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International assessment of bioenergy stakeholders research requirements of GIS based biomass analytics

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Abstract: As the demand and production for renewable energies increases there is a growing need to research new technologies to increase the efficiency, productivity and profitability of production. This study aimed to investigate the priorities of bioenergy stakeholders on Geographic Information Systems based research in a variety of countries including a number throughout Europe, the United States and Australia. A voluntary questionnaire was distributed internationally to bioenergy stakeholders to discern perceived usefulness ratings for various analytics. Participants rated Economic analytics as the most useful followed by Environmental, Product quality and Social assessments. Therefore, future research within the bioenergy sector should be aimed at increasing the economic viability of bioenergy and decreasing its environmental impact. There was a difference between analytic preference and the thirteen countries surveyed and the stakeholder type however, this relationship was not significant.

Keywords: analytic preferences; economic assessment; environmental assessment; product quality; social assessment; geographic information systems

The demand for bioenergy is increasing globally as a result of environmental, economic and energy security concerns (Wall et al. 2008). Currently, biomass provides up to 14% of global energy needs, with the potential to provide 40% by 2050 (Rosillo-Calle 2016). Substituting biofuel for fossil fuel is more effective and cheaper than reforesting or afforesting, as planting trees only temporarily sequesters carbon (Baral, Guha 2004)the use of a given piece of land is not limited to just the period until the forest matures, as in the case of afforestation. At present high costs of existing biomass-based technologies and unavailability of cost-effective technologies (e.g., biomass-integrated gasifier/steam-injected gas turbine (BIG/STIG)). It is improbable that climate targets will be achieved without the use of bioenergy (Sinkala, Johnson 2017) as bioenergy burns cleaner and more efficiently than fossil fuels (Wall et al. 2008).

Biomass is any organic material that is obtainable on a cyclic basis including crops, algae and trees (Zhang, Wang 2013), biofuels can be created using residues that are cheap and underutilised, forestry residues include thinned or deceased trees and the tops or branches of trees (IEA Bioenergy 2018). Biogenergy production can also be beneficial to agroforestry for instance the thinning of forests increases growth and productivity while descreasing tree mortality by increasing the resources available to each tree (IEA Bioenergy 2018). Retaining some biomass on the forestry patch is essential for nutrient cycling, soil fertility, soil moisture and erosion mitigation (Ghaffariyan, Apolit 2015).

Geographic information systems (GIS) research and technologies can be beneficial to the bioenegy industry but it is important to understand which research areas industry stakeholders prioritise. GIS programs (ESRI, USA) can display the spatial distri-

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bution of various types of biomass, and select areas that could be used to produce bioenergy (Walsh et al. 2010; Xu et al. 2013). Remote sensing can be used in forestry to estimate the volume of biomass within a region to approximate the amount of bioenergy that could be produced and its economic viability (Noon, Daly 1996; Voivontas et al. 2001; Lovett et al. 2009; Walsh et al. 2010) which estimates the potential for power production from agriculture residues. A GIS decision support system (DSS. The harvesting and transportation costs for different forests can also be estimated using GIS (Noon, Daly 1996; Voivontas et al. 2001; Kinoshita et al. 2009; Lovett et al. 2009; Walsh et al. 2010; Gowan et al. 2018)which estimates the potential for power production from agriculture residues. A GIS decision support system (DSS. These are technoogies are all examples of developed GIS-based research and contribute to both environmenal and economic research disciplines.The overarching purpose of this report is to determine what category of GIS-based research stakeholders consider the most valuable.

Stakeholder participation in research regarding bioenergy and GIS is important to increase the relevance and significance of bioenergy studies (Lawrence et al. 2013). A number of studies have researched the priorities of stakeholders concerning Economic and Environmental assessment however there is a knowledge gap in regards to Social, Product quality assessment priorities (Radics et al. 2015) and also the comparison between multiple countries. This study aims to address that knowledge gap by surveying biomass stakeholders from numerous countries on their research priorities regarding GIS-based biomass information. The analysis of survey answers will include a comparison between different analytics as well as assessments between stakeholder types and country of employment.

MATERIALS AND METHODS

Research methods

Two voluntary surveys were distributed via International Energy Agency (IEA) Task 43 to various stakeholders, one was to Australian stakeholders and the other to a variety of countries throughout Europe and also to the United States (Appendices 1 and 2). Due to the study being at a large international scale the only viable survey method was to conduct the survey using voluntary participants. The method of voluntary survey was chosen to maximise the number of participants that were available to complete the survey rather than taking a subset of the stakeholder population which would have resulted in lower particpant numbers. The survey was distributed through google forms and aimed to assess the priorities of biomass stakeholders for GIS-based biomass research. Ethics approval for these surveys was obtained prior to the distribution of the survey (ethics approval number A181079). The stakeholders that agreed to participate in the international survey were from a variety of countries including: Austria, Belgium, Brazil, Canada, Croatia, Finland, Ireland, Italy, New Zealand, South Africa, Sweden, Switzerland and the United States of America (USA) (Fig. 1). The survey included nineteen questions in the format of Likert scale, multiple choice and open-ended questions to gain demographic information and research priorities. Firstly, stakeholders were asked to identify the most and least useful analytic out of Economic, Environmental, Social and Product quality assessments, with the Australian survey not including Social assessment. Each of these analytics were then divided into several questions and these were rated on a scale of not useful (1) to very useful (7). This was followed by demographic questions to devise the stakeholder's role in the bioenergy industry, the region of their company and the country they were located in.

Stastistical methods

Descriptive statistics were created through tables and graphs to represent the percent response for each question. After the results were compiled, SPSS (IBM, USA) was used to complete statistical analysis on the main responses. To devise the significance of the major analytic preference a chi-squared test was used. A Kruskal-Wallace test was used to devise the significance between all the detailed analytic questions and between both country and stakeholder type to major analytic preference.

RESULTS

International survey

Out the 34 participants in the study the majority of the majority of them prioritised of Economic assess-

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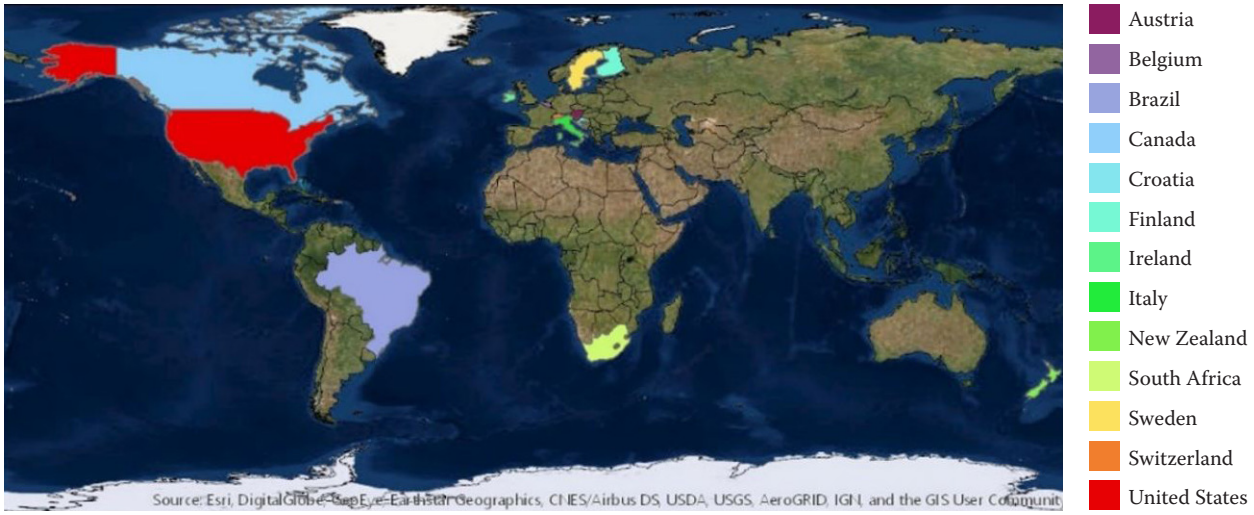

Fig. 1. Countries that participated in the international stakeholder survey

ment (53%) (Fig. 2) followed by Environmental (38%), Product quality (5%) and Social assessments (3%). The difference between major priority analytics was found to be significant ($P < 0.0005$). The response to the importance of each of the detailed assessments was also significantly different ($P < 0.0005$).

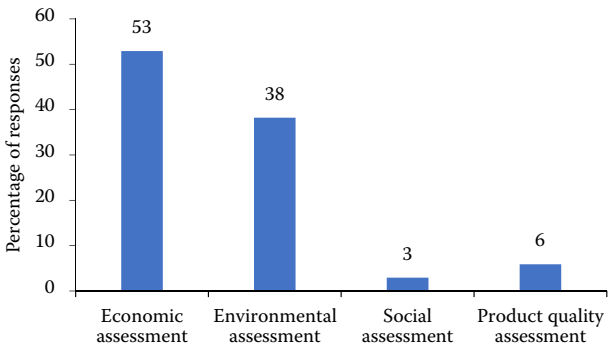

Fig. 2. Stakeholders response to the most useful analytic (%)

Economic assessment

The majority of the Economic analytics were rated at 5 or higher on the usefulness scale (Fig. 3).

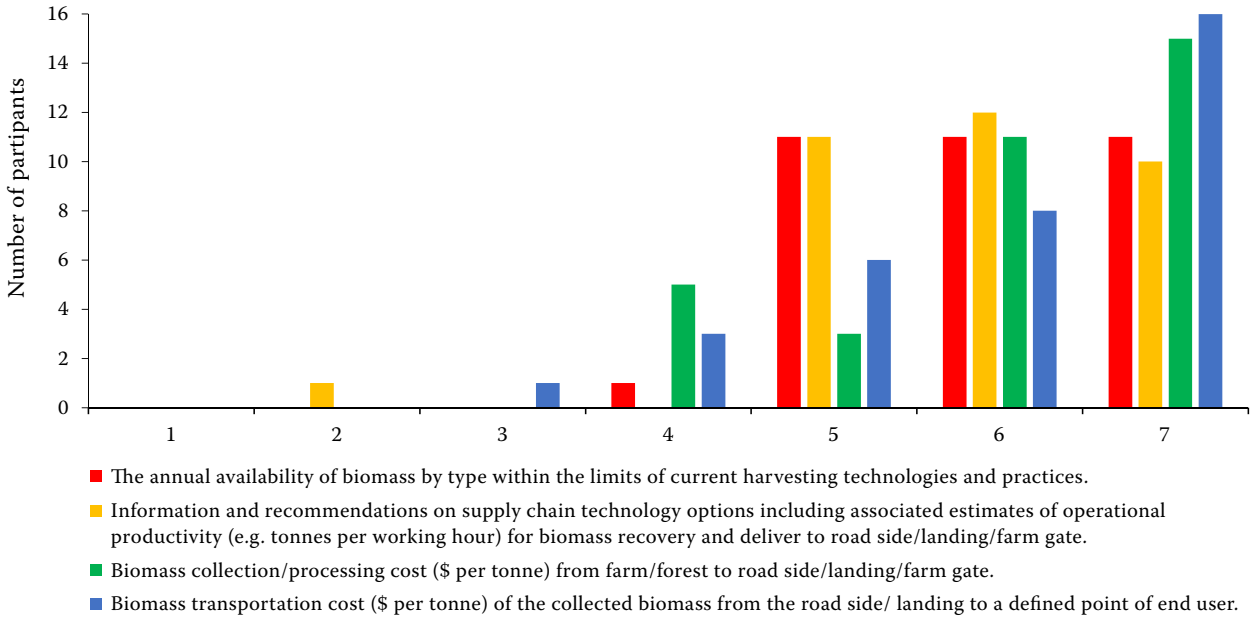

Fig. 3. Bioenergy stakeholder's prioritisation of different economic assessments (scale from 1-not very useful to 7-very useful)

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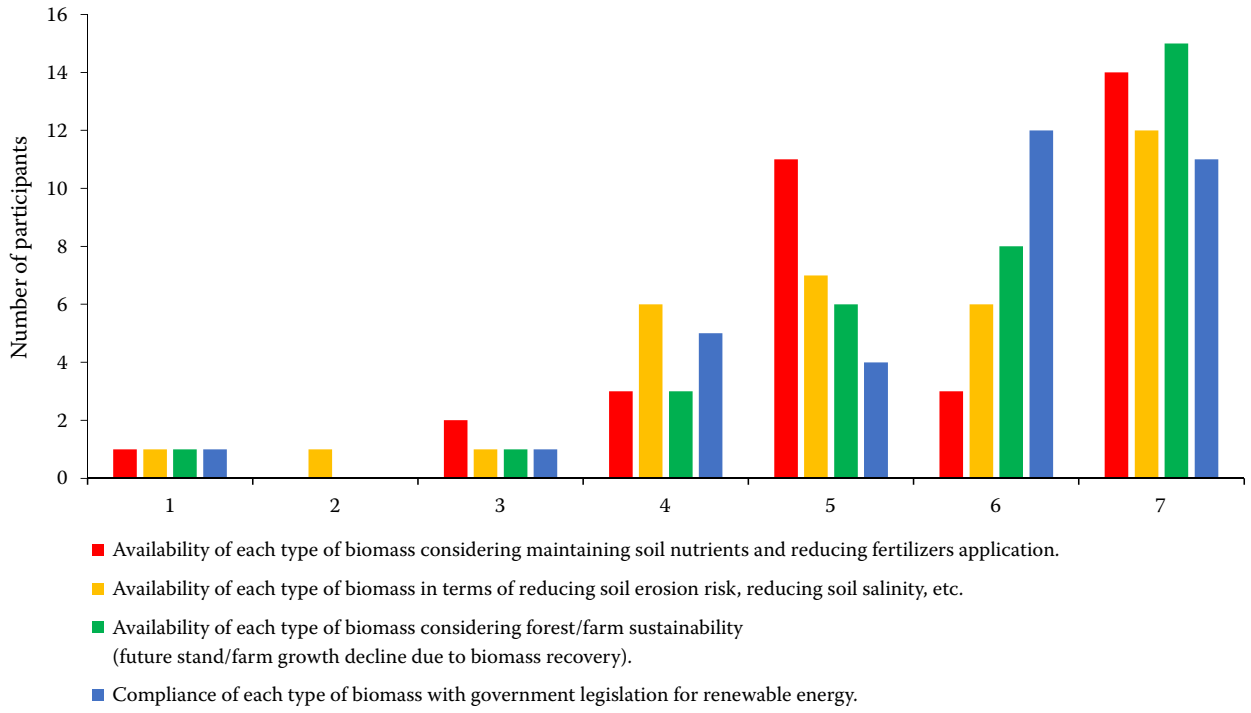

Fig. 4. Percentage score for each Environmental assessment by bioenergy stakeholders (scale from 1-not very useful to 7-very useful)

The cost of biomass transportation was rated very useful by the greatest number of particpants (46%) while information and recommendation on supply chain technology was rated the second lowest usefulness category by a participant.

Environmental assessment

The Environmental assessments were also rated predominately 5 or higher however, all the questions were ranked not very useful by one participant (Fig. 4). The availability of each type of biomass considering sustainability ranked most useful out of the Environmental assessments, as 44% of respondents rated it very useful.

Social assessment

The ranking for usefulness of social analytics was highly varied, with a large spread across the usefulness scale and at least one participant rating each analytic as not useful (Fig. 5). The highest ranked assessment was social acceptance and community engagement with the bioenergy sector, which was given a score of very useful by 27% of participants.

Product quality assessment

The scores given to Product quality assessment were also varied (Fig. 6). The availability of each type of biomass in terms of reducing soil erosion risk was given a score of 7 by 29% of participants.

Relationship between country and assessment priority

Most of countries preferred Economic assessment (seven out of 13) (Fig. 7). Compared to Canada and USA which had a priority of Environmental assessment; Austria of Product quality; and Belgium, Ireland and South Africa having equal priority of Economic and Environmental assessment. This relationship between country and major analytic was not significant ($P = 0.21$).

Relationship between stakeholder group and assessment priority

The stakeholder type was classified into four groups: biomass grower (8.8%), biomass consumer (5.9%), bioenergy investor (8.8%) and others

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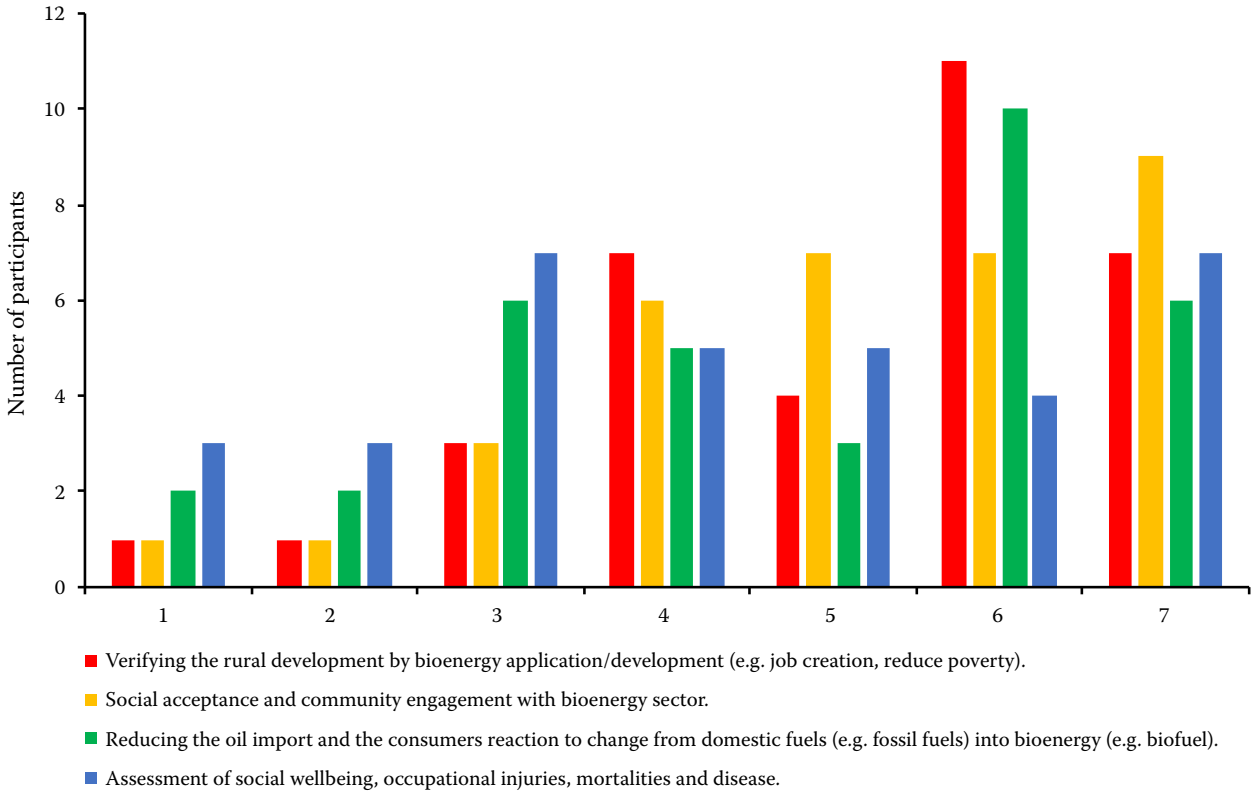

Fig. 5. Prioritisation of Social analytics by bioenergy stakeholders (scale from 1-not very useful to 7-very useful)

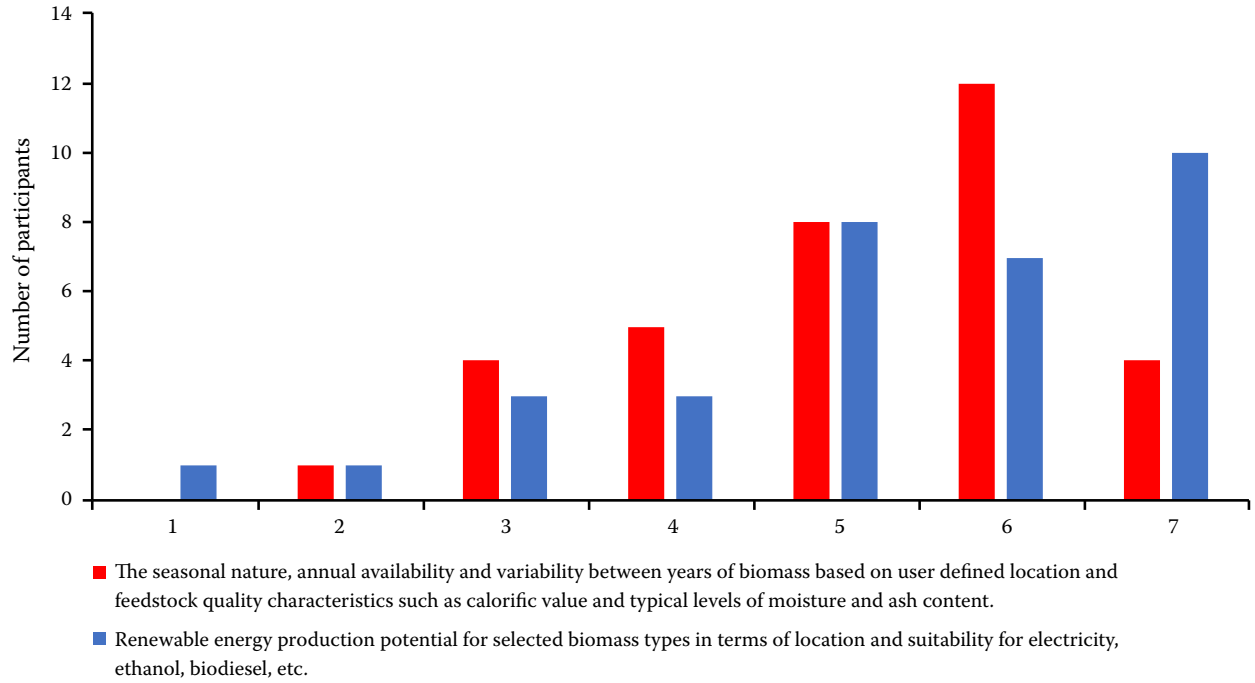

Fig. 6. Usefulness score of Product quality assessment by bioenergy stakeholders (scale from 1-not very useful to 7-very useful)

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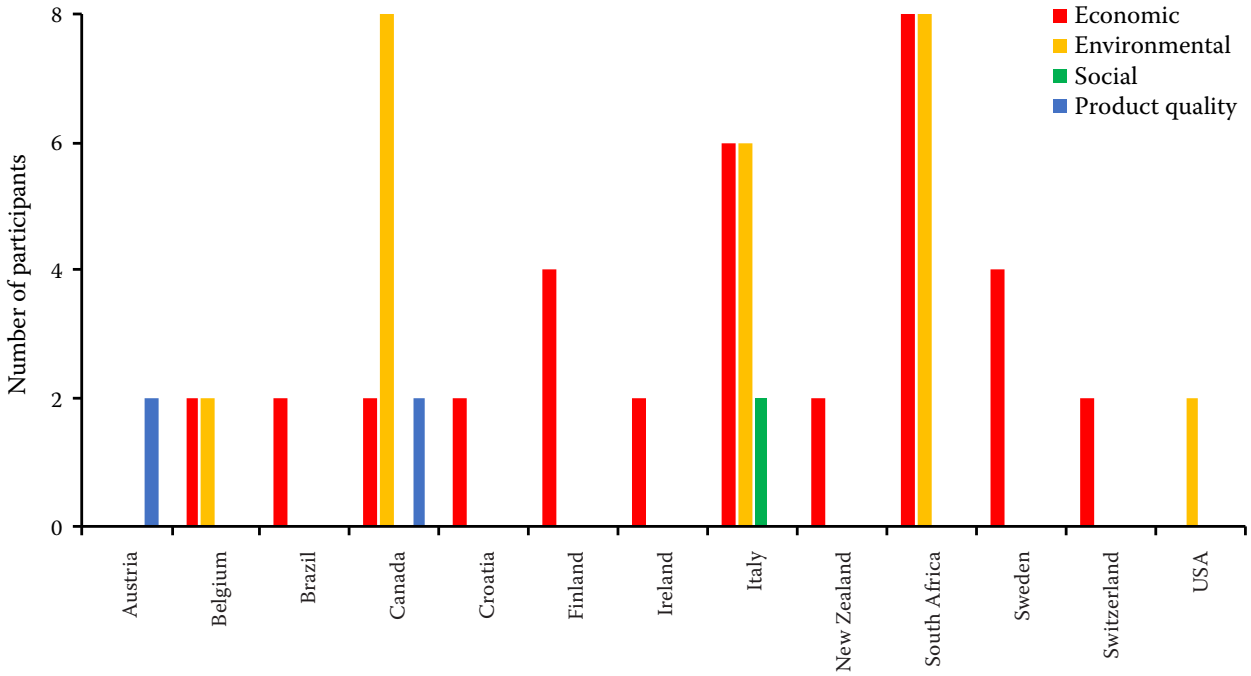

Fig. 7. Percentage of responses to major analytic preference classified into countries

(73.5%). Both biomass growers and biomass consumers were unanimous in their preference of major assessment, with Economic and Environmental respectively (Fig. 8). The major priority of biomass investors was Environmental analytic, followed by Product quality assessment. Other biomass stakeholders predominately gave priority to Economic assessment, followed by Environmental, Social and Product quality assessment. The relationship between stakeholder group and major assessment priority was not significant (P = 0.131).

Australian Survey

The Australian study found the majority of stakeholders to prirotise economic assessment (70%) followed by product qualtiy (27%) and environmental

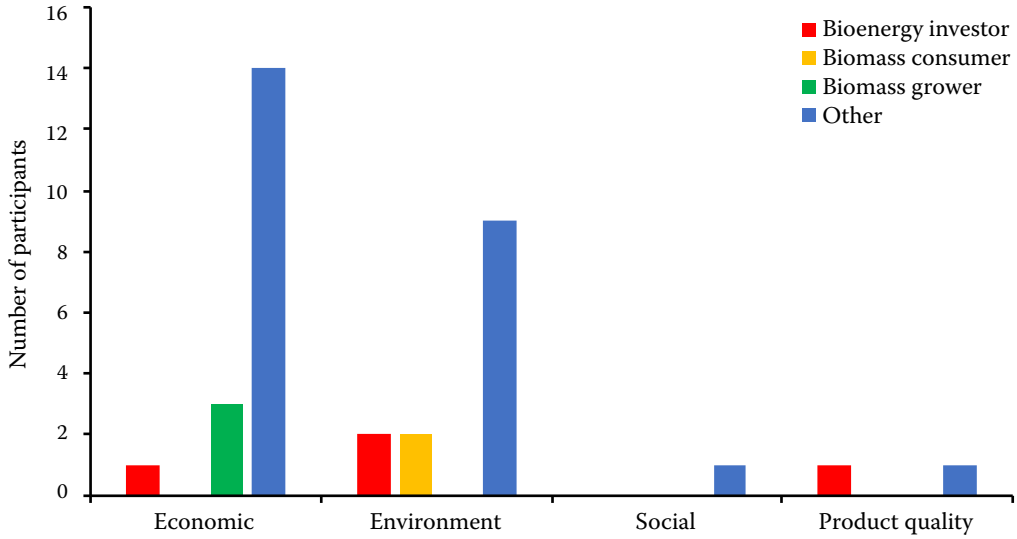

Fig. 8. Major analytic priority nominated by each stakeholder group

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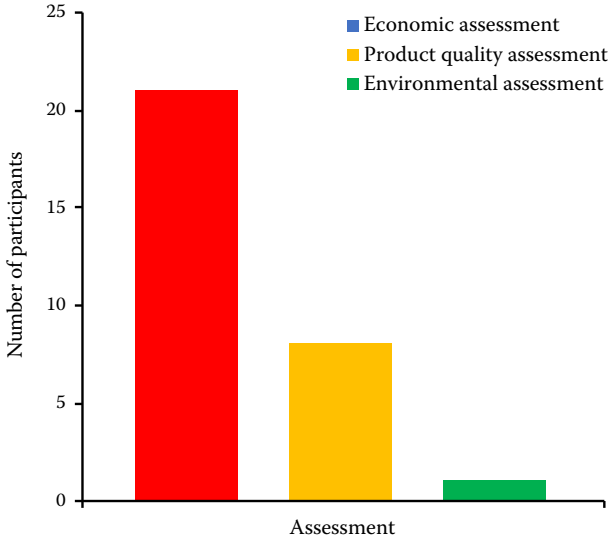

Fig. 9. Percentage of the responses for most useful type of analytics for Australian stakeholders

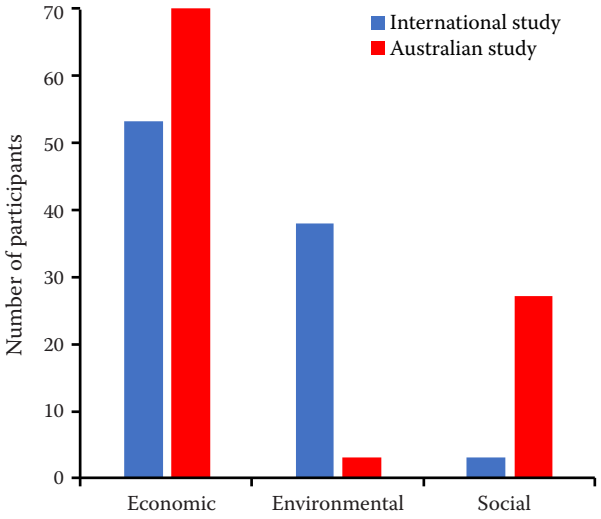

Fig. 10. Comparison between the two surveys major research priorities

assessments (3%) (Fig. 9). The Australian case study did not include social assessment because the bioenergy industry advisory group of the project were mainly interested in evaluating the preferences on economic, product quality and environmental assessment. The social assessment was not a priority for the Australian case study.

The breakdown the the role of participants in the Australain suvery was: biomass growers (16.7%), biomass consumers (e.g. processor or mill) (13.3%), bioenergy investors (20%) and others (50%). Most groups preferred economic assessment to other types of analytics (Table 1). The location of businesses within the survery was: Northern territory (3.3%), New South Wales (6.7%), Queensland (46.6%), South Australia (6.7%), Tasmania (13.3%), Victoria (16.7%) and Western Australia (6.7%).

Comparison between international and Australian stakeholder results

Overall there was a lot lower percentage of stakeholders prioritising Economic assessment in the international survey and a lot higher percentage that prioritised Environmental assessment (Fig. 10).

The major differences were between the two biomass consumer and bioenergy investor groups (Fig. 11).

DISCUSSION

The survey revealed that both international and Australian biomass stakeholders prioritise Economic analytics for GIS based research. Consistent with the highest analytic priority, the detailed analytic rated most useful was the cost of biomass and transportation in the international study and biomass collection and processing cost from the Australian survey. The stakeholder priority found in most studies is either Economic or Environmental concerns (Leitch et al. 2013; Fawzy, Componation 2015; Shakiba 2015; Spartz et al. 2015; Wolde et al. 2016; Dale et al. 2018; Gowan et al. 2018) which was also the result of this study. Shakiba (2015) and Spartz et al. (2015) also observed a high level of Environmental research prioritisation however, this was not ob-

Table 1. Percentage of the responses of each group for most useful type of analytics for the Australian stakeholders

Assessment	Biomass grower	Biomass consumer	Bioenergy investor	Other
Economic	100	75	80	63
Product quality	0	25	20	32
Environmental	0	0	0	5

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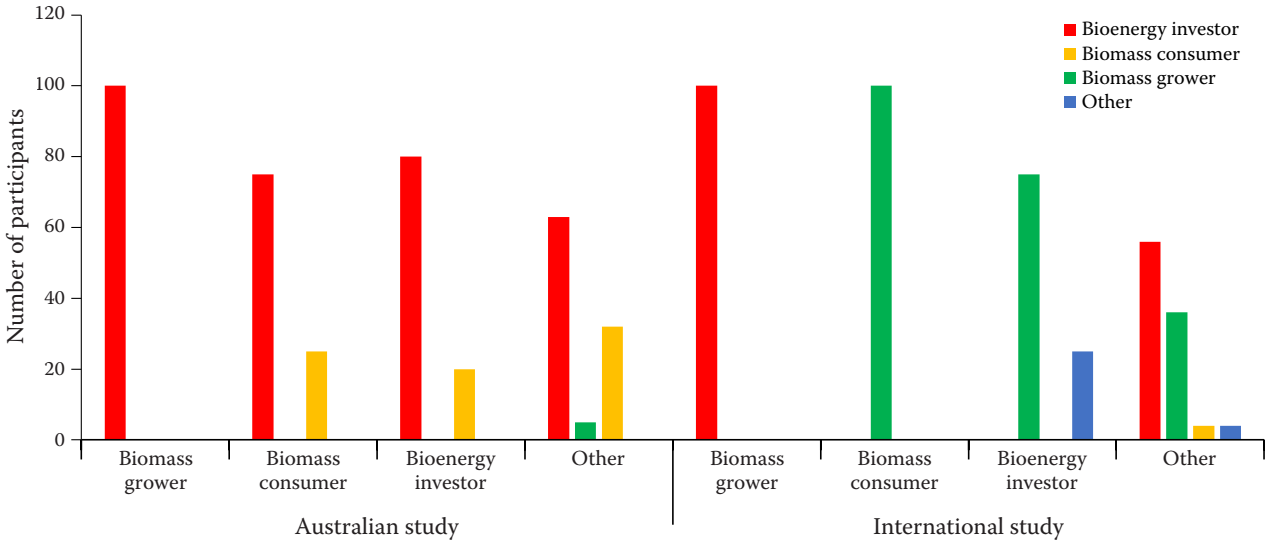

Fig. 11. The difference between stakeholder group priorities from each of the surveys

served in the Australian survey responses. The detailed analytic with the greatest percentage response of not useful was the assessment of social wellbeing etc. which is consistent with Social analytic having the lowest priority out of the four major analytics in the international study.

This prioritisation of Economics is also seen in other studies such as Fawzy and Componation (2015) in the USA and Dale et al. (2018) in the USA. Out of these studies that nominated an overall research priority, there was a unanimous prioritisation of economic assessment, which is similar to this study in that the major preference was economic analytics however, when major research priority was broken up into countries this was not observed to be the unanimous priority (Table 2).

Generally there is a difference in priorities between different stakeholder types (Dwivedi, Alavalapati 2009; Shakiba 2015; Ghaffariyan 2017) however, there was no statistical significance observed in this study (Fig. 8). Despite this, a difference in the priorities of stakeholder types was observed. None of the biomass investors in the international survey prioritised Economic assessment, which differs from the Australian survey which displayed majority of biomass investors to prioritise Economic assessments. This difference may have arisen from the varying priorities of the stakeholder's country or the company that the stakeholder is employed by. The biomass consumers rated Environmental assessment to be the most useful assessment in the international participants which differs from the results of the Australian survey which found biomass consumers to prioritise Economic analytics. All of the biomass growers surveyed preference Economic analytics over other assessments, which was also observed in studies such as Leitch et al. (2013), Shakiba (2015), Wolde et al. (2016) and Gowan et al. (2018). Very few of the stakeholders prioritised Social assessment, which has been observed by Delshad et al. (2010) who found other assessments to be prioritised over Social assessment. It was anticipated that some stakeholder types would prefer a particular analytic however, the hypothesised priori-

Table 2. Comparison of stakeholder priorities in literature

	Biomass grower	Biomass consumer	Bioenergey investor	Other
International study	Economic	Environmental	Environmental	Economic
Australian study	Economic	Economic	Economic	Economic
Gowan et al. (2018), Dwivedi and Alavalapati (2009) and Wolde et al. (2016)	Economic			
Leitch et al. (2013)	Environmental			
Spartz et al. (2015)		Environmental		

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ties were not always supported. It was hypothesised that investors would prioritise Economic assessment whereas the international survey found investors to prioritise Environmental assessment.

A difference was found between countries and major analytic priority, despite this relationship not being significant. This difference in major assessment priority was also found by Shakiba (2015) who compared the biofuel stakeholder priorities between Canada and Belgium. The bioenergy industry is predominately well developed throughout Europe and the United States which may result in the lack of significant difference between the countries priorities.

Comparing the Australian and European stakeholders gives displays the differences between a developing and developed bioenergy industry which showed and overall decrease in prioritisation of Economic assessment (10%) and an increase in Environmental assessment (27%) in Europe compared to Australia. The differences between these two groups of stakeholders could be a result of the development stage of each of the bioenergy industries, the different percentage composition of the stakeholder groups or some underlying difference.

Overall, there was a large amount of variation found between the results of this study and the results of other studies. This suggests that there is a large variation of analytic priority between stakeholders, with less variation when comparing countries or stakeholder types. Future IEA studies could research the importance of reaching legislation targets compared to the other analytics. This study conducted inital research into the research priorities of a number of stakeholders but it would be beneficial in future studies to include a greater number of participants in a larger variety of countries.

CONCLUSIONS

The most useful GIS-based research analytic nominated by the participating stakeholders was Economic assessment followed by Environmental assessment, while few stakeholders gave priority to Product quality assessment or Social assessment. There was no significant relationship found between major analytic preference and either country or stakeholder type however, there were differences observed in these categories. The major outcome in the comparison between an emerging and established bioenergy industry was the similar interest in Economic assessment, with a higher priority of Environmental assessment within established bioenergy industries. The stakeholder groups in both the emerging and established bioenergy regions had similar research priorities. This study addressed the research gap of surveying the importance of Social analytics, the international comparison of bioenergy stakeholder's priorities of GIS based biomass analytics and a comparison between the priorities of an emerging and established bioenergy industry.To increase the relevancy and importance of research future studies within the bioenergy industry should focus on economic and environment analytics.

Acknowledgement

We would like to thank the IEA and Task43 board members, all international researchers and participants who took part in the survey and helped us with distributing the online survey in different countries.

APPENDIX

Bioenergy industry stakeholders' survey - prioritising GIS based biomass resource information

Appendix 1. International stakeholder questionnaire

The survey

There are various studies and projects documenting the quantity and quality of the biomass resources around the globe to answer the specific research questions. This project is designed by IEA, Task43 to capture the preference of key bioenergy stakeholders (including biomass producers, biomass processors, bioenergy investors, etc.) regarding to potential economic, product quality and environmental assessments. This will yield a prioritised list of preferred analytics which can be useful to the academic and industrial users of bioenergy, policy makers, governments and IEA to allocate their efforts on researching most required/preferred analytics. The survey seeks your feedback on the usefulness to stakeholders of the following proposed analytical outputs for a user-defined geographic region.

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Appendix 1. International stakeholder questionnaire

1. What type of analytics do you? Please rank following options from 1 (most useful) to 4 (least useful):

Economic assessment ☐ Product quality assessment ☐ Environmental assessment ☐ Social assessment ☐

2. Please indicate your assessment of the degree of usefulness of economic assessment:

2.1. The annual availability of biomass by type within the limits of current harvesting technologies and practices (circle your answer)

Not Very Useful	1	2	3	4	5	6	7	Very Useful

2.2. Information and recommendations on supply chain technology options including associated estimates of operational productivity (e.g. tonnes per working hour) for biomass recovery and deliver to road side/landing/farm gate.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

2.3. Biomass collection/processing cost ($ per tonne) from farm/forest to road side/landing/farm gate.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

2.4. Biomass transportation cost ($ per tonne) of the collected biomass from the road side/ landing to a defined point of end user.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

3. Please indicate your assessment of the degree of usefulness of product quality assessment:

3.1. The seasonal nature, annual availability and variability between years of biomass based on user defined location and feedstock quality characteristics such as calorific value and typical levels of moisture and ash content.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

3.2. Renewable energy production potential for selected biomass types in terms of location (for example and where appropriate) and suitability for electricity, ethanol, biodiesel, etc.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4. Please indicate your assessment of the degree of usefulness of environmental assessment:

4.1. Availability of each type of biomass considering maintaining soil nutrients and reducing fertilizers application.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.2. Availability of each type of biomass in terms of reducing soil erosion risk, reducing soil salinity, etc.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.3. Availability of each type of biomass considering forest/farm sustainability (future stand/farm growth decline due to biomass recovery).

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.4. Compliance of each type of biomass with government legislation for renewable energy.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

5 Please indicate your assessment of the degree of usefulness of social assessment:

5.1. Verifying the rural development by bioenergy application/development (e.g. job creation, reduce poverty).

Not Very Useful	1	2	3	4	5	6	7	Very Useful

5.2. Social acceptance and community engagement with bioenergy sector.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

5.3. Reducing the oil import and the consumers reaction to change from domestic fuels (e.g. fossil fuels) into bioenergy (e.g. biofuel).

Not Very Useful	1	2	3	4	5	6	7	Very Useful

5.4. Assessment of social wellbeing, occupational injuries, mortalities and disease.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

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6 What is your role in the bioenergy industry? You can tick multiple boxes if required.

☐ Biomass grower ☐ Biomass consumer (processor or mill) ☐ Bioenergy investor
☐ Other (please specify):

7 Where is your business located? You can tick multiple boxes if required.

☐ North America ☐ South America ☐ Europe ☐ Africa ☐ Asia ☐ Oceania

8 What is your country?

Comments (optional): Please provide any other comment/suggestion you have in following box.

Appendix 2.
Australian stakeholder questionnaire

The ABBA Project

The Australian biomass for bioenergy assessment project (ABBA) aims to deliver a national database of biomass resources for bioenergy across Australia. Detailed historic data on the types, volumes, quality and locations of potential bioenergy feedstocks in each state are being collected. This data will be presented through the Australian Renewable Energy Mapping Infrastructure (AREMI) interface - a GIS based system for accessing information on renewable energy resources in Australia. The ABBA project will assist bioenergy project development by providing technical, financial and logistical decision-making support in relation to the nature and availability of biomass resources and relevant infrastructure in Australia. Both ABBA and the broader AREMI projects are funded by the Australian Renewable Energy Agency (https://arena.gov.au/project/the-australian-biomass-for-bioenergy-assessment-project).

The survey

The University of the Sunshine Coast and Queensland University of Technology will be developing analytical tools which will be made available through the AREMI interface. These tools will enable current and prospective biomass producers or users to set up and evaluate regionally specific biomass availability scenarios. A number of potential analytical outputs are currently being considered for implementation in AREMI. This survey seeks your feedback on the usefulness to stakeholders of the following proposed analytical outputs for a user-defined geographic region:

Appendix 2. Australian stakeholder questionnaire

1. What type of analytics do you think has greater importance?
Please rank following options from 1 (most useful) to 3 (least useful):

Economic assessment ☐ Product quality assessment ☐ Environmental assessment ☐

2. Please indicate your assessment of the degree of usefulness of economic assessment:

2.1. The annual availability of biomass by type within the limits of current harvesting technologies and practices (circle your answer)

Not Very Useful	1	2	3	4	5	6	7	Very Useful

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2.2. Information and recommendations on supply chain technology options including associated estimates of operational productivity (e.g. tonnes per working hour) for biomass recovery and deliver to road side/landing/farm gate.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

2.3. Biomass collection/processing cost ($ per tonne) from farm/forest to road side/landing/farm gate.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

2.4. Biomass transportation cost ($ per tonne) of the collected biomass from the road side/ landing to a defined point of end user.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

3. Please indicate your assessment of the degree of usefulness of product quality assessment:

3.1. The seasonal nature, annual availability and variability between years of biomass based on user defined location and feedstock quality characteristics such as calorific value and typical levels of moisture and ash content.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

3.2. Renewable energy production potential for selected biomass types in terms of location (for example and where appropriate) and suitability for electricity, ethanol, biodiesel, etc.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4. Please indicate your assessment of the degree of usefulness of environmental assessment:

4.1. Availability of each type of biomass considering maintaining soil nutrients and reducing fertilizers application.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.2. Availability of each type of biomass in terms of reducing soil erosion risk, reducing soil salinity, etc.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.3. Availability of each type of biomass considering forest/farm sustainability (future stand/farm growth decline due to biomass recovery).

Not Very Useful	1	2	3	4	5	6	7	Very Useful

4.4. Compliance of each type of biomass with government legislation for renewable energy.

Not Very Useful	1	2	3	4	5	6	7	Very Useful

5. What is your role in the bioenergy industry? You can tick multiple boxes if required.

☐ Biomass grower ☐ Biomass consumer (processor or mill) ☐ Bioenergy investor
☐ Other (please specify):

6. Where is your business located? You can tick multiple boxes if required.

☐ Northern Territory ☐ New South Wales ☐ Queensland ☐ South Australia ☐ Tasmania ☐ Victoria ☐ Western Australia

Comments (optional): Please provide any other comment/suggestion you have in following box.

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