only a portion of this material would be suitable for a product, in this case we might assume 70-80% of this material or roughly 3-8 tonnes/ha (2-7m3/ha) may be available for biomass harvesting depending on the site conditions.

Please note that during the product harvest a limited number of biomass trees were also felled due to their large size. These stems (ranging from 0-10/ha) and associated stem volume are not included in this analysis and may help explain the discrepancy in theoretical vs. recovered biomass.

Post-Harvest Biomass – Existing and New.

A limited after-harvest line transect survey was completed to develop an idea of how much biomass is on the ground post-harvest. Please note much of this remaining material would be classified as small diameter material and not suitable for biomass harvest. Further, it is important that some material remains on-site for environmental reasons (e.g. to limit soil erosion associated with bare-soil). This survey also includes material classified as top and head material (as noted previously) so it is not additive to the above values. This all said, the information provides an indication of material left post-harvest and not recoverable (5-23 m3/ha) and existing biomass on biomass floor (4-15m3/ha) (**Table 7**). Furthermore, it also indicates that new large stem volume maybe in excess of 20m3/ha indicating potentially higher volumes of tree heads and debris maybe available for in-field biomass harvest further highlighting additional research into top and stem volume (**Table 7**). The sampling herein was very limited and by no means a robust characterisation of the resource, as such it is recommended that this is explored further as it may be very important to operational viability and for sustainably reasons.

Table 7. Estimated Post-Harvest Left Slash Biomass (existing, new large and small diameter volumes resultant from harvest)

Plot	Total vol (m3/ha)	Existing (baseline) volume (m3/ha)	Volume new >9.9 cm (m3/ha)	Min Volume likely left post harvest (m3/ha)
1	50.04	13.24	26.56	10.24
2	16.30	6.91	3.32	6.07
3	27.11	4.49	11.49	11.14
4	66.81	9.62	34.45	22.73

Note: Material also includes head material
Note: limited line transect length thus high inherent error

Summative Biomass Analysis

Connecting the information pertaining the volumes (namely theoretically available and realized recovered biomass as per Table 5, uncommercial sawlog top and heads as per Table 6 and estimated infield biomass including heads derived from Table 7) the following summary was generated (**Table 8, Figure 4**). This summarizes theoretical biomass availability, recovered material and likely tops and remaining in-field material as per this study and its associated assumptions.

Table 8. Cumulative Biomass Profile and Reconciliation

Value	1	2	3	4
Biomass_Theory (m3/ha)	60.04	26.71	32.20	78.84
Recovered (m3/ha)	39.68	16.54	15.43	28.00
Estimated In-Field Volume (m3/ha)	27.62	8.38	18.56	48.83
Estimated_Top Volume (m3/ha)	9.18	1.01	4.06	8.36
=> Total Volume Accounted for	58.13	23.91	29.94	68.47
% Diff (Theory vs. Estimated)	-3%	-10%	-7%	-13%

*Includes Heads.

Remarkably, the resource profiles (when summed from the data) compared with theoretical values are only off by 3-15%. However, these figures should be viewed very subjectivity given the limitations in the study and analysis.

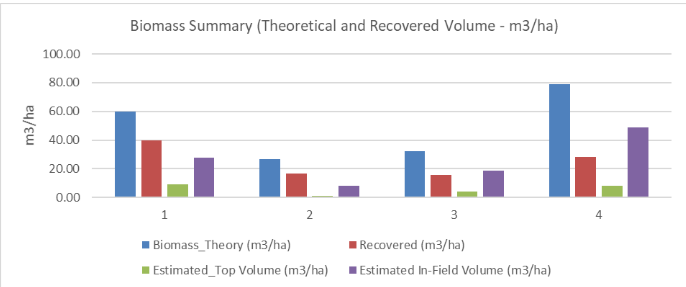

Figure 4. Plot based Cumulative Biomass Profile (note In-field volumes include top and head values).

As discussed previously, top/head material is largely dependent on assumed diameter while theoretical volume is dependent on average diameter and assumption of percentage of material greater than 10cm diameter.

Given this information it appears that the total biomass recovered and head material available ranges from 17m3/ha to 49m3/ha or roughly 19-55 tonnes/ha depending on the site and recovery system with an average of 27tonnes/ha (24m3/ha) for the forwarded sites.

As an average, it can be assumed that roughly 32t/ha of biomass (harvested and stems) are available in the study region. This then informs the local and regional biohub analysis.

Local Biohub Financial and Operational Feasibility

In the local biohub configuration, the material as detailed in the preceding section is assumed to be available for product upgrading in-field. The material on site would have already be amalgamated into one central location for upgrading and processing. When creating biochar, a Tigercat Carbonator would be hauled to the site along with an excavator and convey system to produce Biochar for the market. When producing pellets, it is assumed that there need to be in-field debarking, chipping, drying and pelletizing for bulk delivery to market. When combining the operational costs and efficiencies, the following **Figure 5** is developed:

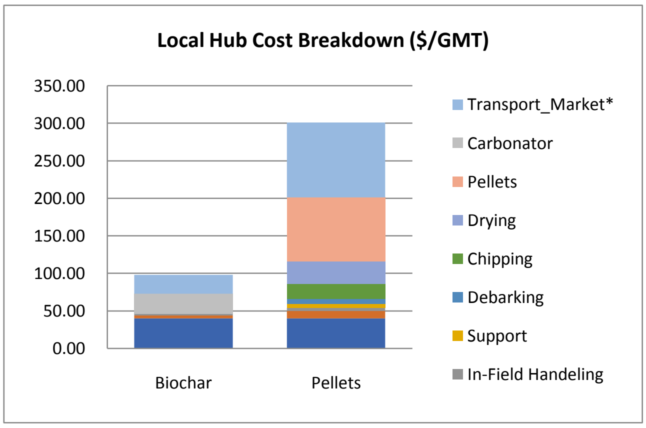

Figure 5. Local Hub Cost breakdown per GMT input.

From a product perspective the cost of biochar would be $780/tonne of biochar produced compared with $276/tonne of pellets produced. For biochar the highest proportion of costs is associated with biochar generation comes from the felling and extraction followed by biochar production itself, whereas with pellet production Pellet machinery followed by felling, drying and chipping are all highly consequential costs. Note that transportation also plays a larger factor in the overall costs of producing pellets given the higher proportion of retain material per green metric tonne.

From an operational perspective biochar production utilizing a highly efficient carbonator equipment makes for relatively easy local hub production wheras locally produced pellets suffer from high mobilization costs, higher operating costs and reduced efficiencies in comparison.

Regional Biohub Financial and Operational Feasibility

Similar to the local biohub scenerio, material would start in the same configuration (after felling and extraction) for the regional biohub scenario. In this case material from a number of local hubs would be transported in its raw from to a regional biohub for consolidation and product processing. In this configuration when creating biochar, a Tigercat Carbonator would be used with more permanent support systems to more economically produce Biochar for the market whereas when producing pellets, onsite debarking, chipping, drying and pelletizing would be available for streamlined bulk delivery to market. When combining the operational costs and efficiencies, the following **Figure 6** is developed:

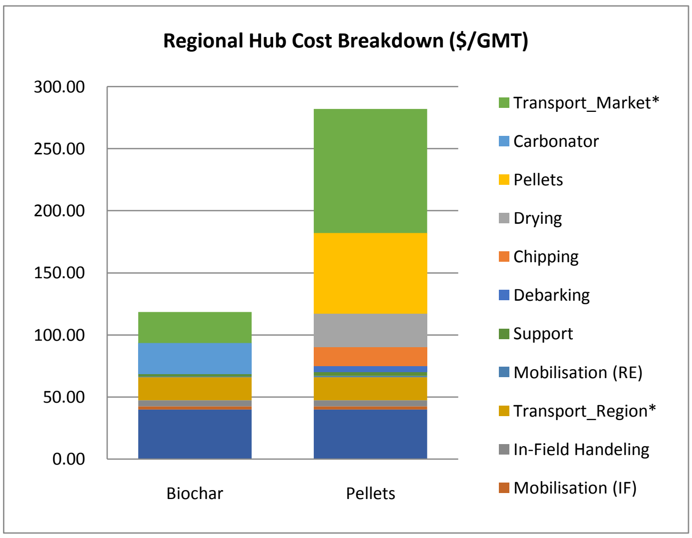

Figure 6. Regional Hub Cost breakdown per GMT input

From a product perspective the cost of biochar would be $985/tonne of biochar produced compared with $252/tonne of pellets produced.

From an operational perspective movement of raw material from a local setting to the regional potentially adds significant transportation costs (~20/tonne) which can be particularly costly to biochar operations with low product recovery. Transporting raw material to a regional site with more efficient support mechanisms and pellet production, however can reduce the cost of production and easy operational inefficiencies from a social and technical perspective.

Comparison of BioHub Models and Sensitivity Analyses

Local vs. Regional Hubs

Ideal biohub configurations vary greatly depending on numerous factors including technologies, raw materials, regional markets and labour availability. In this case study, we can see that when utilising a carbonator to produce biochar it is much more cost effective to do this in a local hub with a little as possible additional movement, transport and handling of the feedstock as physically possible. This is because for every $10/GMT spent on handling equates to roughly $100/t of product cost. In this comparison the regional hub required additional transportation (roughly $20/GMT or nearly $200/t product) which was not offset by much greater efficiencies in the regional hub ultimately yielding a higher cost of roughly 27% in the regional scheme (**Table 9**). In a highly variable market like biochar where product values can range from 500-1000/t of product this indicates that the local hub maybe viable whereas the extra costs associated with the regional hub would not be profitable.

Table 9. Local vs. Regional Hub Financial Comparison

	Local	Regional	Units
Biochar	78.00	98.50	$/GMT
	780.00	985	$/t Product
% Difference	-26.28%		
	Local	**Regional**	**Units**
Pellet	221.00	202.00	$/GMT
	276.25	252.5	$/t Product
% Difference	8.60%		

Conversely, when evaluating local vs. regional hub pellet operations the economics favour a regional platform for product production. In this case, the additional cost of raw material transport is less than the efficiencies gained by lower costs of pellet production, drying, debarking and chipping at a facility designed for higher overall production. The overall benefit of this shift in operation resulted in a cost savings of roughly 8% for a total cost of production of around $250/t of pellets produced. Even though regional hub cost of production may be lower, it is important to note that the commercial production of pellets can also be greatly sensitive to feedstock, transportation and production costs as export pellets from the Australian market may bring between $250-350/ t. In this line of thinking, the cost to transport pellets from a market which can easily exceed $20/t and the high cost of PNF extraction may jeopardize the financial viability of any regional hub configuration when compared to more easily accessible commercial lumber mill sawdust and off cuts or timber residues which have lower feedstock and transportation costs compared to the PNF resource. The calculus, however, changes if a premium price can be obtained for PNF hardwood pellets in local or foreign markets which is often the case.

Break-Even Analysis

A breakeven analysis was prepared to compare the break-even point of 1) local vs. regional hubs based distance required to move raw material from a site to a regional hub and 2) the ideal hub configuration and accessible distance to market.

For biochar production under the outlined conditions, it can be said that the additional cost of handling, moving and transporting raw material any distance is greater than any efficiency made in biochar production given the high utilization in both configurations.

With regards to pellets, it was found that a regional hub could be located as far as 102km away from the source and still be economically preferable compared to the local hub manufacturing given the operational efficiencies outlined.

When assuming biochar market value of $1000/t and pellet values of 350/t and using a local and regional hub as outlined above the break-even distances to market were derived. To this extent, a local hub biochar production could deliver biochar to a market 550km away whereas a regional hub produced pellet could deliver product to a market 500km away and still breakeven on the cost of production.

Biomass Availability Sensitivity

In this analysis, a global assumption of 32GMT/ha of biomass were available for product production and 50ha coupes were most common. As either of these values change the associated mobilization and utilization of key equipment may change. To this effect, in the first study (Berry 2021a) we saw that biomass maybe as low as 20t/ha (or as high as 50t/ha) in some coupes furthermore a local hub could be sourced from 25ha (or 100ha) instead of 50ha.

The results of this analysis (**Figure 7**) indicates that the sensitivity of biomass availability is much higher in the local hub and biochar pricing is much more sensitive than pellets. To this end Local Hub produced biochar could increase by nearly $100/t under low biomass conditions whereas pellets may increase by $25/t of product produced. In a regional setting it would be cut by a factor of 5. Conversely, under higher than anticipated biomass availability conditions these prices may reduce $25/t and $7/t with biochar and pellets respectively in a local setting and $5/t and $1.5/t.

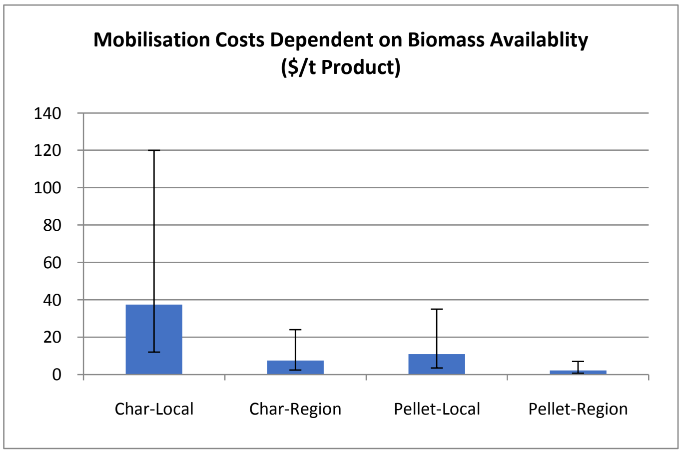

Figure 7. Biomass Availability and associated Mobilisation Costs. Bar chart indicates modelled values, high = 100ha/local and 50t/ha, low = 25ha/local and 20t/ha.

This sensitivity analysis is overlaid by a potentially +/- $10/GMT in harvesting costs associated with feedstock recovery which could yield another $100/t of biochar and $15/t of pellets. Thus we can see in a compounded situation of very low biomass availability there could be upwards of an additional $200/t cost of biochar (Local Hub) and an additional say an additional $40/t cost of pellets (Regional Hub) whereas cost savings in a very high situation could be in excess of $125/t of biochar produced and ~$17/t of pellets produced. As a proportion of the total cost of production, biochar production in this scheme is untimely more susceptible to these adjustments (+25%, -16%) vs. Pellets (+16%, -7%).

Conclusions and Recommendations

This study highlights key considerations when looking at biomass availability and biohub configurations associated with the private native resource in Queensland, Australia. It was found that recoverable biomass in PNF coupes can vary from roughly 20t/ha to 50t/ha with roughly 80% of that material coming from a biomass harvest and the other 20% from tops. Furthermore, it was found that theoretical values of biomass are likely a good indicator when predicting material availability in this setting. It was found that local biohubs where preferable when generating biochar (save 27%) with an efficient track mounted machine (reduce transportation and handling costs) while pellets were better suited for a regional hub (reduce costs by 8%) to capitalize on operational efficiencies associated with greater scale. It was initially found that the hub preference can initiate viable operations when compared to market prices and these incentives can equate to up to 500km in viable market distance.

Further Research Suggestions and Notes:

This study highlights an abundance of supplemental questions, considerations and areas for further research, some of which are itemized below:

Biohub and Biomass

- Biomass Harvest vs. Top Material for Product Generation
- Co Generation of products at local or regional hub
- Small Trees with Comparison of Bark and Debarking
- Labour considerations in Rural Environments
- Hub Longevity and Configuration Design

Acknowledgements:

GMT – Adan Taylor and Tony Miller
PFSQ – Sean Ryan and Dave Menzies
DAF – Tom Lewis
FIRC – Rick Mitchell

Notes:

All financial values in Australian Dollars (AUD)

References

Berry. M. 2021a. Integrated land management using small-scale harvesting operations for biomass utilization. IEA Bioenergy Report.

Paul, K. I., Roxburgh, S. H., Chave, J., England, J. R., Zerihun, A., Specht, A., Lewis, T., Bennett, L. T., Baker, T. G. & Adams, M. A. (2016) Testing the generality of above- ground biomass allometry across plant functional types at the continent scale. Global change biology 22(6): 2106-2124.

Fabiano A. Ximenes , W. David. Gardner & Gary P. Richards. 2006. Total above-ground biomass and biomass in commercial logs following the harvest of spotted gum (Corymbiamaculata) forests of SE NSW, Australian Forestry, 69:3, 213-222, DOI:10.1080/00049158.2006.10675001

FPC. 2020. Forest Products Commission of Australia chards. 2006. Total above-ground biomass and biomass in commercial logs following the

McEwan A., Brink M., Spinelli R. (2017). Factors affecting the productivity and work quality of chain flail delimbing and debarking. Silva Fennica vol. 51 no. 2 article id 1599. https://doi.org/10.14214/sf.1599

Visser, L., R. Hoefnagels, M. Junginger. 2020. Wood pellet supply chain costs – a review and cost optimization analysis. Renew. Sustain. Energy Rev., 118 (2020), p. 109506, 10.1016/j.rser.2019.109506

Ghaffariyan, M.; Brown, M.; Spinelli, R. 2013. Evaluating efficiency, chip quality and harvesting residues of a chipping operation with flail and chipper in Western Australia. Croat J. For. Eng. 2013, 34, 189–199.

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