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Exploring the Potential of Bioeconomies in Watersheds-Case Study of the Lake Winnipeg Watershed

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Abstract

The bioeconomy at the watershed scale project is a project initiated by the International Institute of Sustainable Development situated in Manitoba Canada. This project aims to create a bioeconomy using the Common Cattail as the feedstock, while also creating ecosystem services in the watershed through the maintenance of cattail cover. These services include decreasing nutrient loading into Lake Winnipeg, and reducing the incidence of flooding, among others. The dominance of the alternative sources of energy in Manitoba — hydropower and natural gas prove to be the biggest socioeconomic barrier to overcome for the expansion of the bioeconomy aspect of the project, of which bioenergy generation is presently the strongest component. The biggest socioeconomic drivers of the project were the ecosystem services of flood and drought mitigation and reduction of nutrient loading into water bodies that the project has the potential to contribute to. This has a strong potential to attract private and public funding for the project, as both are serious concerns for the Province. While the project has the ability to create different kinds of private and public benefits it is the integrated nature of the benefits that the stakeholders involved consider is of most importance. When a similar context from Minnesota in the USA was examined however, a different set of benefits were given importance. This validates the importance of adapting the project to generate the benefits that are important to that particular context, if this concept is to be transferred to other watersheds.

Keywords: cattail, bioeconomy, Lake Winnipeg Watershed

Executive Summary

This research takes the form of a case study set in Manitoba, Canada. The Province of Manitoba faces quite a few environmental issues, including large scale flooding and potentially drought into the future, brought about by both climate change and widespread conversion of a landscape that was once dominated by prairie grass and wetlands ecosystems. The resultant manifestation of intensive agriculture in the area has resulted in a transfer of nutrients mainly phosphates, into the waterways, with an ultimate discharge into Lake Winnipeg. This is further aggravated by an influx of nutrients from the US, brought in by the Red River which empties into the Lake.

The widespread and conspicuous pollution of the Lake is a subject of a lot interest to the residents of Manitoba, and has generated interest in solutions to tackle this. One such solution was the concept of generating bioeconomies at the watershed scale, a project initiated by the International Institute of Sustainable Development (IISD), headquartered in Winnipeg, Manitoba. The focus of this project is the common cattail, which shows abundant and ubiquitous growth in wetlands.

The opportunity to generate a bioeconomy arises from the variety of applications that could be pursued using the cattail, including the production of bioenergy, phosphorous fertiliser and biofibres, with the production of bioenergy being the predominant application that is being looked into, at the moment. The project is also unique in that along with a bioeconomy, broader ecosystem services can also be generated. The ability of the cattail to absorb in large amounts of phosphorous into its biomass, makes it an excellent means thorough which this nutrient could be mined from the system. Patches of cattail are associated with wetlands, and the maintenance of wetlands can contribute to flood and drought mitigation through buffering of water levels, provide habitat for wildlife and other ecosystem services. Thus, the project has the potential to generate a collection of both private and public benefits.

However, the viability of the project into the long run will depend on how well it resolves the socioeconomic drivers barriers that it will face as it expands form its current pilot phase. Further, the drivers and barriers along with the pressures faced by the existing system would influence the relative importance of the different benefits that the project could generate in the eyes of the stakeholders involved and determine their willingness to participate. This relative importance is therefore highly context-specific. Further, if the concept of stimulating bioeconomies at the watershed level is to be transferred to other watersheds, it would require an understanding of which of the benefits are given importance by the stakeholders involved in that particular context.

This research sought to investigate the socioeconomic sustainability of the project by IISD, and through this, understand factors that would influence its transferability to other contexts.

In order to achieve the overall aim stated above, the following objectives were fulfilled:

1. Development of an analytical framework to identify the factors that can act as drivers and barriers for the socioeconomic success of such systems.

2. Construction of a case study to reflect upon the socioeconomic sustainability of the project. This included an analysis of,

- The current status of the watershed and the project and the stakeholders involved
- Socioeconomic drivers and barriers faced by the different elements of the project

3. An analysis of the transferability of the project to other contexts consisting of,

- A study of the public and private benefits generated by the project and their relative significance to the stakeholders involved

- A comparative case study to understand how the perceived importance of benefits to stakeholders could change in the two different contexts

All of the fieldwork was done in in Manitoba. The majority of the data collection came from interviews, which were in-depth and semi-structured in format, mainly conducted through the phone, and some in person. Data was also collected from two field visits — to Providence College and the Greenwald Hutterite Colony. A total of 31 stakeholders were thus interviewed for data collection. The collected data was then analysed using an analytical framework constructed from the literature review.

It was found that the Province of Manitoba, as described earlier, while being heavily dependent on agriculture, is threatened by more frequent droughts and flooding into the long term. This and the status of Lake Winnipeg were topics of high priority as pressing environmental and socioeconomic issues faced by Manitoba. The inability to utilise biomass effectively in generating renewable systems of energy production, as opposed to a heavy reliance on fossil fuels was a third issue of concern. The large scale impoverishment of the First Nations community in Manitoba was also considered to be an important socioeconomic concern.

The project faces a variety of socioeconomic drivers and barriers as it develops further into the future. Despite the abundance of biomass in the Province, its utilisation was limited, except in the agricultural sector. While the lack of viable applications in other sectors was not pursued, in the energy sector, it was found that this is due to heavy dominance from alternative sources of energy. Hydropower is generated in the Province, and meets most of its electricity needs, while natural gas brought in from Alberta meets much of the heating needs. In addition a lack of regulation that prices energy, also taking into account broader socioeconomic costs, has meant that these are supplied at low prices. Taken together with convenience of access, this makes it the most significant barrier to overcome in the view of the stakeholders interviewed. A coal ban, which comes into effect in 2017, would have some impact on this, as those that currently use coal are those that do not have access to natural gas. However, the resultant increase in demand in biomass is not expected to be high enough to stimulate large scale, viable markets for the product.

When considering the potential for the application of the cattail in the bioeconomy, there are several promising applications. In addition, the cattail is a feedstock that could easily interchange with others, an important strength in ensuring the reliability and continued supply of biomass systems. The technological infrastructure that is needed to harvest, process and burn it already exist from that used for other types of biomass. The cattail, being similar to other grassy biomass has a high mineral content, which can interfere with its usage as a feedstock for bioenergy generation, an obstacle that it has been found can be overcome by blending the cattail with wood. However, these were considered to be drivers of less strength in pushing the project forward, when compared to the strong barrier imposed by the alternative sources of energy.

In contrast, it was felt by the stakeholders that the more public benefits such as the application in both flood and drought mitigation, and in playing a role in reducing nutrient loading into the river, have a better chance of assisting the potential to expand. Both of these are serious considerations for the Province, with the Provincial Government spending enormous amounts of money on flood mitigation and damage payments. In addition, the public concern over the status of the Lake, which has also stimulated political action in this regard are felt to be strong drivers that the project would be supported by.

This collection of drivers and barriers was also reflected in what stakeholders thought would be the benefits that would be of most importance to Manitoba. Flood and drought mitigation was mentioned frequently, followed by the potential to contribute to nutrient loading, and finally the application in the bioeconomy. However, the majority of the stakeholders felt that it is the integrated nature of the benefits that would be created, that would be of most importance to the Province, a finding that aligns well with the project's objectives.

Within the integrated system, it was felt that the development of the project in the short term would be led by the development of bioenergy (and potentially other applications of the bioeconomy). The large amounts of investments as well as the strong backing by the government that would be needed for the water management benefits to materialise was the main argument behind this. However, in the long run, it was felt that the water management benefits have the potential to become the stronger component of the project in attracting financial support.

This ranking of benefits however is highly context-specific, and to analyse how this ranking of benefits might change in another context, the North Ottawa Project by the Red River Basin Commission was looked at. The North Ottawa Project is a system of flood storage areas and is located in the Red River Valley in Minnesota in the USA, and was constructed with the goal of achieving a reduction in large scale frequent flooding in the basin.

The two case studies have contexts that share a lot of similarities, as both are located in the Red River Basin. Many of the issues that are common to the basin are thus found in both cases. One of these is the occurrence of large scale flooding, with extensive damages mainly to agricultural land. The second issue faced by the two cases is that of phosphate or nutrient loading into waterways, as a heavy dependency is seen on agriculture in both situations. However, in the case of Minnesota, the nutrient loading is to more downstream areas, and therefore largely away from the State. In contrast, Manitoba is the recipient of this water, and the impact of the nutrient flow into the largest lake in the Province is very visible, and is an issue the Province is very keen to address. With regard to the possibility of generating bioenergy from the cattail in Minnesota, the abundance of cheap coal produced in the Province does not make it an exciting option to pursue.

For Manitoba therefore, the range of benefits that the project can generate —flood and drought mitigation, ability to reduce nutrient loading and application in the bioeconomy would all be important. Thus, an integrated approach was felt by the stakeholders as the most important benefit that the project could generate. If the drivers and barriers for Minnesota are considered, the proven potential for flood mitigation by the retention basins, give it the highest priority in terms of the most important benefit the project could generate, with the other benefits being given lesser importance.

Thus, it can be concluded that given a standard set of benefits the drivers and barriers and the existing status of the system would lead to a reclassification of the benefits in different contexts. This makes a clear case that the project should to be adapted to generate the benefits considered important in a particular system.

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1 Introduction

This chapter will provide an introduction to the background in which the research is placed, a brief description to the topic of the study and the significance of the study. The specific research aims and objectives that will be fulfilled to achieve the purpose of the study are then outlined, followed by the scope of the study, the limitations faced, the audience targeted and the disposition of this thesis.

1.1 Background

The sustainable management of the earth's freshwater resources is becoming an increasingly urgent issue, with the consumption of this scarce resource having increased by six times in the last century (Bogardi et al., 2012). The health of freshwater resources such as rivers and lakes, wetlands and aquifers are determined by the status of the watersheds that feed them. A watershed is defined as the expanse of land through which water flows and drains into a common body of water (Postel & Thompson, 2005). Thus, watersheds throughout history have played an integral part in the development of human civilisations, providing drinking water, means of food production, energy production and transport, and are considered vital for the survival and economic progress of most societies of the world. (Sadoff & Gray, 2002).

However, while access to and consumption of water increases as a result of increasing urbanisation, industrialisation and through engineering interventions, the watersheds that are responsible for the provision of much of this water are facing large scale changes (Vorosmarty et al., 2010; Postel & Thompson, 2005). Many of the world's watersheds have undergone land use changes, being converted to agricultural land and urban areas, resulting in a diminished ability to provide ecological services. Of nearly 106 watersheds surveyed around the world, it was found that in one third of them, that conversion for the above mentioned purposes have led to changes in nearly half of the area (Postel & Thompson, 2005).

These changes are also reflected in the watershed of Lake Winnipeg, the second largest watershed in Canada (Environment Canada, 2011), with the long grass prairie ecosystem that had dominated much of the land being gradually replaced by agricultural land throughout the 20th Century. The lake lies within the borders of Manitoba Province in Canada, and is considered to be the 10th largest freshwater lake in the world (Voora & Venema, 2008).

The impact of the changes to the watershed on the lake are particularly pronounced, since the ratio of the surface area of the watershed to the area of the lake, is extremely high (Voora & Venema, 2008). One of these impacts is elevated levels of phosphorous in the lake, resulting in severe eutrophication of the waters, particularly through blooms of nitrogen fixing cyanobacteria species (Schindler et. 2012). The algal blooms and the production of toxins by the algae and consequent fish kills threaten the tourism and fishing sectors which contribute significantly to the economy around the lake (Environment Canada & Manitoba Water Stewardship, 2011).

Three major rivers flow into Lake Winnipeg — the Saskatchewan, Red and Assiniboine Rivers. Of these, the Red River which contributes 16% of the water flowing into Lake Winnipeg, accounts for 68% of the phosphate load into the lake (Environment Canada & Manitoba Water Stewardship, 2011). The origin of this nutrient in the river is largely attributed to two reasons- intensified livestock rearing and the use of inorganic fertiliser for agriculture in the Red River Basin and an increase in the magnitude and frequency of flooding of the Red

River basin, resulting in more rapid transfer of this nutrient into the river, and ultimately into the lake (Schindler et al., 2012).

The Red River originates from Minnesota, USA and is a transboundary river shared between the USA and Canada, with approximately 20% of the basin lying within the Canadian borders (Environment Canada & Manitoba Water Stewardship, 2011). Flooding is the foremost challenge facing the Red River Basin itself. Prior to significant land use change, wetlands and channels across the basin that naturally drained out water assisted in regulating excess water flow. However, widespread conversion to agricultural land and settlements through large-scale artificial draining has disrupted this process of buffering. Major flooding is a challenge facing the basin, with the most recent one being in 2009, resulting in the need for interventions in the form of water diversion and control measures (Roy et al., 2011).

The International Institute for Sustainable Development (IISD) has taken measures to address the challenge of nutrient loading into the lake, through the initiation of a pilot project that also takes into account the principles of the bioeconomy. A bioeconomy can be described as an economy where the raw material for the production of energy, chemicals and other material in industry is obtained from biological sources that are renewable, such as plants, as opposed to from fossil fuel based sources (European Union 2012; Organisation for Economic Cooperation and Development, 2009).Thus, through the integration of the concepts of the bioeconomy, it is hoped that socioeconomic benefits are created, that extend beyond the benefit of environmental protection of the lake.

The project by IISD centres around the Common Cattail (Typha spp), a fast growing aquatic reed species that grows abundantly in wetlands and degraded land. As it grows, the cattail absorbs substantial amounts of phosphorous (20 to 60 kg per hectare/year) into its biomass (Grosshans et al.,2014). Thus removing the cattail, in effect, also removes the phosphate from the wetland system. The application of the principles of the bioeconomy lie in the fact that the harvested cattail is suitable to function as the raw material for the production of different types of biofuels, fertilisers and other products.

The application in fertiliser production is of importance when the fast diminishing nature of the global supply of phosphorous fertiliser is considered. Phosphorous input for agriculture usually comes in the form of inorganic fertiliser, which is produced by processing mined rock phosphate. However, this is a non-renewable and scarce resource, and it is estimated that at current and predicted future demand, that global reserves will be depleted within the next 50-100 years (Cordell et al.,2009)

Hence, the project has potential to generate benefits that extend beyond the realm of environmental protection — to creating economic benefits that could therefore enable the project to become financially independent, if managed properly. Other co-benefits include the generation of carbon credits, water quality credits and improved habitat for wildlife. The ability to contribute towards flood mitigation, by integrating the harvesting of the cattail with wetland management for the purpose of water buffering is another anticipated benefit from the project (Zubrycki et al., 2014). Thus, the project is expected to generate a combination of both private and public benefits.

1.2 Research Problem

The 3-year pilot project on generating a bioeconomy at the watershed level appears to be promising, benefitting not only the environment but also the local economy. However, the project as of now has been financially supported by various institutions including Manitoba

Lotteries, Manitoba Conservation Department of Water Stewardship and Manitoba Hydro, (IISD, 2013) and its financial viability after the pilot phase is unknown.

In a forum organised jointly by the University of Manitoba and IISD on Manitoba's Green Economy Action Plan, the importance of the bioeconomy, and its drivers and barriers for expansion into the future were identified. The abundance of biomass produced by the province from various sources including cattail and prairie grass, and easy access to markets that use biofuels at a large scale were identified as the main drivers. The main barriers for further development were identified as limited access to capital, a shortage of skilled labour, transportation costs, competition from conventional sources of energy and a policy system that was more flexible to change. (IISD, 2014).

The ability of the project to sustain itself into the future is not certain, and will depend on many factors. These include among others, the project's financial viability, which in turn is determined by how the project fits into the existing local economy and can contribute to it and the need and drive both by the government and local communities to move away from conventional alternatives to fuel sources. This would be influenced by factors such as supporting institutional and governance structures, supporting infrastructure and access to capital, technology and skilled labour. In terms of the public benefits such as flood control and water quality improvement, influencing factors would be the ability of the project to reduce costs of mitigation and any damages caused. Thus, the viability of the project would be determined by the collection of socioeconomic drivers and barriers that it would face, as it develops further.

Together, these factors would influence the relative importance of the different benefits (private and public) that the project could generate, in the eyes of the stakeholders and their willingness to participate.

This viability is also one factor that would determine the 'transferability' of the concept to other contexts, another aspect of the project currently being considered by IISD. Watersheds around the world are home to millions of people, who depend on the ecological services provided by the watersheds and associated waterbodies for their livelihoods. As discussed earlier, many of these watersheds have undergone changes that are similar to what is currently occurring in the Lake Winnipeg watershed. Therefore, stimulating a bioeconomy that could concurrently meet environmental and socio-economic needs in such watersheds as a means of reducing anthropogenic impact could be a concept that could be transferred to other watersheds.

While this is a promising idea, each watershed is subjected to a unique combination of challenges. Thus, the collection benefits that would have to be generated to address these challenges is highly context-specific, and the project would have to be tailored to meet this. Thus, the study of the transferability of the concept should first involve an understanding of how the existing status and the socioeconomic drivers within this particular watershed influence the relative importance of the benefits created.

1.3 Aims and Objectives

This MSc thesis seeks to investigate the socioeconomic sustainability of the project on stimulating a bioeconomy at the watershed level, and through this, understand factors that would influence its transferability to other contexts.

In order to achieve the overall aim stated above, the following objectives need to be fulfilled:

1. Develop an analytical framework to identify which factors can act as drivers and barriers for the socioeconomic success of such systems

2. Conduct a case study to reflect upon the socioeconomic sustainability of the project. This would include an analysis of

   - The current status of the watershed and the project and the stakeholders involved

   - Socioeconomic drivers and barriers faced by the different elements of the project

3. Evaluate the transferability of the project to other contexts. This would include,

   - The public and private benefits generated by the project and their relative significance to the stakeholders involved

   - A comparative case study to understand how the perceived importance of benefits to stakeholders could change in the two different contexts

1.4 Limitations and Scope

The study focused mainly on the socioeconomic sustainability of the IISD project. The environmental impact and sustainability, while being a crucial element in determining the viability of project, was only looked at when overlaps occurred with the socioeconomic aspects. This was due to the limited time period of the study and the tremendous complexity and variability of the system.

The Integrated Water Resources Management (IWRM) framework was used to assess the drivers and barriers faced by the aspects of the project related to watershed management. Since the IWRM is vast in scope, only the elements that were of relevance to this project and to the management of the Lake Winnipeg Watershed were selected and used in the assessment.

The transferability of the project was assessed through a comparison with another case study from the Red River Basin called the North Ottawa Project. However, as the focus (and time allocated) was on the Lake Winnipeg case study, this was a smaller study in scope, and the information required was obtained from three stakeholders, as opposed to the numerous stakeholders interviewed for the Lake Winnipeg case study. The difference in the number of interviewees could have an influence on the relative importance of benefits to the different stakeholder groups discussed in Chapter 6.

1.5 Audience

The study and its main findings would be of interest to IISD, and other stakeholders involved in and interested the project. Readers interested in the topic of wetland management, sustaining bioeconomies in rural landscapes and in watersheds, as well as other readers from the International Institute for Industrial and Environmental Economics (IIIEE), would also be other target audience.

1.6 Disposition

- **Chapter 1 (Introduction):** This will provide the background in which the research is placed, the significance of the study as well as the specific research objectives that the study hopes to achieve. Further, the method to be followed, as well as expected limitations in terms of both scope and practicalities are outlined.

- **Chapter 2 (Literature Review):** The objective of this chapter is to review the existing literature on the topic, and to use it to develop an analytical framework that could be used to examine the case, to evaluate both the drivers and barriers faced by the project, and its portability to another situation.

- **Chapter 3 (Research Methodology):** This chapter will present the methods and frameworks followed to achieve the research objectives laid out in Chapter 1.

- **Chapter 4 (Background to the Case Study):** This chapter will present background information to the case, including the main environmental and social issues faced by Manitoba, current status of the project and stakeholders invovled

- **Chapter 5 (Analysis of the Case):** The template on which the case study will be constructed and analysed will strongly align with the framework developed in Chapter 2. The framework will be applied to the case study, to identify the different drivers and barriers to the project

- **Chapter 6:** This chapter will evaluate the significance of the drivers and barriers identified, the private and public benefits created, the relative importance of the different benefits to different stakeholder groups and how the benefits maybe integrated. A comparative analysis with a case study from Minnesota, will be done to evaluate how the relative importance of benefits would change according to the context.

- **Chapter 7 (Conclusions):** This chapter will reflect on the analysis from Chapter 5 and 6 to draw conclusions on the findings as well as on the study itself, propose recommendations as well as to make suggestions for further directions in which the study could be taken.

2 Literature Review

This chapter attempts to review the literature that is available at present on different aspects of the project by IISD, on implementing bioeconomies at the watershed level, to derive a framework to be used in the analysis of the case study in Chapter 5.

The main objectives of the project are the management of the phosphorus loading into Lake Winnipeg taking an integrated approach, and the generation of a bioeconomy to achieve this objective. Along with this, it is hoped that co-benefits associated with flood control and other water resources management objectives would be realised.

The structure of the literature review will strongly align with these objectives. First, the literature around the topic of integrated water management is looked at, followed by that on bioeconomies and the production of bioenergy. Finally, the literature on the two distinguishing features of the project— the use of marginal land for the production of bioenergy feedstock, and the use of reed for this purpose is reviewed. On each of these topics, the socioeconomic drivers and barriers are identified and reviewed.

2.1 Integrated Water Resources Management

Global freshwater use is one of the nine planetary boundaries put forward by Rockström et al. (2009). A planetary boundary is defined as the limit within which humanity can function safely with a degree of socio-ecological resilience, and which if transgressed, will bring about abrupt and non-linear change (Rockström et al., 2009). It is believed that the boundary for global freshwater use, which is 4000 $km^{3,}$ has not yet been surpassed. However, freshwater usage and the hydrological cycle are intimately linked to other planetary boundaries such as biodiversity loss and climate change, both of which have been surpassed. Further, the reciprocal influence by these on the status of freshwater bodies, and an expected growth in human demand into the future necessitates urgent intervention into the management of his resource (Bogardi et al., 2012; Gerten et al., 2013).

Surface and subsurface freshwater bodies are fed by their watersheds. However, many of the watersheds around the world have undergone anthropogenic modification arising from different causes, such as conversion to agricultural land and cities (Vorosmarty et al., 2010). The management of watersheds is also complicated by their nature of extending beyond political borders. Today, nearly 40% of the world's population is estimated to live in river basins which are shared by two or more countries (Giordano & Wolf, 2003).

2.1.1 The Integrated Water Resources Management Framework

Integrated Water Resources Management (IWRM) is recognised as a framework that brings together many disciplines, stakeholders and interests to coordinate the management of land and water resources, while ensuring the healthy functioning of ecosystems. Under the IWRM framework, hydrological boundaries, instead of political ones are considered (Biswas, 2004; Jaspers, 2003; Roy et al., 2011). The most quoted definition is that put forward by the Global Water Partnership and reads as follows, "IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." (Global Water Partnership, 2000)

The IWRM framework has also been the subject of criticism, mainly revolving around an absence of discourse about practical implementation. Biswas (2004) argues that while its potential cannot be disputed on a conceptual basis, that it does not provide concrete guidance on how it can be operationalised, especially considering the diversity of water management issues and practices around the world. Molle (2008) agrees that it is more appropriate to consider the IWRM framework as a vision of the ideal state to be achieved in water management, but nevertheless states that it can be useful as an endpoint to strive for.

However, it is also agreed that the framework or principles of it are widely accepted as the dominant paradigm in water resources management at present, with implementation in various degrees around the world. (Rahaman & Varis, 2005; Jaspers, 2003; Anderson et al., 2008). Therefore it is used in this study, as a means of guidance on the main concepts on how water resources can be managed taking a holistic approach. The components that are related to the implementation of the entire framework are given in Appendix 1.

The focus of the study is to evaluate the socioeconomic sustainability of the project through an analysis of the governance and legislative systems present, the institutional support available and the extent of support by the stakeholders involved, and the factors that influence these. Therefore, of the different elements described as being important for consideration for the implementation of IWRM, those that are of particular relevance in meeting the objectives of the study are discussed in more detail below. These elements were also selected taking into account the IWRM systems that are expected to be in place in both the Lake Winnipeg watershed and the Red River (a transboundary) basin.

2.1.1.1 The Role of the Government

The management of water is done at the national level or at a more local (e.g. provincial) level. It is recommended that the role of the government changes from that of playing a prescriptive and centralised function in water management to that of an enabler in facilitating a more participatory approach. The provision of services is to be thus decentralised, thus freeing up resources for other more overarching functions such as planning, policy making and enforcement. However, a continued active role in the public investment in the provision of certain services such as flood protection is suggested. An overarching body at the national level that oversees the functioning of the entire IWRM network is also endorsed. (Global Water Partnership, 2000)

2.1.1.2 Management at Watershed Level

Recognising the nature of watersheds that extend over administrative and political boundaries, the establishment of Committees or Commissions that oversee the management of the entire watershed is recommended. However, it is noted that the success of these Committees in meeting their objectives is strongly dependent on the support obtained from other institutional structures involved in the utilisation of the resources of the watershed. (Global Water Partnership, 2000)

The three main characteristics that could lead to the successful functioning of a river basin organisation, are considered to be, 1) motivation and understanding of the purpose of the organisation, 2) the presence of a forum in which all relevant stakeholders, including the central government take active part in and 3)financial and resource support to meet its objectives (Global Water Partnership, 2000).

The importance of sustained financial support is further reiterated by Hooper (2006), as one of the attributes that characterise the river basin organisations (Commissions responsible for watershed management at the river basin level) of the world that can be said to be implementing the IWRM framework with a measure of success. Other distinguishing features are, decision making that occurs within a national resource management plan and the presence of national legislation that defines the role of the river basin organisation and supports IWRM (Hooper, 2006).

Mitchell (2006) reflects on the experience of the implementation of IWRM at the watershed level in Canada, and discusses the importance of sensible planning, in ensuring efficient management. It is suggested that a joint vision of what is hoped to be achieved, and a focus on the components that are responsible for the biggest impact to the system could lead to more efficient and timely management. Further, consideration of the spatial scale at which management is intended to take place— be it basin/catchment, sub-catchment, tributary, environmental site plan is advised, so that the information necessary for decision making is collected with optimal use of resources (Mitchell, 2006).

2.1.1.3 Financial Support for IWRM Implementation

The importance of sustained financing for the implementation of the IWRM framework is discussed by Roy et al. (2009). In Canada, one method through which this has been achieved is considered to be joint ownership of IWRM projects by different governmental bodies. Further, the need for financial incentives (for example, environmental conservation measures upstream supported by the purchasing of credits by those responsible for emissions to the water downstream) is stated (Roy et al., 2009).

2.1.1.4 Multi-sectoral and Multi stakeholder Participation

The IWRM framework stresses on the need for a top down, and bottom up approach, to involving stakeholders (from the private sector to local communities) in the management of water resources and related decision-making (Global Water Partnership, 2000). Along with this multi-sectoral involvement, it is also suggested that priority is given to taking into account the views and needs of both upstream and downstream users of water (Global Water Partnership, 2000).

To facilitate this, Jaspers (2003) suggests a forum for participation, the representative mix of which would depend on the level of decision making and planning. A forum that is required for decision making at the operational phase would require the representation of all water users —direct, indirect and potential. At the level of strategic planning, apart from water users, the participation of government, NGOs, civil society and expert groups is recommended. Further, it is suggested that the forum should have the capacity and authority to make important decisions and the power to sanction them (Jaspers, 2003)

Multi-sectoral participation is considered to be the most important requirement for successful IWRM implementation in Canada. Indicators of such participation were considered to be, interdepartmental participation in projects with government involvement and diverse membership in committees, among others. Leadership initiatives and drive at a local level are considered another factor that could lead to success (Roy et al., 2009).

2.2 The Bioeconomy and Bioenergy Production

The production of energy from plant based sources, while having been a traditional method of energy production, is a practice that is experiencing revival in many parts of the world. This is seen as a crucial element of the concept of the bioeconomy, the main objectives of which are, enhancing food security into the future, the sustainable use and management of natural resources, transitioning to a low carbon economy through the use of renewable resources, reducing greenhouse gas emissions, and mitigating the impacts of climate change (European Union, 2012). This is accomplished through the use of raw materials sourced from renewable biological sources in the production of materials, energy and chemicals. Potential for its application is seen in the sectors of manufacturing, agriculture and health (European Union 2012; Organisation for Economic Cooperation and Development, 2009).

The role of the bioeconomy in the production of energy, or bioenergy has been widely recognised across the world. The European Commission defines bioenergy as "the conversion of biomass resources such as agricultural and forest residues, organic municipal waste and energy crops into useful energy carriers including heat, electricity and transport fuels"(European Commission, 2013). It is generally accepted that factors such as the global effort to reduce greenhouse gas emissions and mitigate the impacts of climate change, price fluctuations of fossil fuels and the potential unpredictability of their supply and a lack of consensus over other sources of energy such as nuclear power are pushing governments to design policies and national targets that facilitate the increased production and use of bioenergy (Goldemberg, 2007; McCormick & Kåberger, 2007; Rossi & Hinrichs, 2011). Further, the creation of employment opportunities and the contribution to the economy, which can also be felt in local, decentralised systems, is another anticipated benefit and motivation to invest in the development of bioenergy (Mangoyana & Smith, 2011; Rossi & Hinrichs, 2011).

2.2.1 Bioenergy Development

The various factors that shape and determine the success of whether bioenergy can successfully develop into providing for a country's energy needs is discussed by several authors. These authors agree, that these factors, which can act as barriers, can, when resolved transform into drivers that can accelerate the development of bioenergy. It is also generally concluded, that non-technical or institutional factors can be more important in determining the success of bioenergy projects, than technical elements (Costello & Finnell, 1998; McCormick & Kåberger, 2007; Roos et al., 1999; Rösch & Kaltschmitt, 1999).

These factors, or drivers and barriers, as discussed and categorised by different authors show a high degree of overlap. McCormick & Kåberger (2007) present an overarching classification, which is used here as the framework to discuss the literature on the topic.

2.2.1.1 Regulatory/Financial Support

McCormick & Kåberger (2007), through an analysis of case studies in Europe, discuss the need for policies and instruments to be deployed by the government to stimulate bioenergy development. Investment grants and subsidies for bioenergy projects and taxes on the use of fossil fuels are suggested as strategies to push the bioenergy sector to become competitive with that of fossil fuels. Further, they also discuss the need for suitable financial incentives on the side of the farmers, to switch from previous methods of production.

Costello & Finnell (1998) discuss the importance of regulation that anticipates the need for it. They suggest that when regulation lags behind the development of a new technology, it can hinder its expansion, but that when it adopts a more anticipatory approach that it can open up space for innovation.

In addition to the role of regulation and economic instruments in creating an enabling environment, constraints in obtaining private financing for bioenergy projects is identified as another financial barrier, by Costello & Finnell (1998) and Rösch & Kaltschmitt (1999). The emerging nature of bioenergy technologies are considered to be viewed as containing a higher element of risk, thereby resulting in more unfavourable terms and higher rates of return if private financing is to be sought (Costello & Finnell, 1998; Rösch & Kaltschmitt, 1999).

2.2.1.2 Know-how and Institutional Capacity

McCormick & Kåberger (2007) suggest that this can be considered from three aspects. These are, the knowledge and learning processes surrounding the technology and its implementation, the experience of farmers in growing the feedstock for bioenergy, and elements of support that enable them to obtain this and the perception of the public and policy makers. On the first aspect, the authors demonstrate how substantial investment in research and development and the provision of grants has paved the way for accelerated penetration of bioenergy production in Finland (McCormick & Kåberger 2007). On a related topic, Rösch & Kaltschmitt (1999) discuss the presence of excessive administrative procedures and bureaucracy, and state that unless the knowledge to navigate this is present, it may act as a deterrent against setting up and running projects.

The third aspect of perception, by the public, related industries and local politicians as an important influencing factor is discussed by many authors. McCormick & Kåberger (2007) discuss how perception of the fuel can act as either a driver or barrier. They look at a case in Finland, where the reaction to using waste for bioenergy generation has received support from the community, thus resulting in a swift installation of a biomass gassifier to meet this purpose. Conversely, the use of waste as feedstock acted as a barrier for acceptance by the public in a case in Italy, where the process was viewed as waste incineration (McCormick & Kåberger, 2007).

Familiarity with biomass technology is discussed as an important factor that influences perception. This can be from the side of the public, where the impression of bioenergy as an outdated technology associated with woodstoves may cause a lack of enthusiasm for implementation of new projects. Similarly, this could be from other industries dealing with biomass, such as the food and fibre industry. Here, a lack of familiarity regarding the potential to utilise any by-products and waste products for energy production may result in a lack of interest to move into this sector (Costello & Finnell, 1998; Rösch & Kaltschmitt, 1999).

2.2.1.3 Infrastructure and Supply Chain Coordination

The absence of existing infrastructure, including elements such as transportation routes for biofuels and personnel with the necessary expertise is considered to be a significant barrier in deploying bioenergy projects (Rösch & Kaltschmitt, 1999).

Infrastructure is a general term used for the entire energy service production and delivery system, including till the final consumer. In other words, this is the network of supply chains that meet the requirements of all of the stakeholders involved. Of the components of the supply chains, energy companies and biomass producers and suppliers are considered to be the most critical (Costello & Finnell, 1998; McCormick & Kåberger, 2007).

Roos et al. (1999) discuss the importance of competition, both within the bioenergy sector and with other businesses. Within the business, competition is required to stimulate innovation and technical development. Competition with other businesses is described as being one of the most crucial factors that can act as a barrier, and can be at the beginning of the supply chain (competition with other industries that use the same biomass as feedstock) and at the end (with other sources of energy) (Roos et al. 1999).

McCormick & Kåberger (2007) discuss how, in contrast to competition, synergies can be generated, by integration with businesses that produce waste products or by products that can be used as feedstock for bioenergy systems. An example from a town in Austria is considered, which has gained energy autonomy through synergies generated by close linkages between different actors. A farmers cooperative produces biodiesel from rapeseed (cultivated and supplied by farmers) and used cooking oil, which is then used for transportation and returned back to the farmers. A combined heat and power plant and a biomass plant that uses biomass from various sources (mainly waste products from other sectors) meet the town's heat and power needs. (McCormick & Kåberger, 2007)

The importance of looking at the potential of integration in supply chains is also discussed by Roos et al. (1999). The bioenergy sector as it is practiced today, is often integrated with other sectors such as agriculture or forestry, and can be based on feedstock (utilising the waste product from one sector), or the utilisation of structures such as machinery and the knowledge and infrastructure that are already in place. It is argued, that this can bring about synergies, thus reducing costs and risks, thus agreeing with what is discussed by McCormick & Kåberger (2007) (Roos et al., 1999).

Roos et al. (1999) also discuss the importance of scale effects in supply chains, which can be both in terms of economies of scale which can increase profitability and increased attractiveness for investment as the confidence in the market grows. This however, requires a certain degree of standardisation of the industry, which makes it different from the previous factor of integration that depends on adapting to a local context for success.

McCormick & Kåberger (2007) suggest that stimulating cooperation between different actors in the supply chain, and resolving the competition for biomass resources from different sectors are of particular importance in either hindering or advancing the progress of bioenergy projects. A case in Sweden is looked at, where contracts between farmers and the energy companies involved were needed to build trust and secure land for feedstock cultivation. In contrast, despite the presence of a regulatory environment that favours the implementation of bioenergy projects, bringing together the different actors involved and inducing trust and cooperation between them proved to be an important obstacle in an Italian case study (McCormick & Kåberger, 2007).

2.2.2 Bioenergy and Rural Development

A large proportion of the literature that looks at the socioeconomic aspects of bioenergy production looks at its potential to generate employment and to enhance rural development (Dauber et al., 2012; Mangoyana & Smith, 2011; Raslavičius et al., 2011; Rossi & Hinrichs, 2011). The application of the bioeconomy in energy production has also made it possible to shift from large centralised production systems driven by the need to maximise economies of scale to decentralised systems that make it possible to achieve the abovementioned benefits (Dauber et al., 2012; Mangoyana & Smith, 2011).

2.2.2.1 Decentralisation

Focusing specifically on decentralised bioenergy systems, Mangoyana & Smith (2011) discuss what factors would be of critical importance in generating successful bioenergy projects. The authors define decentralisation as "localisation of ownership, management, production, and marketing of bioenergy and related products" and consider heat and power generation in biomass plants of small and medium level (in Europe) and small biomass gasification plants in India as examples of this concept (Mangoyana & Smith, 2011).

Faaij & Domac (2006) make a comparison between the largely centralised bioenergy sector in Finland, and the more entrepreneurs driven, decentralised systems in Austria and Sweden, and find that the more bottom-up approaches led to an industry that was more diversified.

(Mangoyana & Smith (2011) conclude that economic sustainability is the most important driver, with acceptance by the broader community (through education and awareness creation, initiated at an early level) considered as another. Feedstock selection based on what is available in abundance both naturally and through other industries in the area, and a technology that is able to accommodate different types of feedstock is considered to be another factor for success.

Further, the development of synergistic systems through close-loop integrated systems and supply chains is considered to be a means through which successful decentralised systems can be developed (Mangoyana & Smith, 2011).This reinforces the view held by McCormick & Kåberger, (2007 and Roos et al. (1999) on the importance of integrated systems in driving the success of bioenergy projects.

A decentralised system of small and medium projects may in turn act as a driver to facilitate participation by local farmers. A survey conducted amongst rural famers in the United States revealed that farmers were sceptical of being the ultimate beneficiaries from bioenergy projects, as they felt that this will largely be captured by corporate businesses involved in energy and agricultural businesses, with vertical relationships between them. Government support was not viewed as a factor that may influence this. However, the formation of cooperatives among farmers, was viewed as a means of spreading the risk for those interested in cultivating the feedstock, although it is admitted that the success of such cooperatives depended strongly on cultural factors, such as the general degree of collectivism that is displayed (Rossi & Hinrichs, 2011).

2.2.2.2 Employment Generation and Rural development

According to Domac et al. (2005) the social sustainability of a bioenergy project can essentially be gauged by how different sections of society perceive the project, and how benefits are generated for them by the project. While developments on the global level such as climate change and energy security may concern local communities, factors that would influence a favourable view would rather be the generation of employment opportunities and local economic development (Domac et al., 2005).

The socioeconomic contribution of bioenergy systems is usually measured by different economic indices, quite often determined by a variety of factors ranging from the technology that is used and method of production, to the social structure and profile of the community

(Domac et al., 2005). However, Rossi & Hinrichs, (2011) reinstate the importance of going beyond what they describe as an 'instrumental view' of farmers as automatic suppliers of feedstock, and taking into account the more complex factors that may motivate or dissuade them. For example, in a survey done in the US on what motivated famers to move into switch grass cultivation, profitability emerged as a leading factor, but a factor that was also influenced by non-economic concerns such as other benefits generated for the community, potential contribution to rural revitalisation and personal values (Rossi & Hinrichs, 2011).

Domac et al., (2005) suggest that two interconnected aspects of the social dimension can act as drivers—rural development and employment generation.

Rural Development and Revitalisation: The potential of bioenergy to contribute to an increased standard of living of members of a community, by providing both direct employment and other socioeconomic benefits generated by both its operations and by those of supporting industries is generally agreed on. In addition to this, it is also expected to enhance social cohesion by contributing to rural development and by mitigating the tendency for rural out-migration (Domac et al., 2005; Rossi & Hinrichs, 2011)

Employment Generation: When all of the renewable energy sectors are considered, it was concluded that bioenergy has the highest potential for job creation. Employment potential can be further enhanced by deploying projects of a smaller scale, projects that use agricultural crops as a feedstock and by those used manual systems over mechanised ones. The employment generated can be through direct employment in the bioenergy and supporting sectors, or it can be induced employment. This is described as employment opportunities from businesses that either expand or spring up in the area, in response to the general increase in the purchasing power by bioenergy development. (Domac et al., 2005)

2.2.3 Utilisation of Marginal Land

Kuhlman et al. (2013) classify the types of feedstock used for bioenergy into four kinds— 1) starch crops widely used for the production of ethanol 2) oilseed crops used for the production of biodiesel 3) residues which can originate from agriculture, forestry and urban areas (municipal waste and associated products), and 4) biomass (grass, short rotation forests and other crops grown for the purpose of bioenergy production). The last two categories differ from the first two in that the entire plant body is used to produce energy, either from direct combustion or used as the raw material for the production of second generation biofuels (in the first two categories, only selected parts of the plant are used, resulting in less effective utilisation of the biomass) (Kuhlman et al., 2013; Sims et al., 2010).

The first two categories, also referred to as 'first generation biofuels' and which are the type predominantly being produced and in use today, have also faced controversy due to the nature of cultivation of the feedstock. The feedstock in the case of that for ethanol can also be used in food production, thus resulting in potential increase in food prices and decreased food security in other parts of the world—the 'food vs fuel' debate. In the case of oil seed crops, they have been traced to large scale deforestation of tropical rainforests. They have also been described as one of the reasons driving 'land grabs', where areas of land are leased or bought by transnational corporations or governments for various purposes, including the cultivation of the above mentioned feedstock. Further, the cultivation of the two types of feedstock have been described as requiring inputs in terms of fertilisers (and emissions of nitrous oxide and greenhouse gas) and energy for cultivation and transportation, both of which contribute to greenhouse gas emissions (Dauber et al., 2012; Kuhlman et al., 2013; Liu et al., 2011; Zoomers, 2010).

These concerns have resulted in an interest in other types of feedstock for bioenergy namely, residues from other industries and processes and the utilisation of the entire plant matter. Other advantages would be that land that is not conventionally used for the cultivation of crops (surplus land), could be utilised. It is believed that depending on the plant selected, that cultivation could be done with a reduced amount of input in the form of pesticides and fertilisers (Dauber et al., 2012; Kuhlman et al., 2013; Liu et al., 2011).

Surplus land could originate as a result of land not currently used for production due to unsuitable conditions, or spare land that has arisen as a result of more intensified cultivation elsewhere, thus removing the need for use. It is argued that taking into consideration the growing demand for food, that utilisation of the second category may have ethical implications and that instead, the possibility to use the first category should be pursued further. (Dauber et al., 2012)

Such surplus land could be of different types. Marginal land is that which under given natural conditions, technological advancement and other related policies and legislation, cultivation cannot be done in a cost effective manner. Degraded land is that which has lost its productivity due to previous use, and where this process is difficult to reverse. Waste land is that which naturally is unsuitable for cultivation and other human use (Dauber et al., 2012).

The advantages and disadvantages of using marginal land for the production of bioenergy is discussed by Dauber et al. (2012) and Liu et al. (2011). Of these, those factors that can act as socioeconomic drivers and barriers (other than those that have been previously discussed under those for bioenergy development) are reviewed below.

2.2.3.1 Extended Land Availability for Feedstock Cultivation

Marginal land can increase the amount of land that is available for feedstock cultivation, and depending on the feedstock, may require less input, while enriching the organic content of the soil that did not previously experience cultivation (Dauber et al., 2012; Liu et al., 2011). However, while it is expected that certain crops that require lower levels of input can be considered for cultivation, it is felt that this has not been studied enough. Therefore on the flip side, cultivation in marginal land can result in marginal yields (Dauber et al., 2012; Liu et al., 2011).

2.2.3.2 Low Profitability of Cultivation

Difficulties in accessibility (which could have been a reason the land has been considered cost ineffective for cultivation), and a topography that requires increased effort and machinery use for cultivation and harvesting may increase costs. In connection to this, the remote nature of many marginal lands could result in increased transportation and fossil fuel use, and once again, reduce profitability. The carbon debt that could arise through the conversion of ecosystems such as grasslands and peat land can also be considered an economic cost, if it is accounted for (Dauber et al., 2012; Liu et al., 2011).

It is suggested that these disadvantages could be mitigated at least partially by decentralisation of energy production and use (smaller boilers, in combined heat and power plants and anaerobic digestion are suggested as suitable technologies), the processing of feedstock to reduce its weight through techniques such as pelleting before transportation, and the conversion into electricity carriers such as biogas or electricity, in the case of distant markets. The suitability of such solutions in a given context would become a decisive factor in deciding the cost effectiveness of such cultivation (Dauber et al., 2012).

Wetlands are recognised as marginal lands for bioenergy production. However, it is cautioned that while the limited potential as areas of cultivation make them marginal for agricultural use, that their immense value for providing other ecosystem services, as well as being a habitat for biodiversity would mean that any utilisation should be carefully planned (Kang et al., 2013; Paine et al., 1996).

2.2.4 Utilisation of Reed for Biomass

A feedstock category that can be cultivated on wetlands, although not widely practiced at present, is reed. Much of the literature focuses on the Common Reed (*Phragmites australis*), which also has other traditional uses in weaving and roof thatching (Köbbing et al., 2014; Kuhlman et al., 2013; Vaičekonytė et al., 2014). The following factors can act as economic and social drivers or barriers, if reed is considered to be used for bioenergy production.

2.2.4.1 Characteristics that Favour its Utilisation for Feedstock

The Common Reed is considered suitable for bioenergy production for many reasons. It has high lignocellulostic content (a preferred characteristic in biofuels), displays rapid increase in biomass, does not require inputs in the form of fertiliser for growth, and grows in single species clusters, which makes it easier for harvesting. Further, it can be cultivated in land that is considered marginal for other forms of land use for example, peat soil. In such soils, the common reed is able to tolerate high levels of salinity (Köbbing et al., 2014; Kuhlman et al., 2013; Vaičekonytė et al., 2014).

2.2.4.2 Technological Feasibility

On the availability of the technology for harvesting and processing into bioenergy, it is felt that being similar to switchgrass, also cultivated for bioenergy production, the same technology that is widely available in North America for processing into pellets can be utilised (Vaičekonytė et al., 2014). With regard to conversion to energy, Kuhlman et al. (2013) conclude that in the Netherlands, direct combustion for district heating and/or production of energy would be the most feasible in terms of cost, with co-digestion with other waste products also considered an option especially for smaller units. Another study conducted in Inner Mongolia, China, found that if used in straw furnaces for direct combustion in rural households, the practice becomes cost competitive with coal. However, it was concluded under the existing policy and legislative environment, and technological advances, more large scale processing is yet to become cost competitive (Köbbing et al., 2014).

2.2.4.3 Generation of Carbon Credits

On other advantages of utilising reed for bioenergy production, the maintenance of peat soils without conversion to drier landscapes, a process which results in a net release of greenhouse gases into the atmosphere, with the commercial implication of generating carbon credits through this process is considered. This has an additional benefit that is, the conservation of such areas for biodiversity protection. (Kuhlman et al., 2013; Vaičekonytė et al., 2014)

2.2.4.4 Controlling Invasiveness

The ability to grow rapidly which makes the plant a suitable candidate for bioenergy feedstock, also contributes to an increased potential by the plant to become an invasive species in new habitats. The removal of the common reed in such situations, can be financially consuming in terms of harvesting and disposal. Thus, it is believed that the further processing of the plant for bioenergy generation can lead to an integrated approach to habitat management. This is already implemented in Finland, where the common reed, harvested from the wild, under carefully controlled conditions is utilised for bioenergy production. Such harvesting could open up new spaces for wildlife habitat, but continuous harvesting is believed to cause the reed beds to thin over time, resulting in less biomass being produced (Kuhlman et al., 2013; Vaičekonytė et al., 2014).

2.2.4.5 Role in Integrated Management

It is suggested, that the utilisation of reed is not financially feasible under the current scenarios studied. However, it is believed that this could change into the future, as policies and targets by governments around energy use and climate change evolve. The greatest potential is seen in an integrated approach, along with land and water management strategies such as IWRM (Kuhlman et al., 2013). Under this, the ability of reed to absorb large amounts of nitrates and phosphates, thus contributing to water purification (especially when harvesting is done in late summer), and the ability of the wetland habitats created by reed species contributing to water buffering through storage of water during periods of flooding, and release during drier spells is expected to be a characteristic that can contribute to cultivation of reed as part of a multifunctional land-use system, under the IWRM framework (Kuhlman et al., 2013; Vaičekonytė et al., 2014).

3 Research Methodology

This section outlines the overall research methodology used for the study. It describes the different methods used for data collection and the analytical frameworks used to meet the objectives outlined in Chapter 1 and which develops into Chapter 2 (Literature Review), Chapter 4 (Case Study) and Chapter 5 (Analysis of the Case). The overall structure of the research methodology will be in the form of a case study.

3.1 Literature Review

The Literature Review was performed utilising online search engines, of which, the most extensively used was 'Google Scholar'. Peer reviewed journal articles and publications by different organisations (including IISD) were reviewed. A preliminary review of the literature revealed, that there was a dearth of publications on similar contexts to the one in which the project is based, where land and water management is integrated with bioenergy production. Therefore the main aspects of the project were selected, and a review of the available literature on each of these was done separately, focusing on the socioeconomic drivers and barriers, keeping in line with the objective of the study. The following five aspects were looked at,

- Integrated land and water management
- General bioenergy development
- Bioenergy production in the rural context
- Utilisation of marginal land for bioenergy production
- Utilisation of reed as bioenergy feedstock

Although the different aspects were looked at separately, taking into account the integrated nature of the projects, points of overlap between the different aspects were identified. This overlap, along with the drivers and barriers identified from the literature review, was used to construct the analytical framework presented in Figure 3-1. The detailed literature review is presented in Chapter 2.

3.2 Data Collection and Analysis

Part of Objective 2 (construction of the case study) was done through a desktop study, and through the use of materials provided by IISD. This was mainly used to obtain background information on the project itself and the environmental and socioeconomic issues faced by the watershed.

All of the fieldwork was conducted from the IISD office in Winnipeg. The initial phase of data gathering consisted on informal discussions with the staff from IISD, and through attendance at meetings related to the project. However, the majority of the data collection came from the interviews. The interviews were of an in-depth, semi-structured nature, mainly conducted through the phone, and four in person, each lasting about half an hour to 45 minutes. When permissible, they were recorded for clarification, and to maintain accuracy. A total of stakeholders were thus interviewed for data collection.

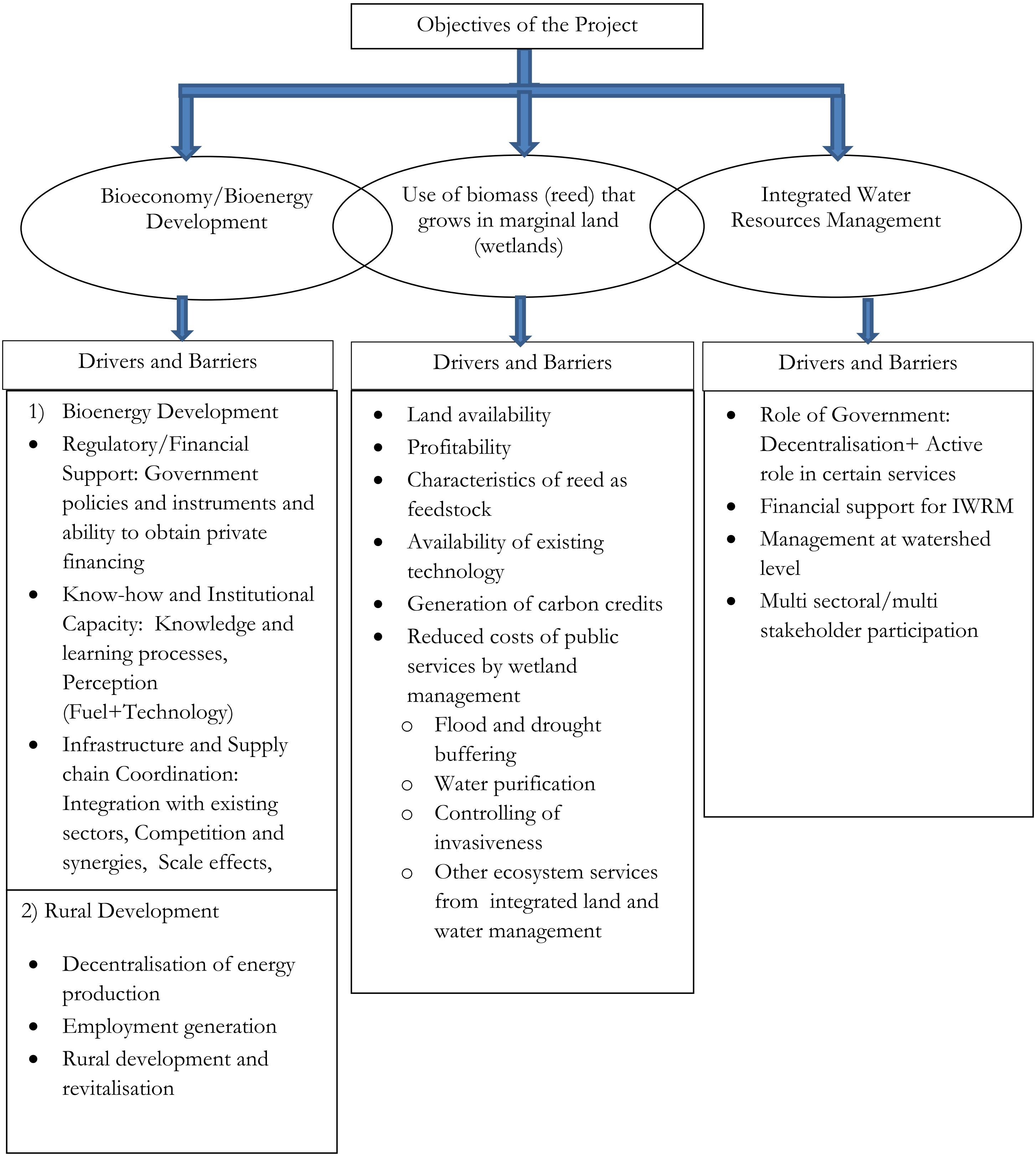

Figure 3-1: Analytical framework developed from Literature Review

The interviewees were selected based on the expertise and contacts of IISD. The categorisation of the different stakeholders for the purpose of organisation, and questionnaire design are given in Figure 3-2. The detailed list of the stakeholders interviewed, and their areas of occupation and expertise are given in Appendix 2.

The framework developed from the Literature Review in Chapter 2 was utilised to identify specific areas of focus for discussion with each stakeholder group. This is presented in Appendix 3. However, it must be noted, that the questions were not limited to these categories, but that an attempt was made to obtain their views on all aspects of the project.

Data was also be collected from two field visits to Providence College and the Greenwald Hutterite Colony, the two main end users of bioenergy.

The results from the interviews were transcribed, and main themes that emerged were selected and analysed in more detail. The data from different sources (interviews and literature) was triangulated to maintain accuracy. The importance of the benefits (through a method of ranking) for the different stakeholder groups was performed

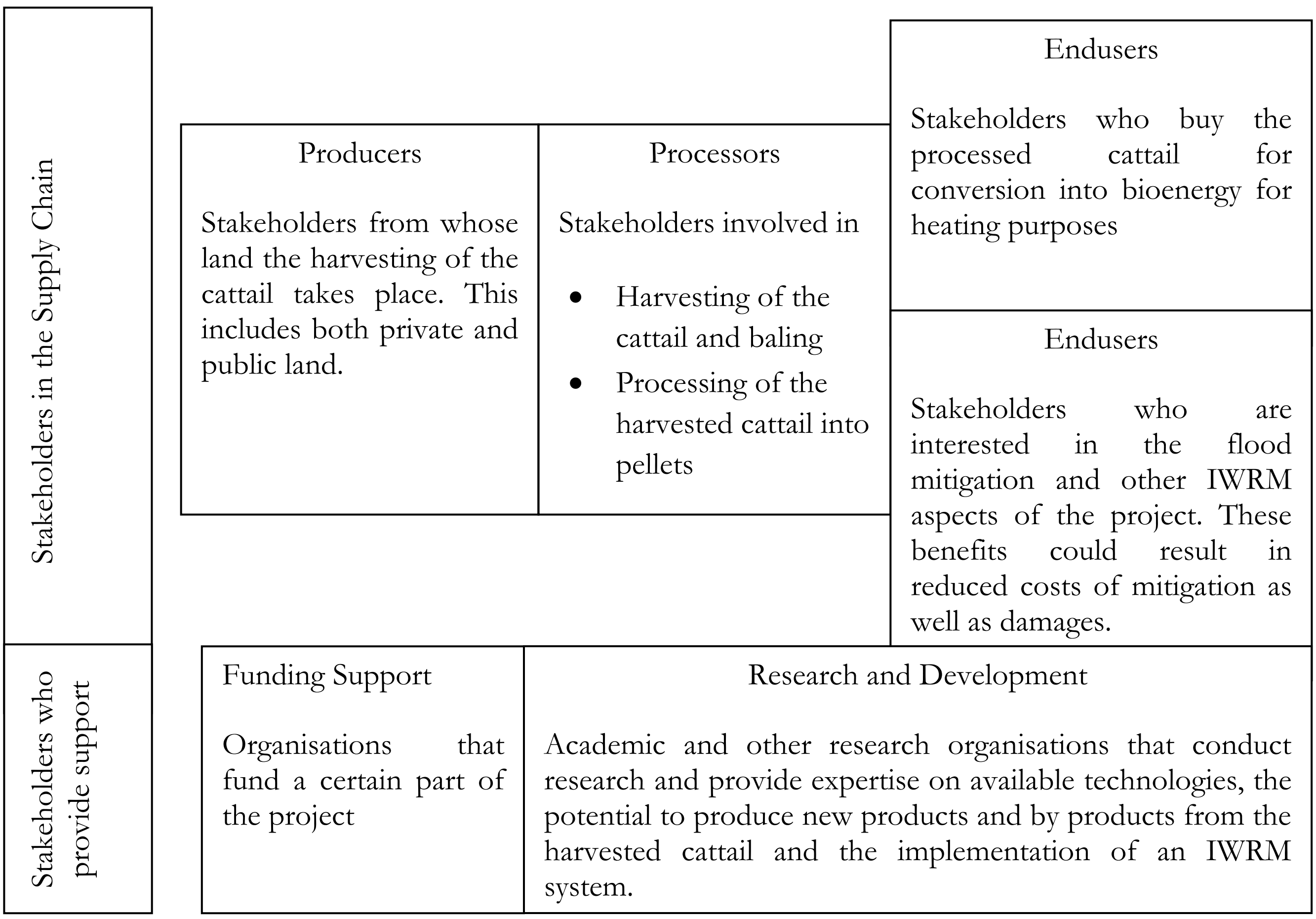

Figure 3-2: Categorisation of stakeholders into different groups for data collection

3.3 Construction and Analysis of the Case Study

The case was constructed using the data collected from the interview, as well as from the desktop study, and through the main themes that were identified from data analysis. The analytical framework constructed from the Literature Review in Chapter 2 was used to identify the main socioeconomic drivers and barriers, and to analyse them further. Case study and analysis of the case were based on the structure of the analytical framework.

These, along with the information about the existing status of the system, was then studied along with the ranking of the benefits, obtained from the data analysis, as described in section 3.2. The purpose of this was to identify why certain benefits would be of more importance to a particular stakeholder group, and what factors (current status and drivers and barriers that could change the current status) may influence this. This was a qualitative analysis. The conceptual diagram that represents this process is given in Figure 3-3.

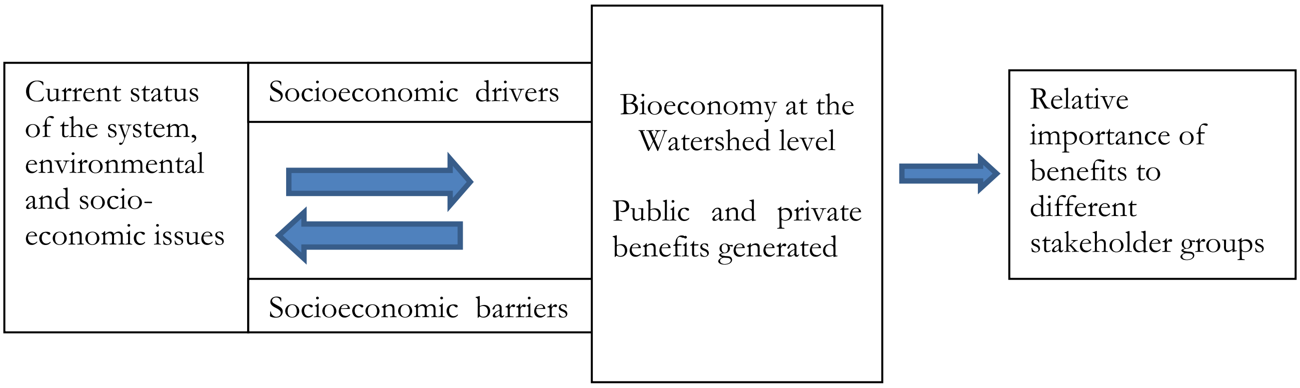

Figure 3-3: Conceptual diagram for transferability—analysis of the influence of the existing status and drivers and barriers of the project on the ranking of benefits in different contexts.

The transferability of the study was examined through a comparison made with another case study from Minnesota, US which shares many similarities to the current study. The information for the case study was obtained through in-depth interviews with members from the Red River Basin Commission. This analysis was along the same structure, as the one followed for the case in Manitoba.

The benefits that were used for analysis from both of the case studies were those that were common to both cases. Thus, the analysis was used to identify how, when given a standard set of benefits that such a project could create in two similar watershed, the combination of the current status and the drivers and barriers the project would face will influence the importance of the different benefits to the different stakeholders. This is conceptualised in Figure 3-4.

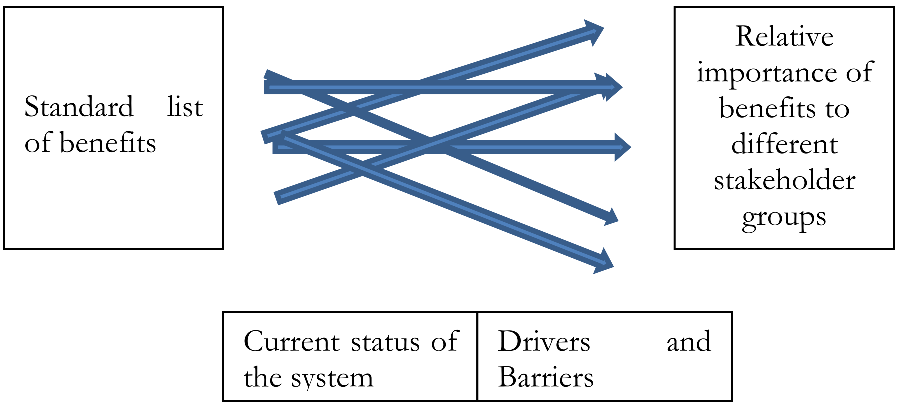

Figure 3-4: Conceptual diagram showing the relationship between a) the existing status of the system and the drivers and barriers to the project to the benefits created b) to the ranking of benefits by stakeholders

4 Background to the Case Study

The purpose of this chapter is to provide conformation that would act like a foundation for the case study construction and analysis done in Chapter 5. The unit of the case study is the entire project by IISD on stimulating a bioeconomy in the Lake Winnipeg watershed and its implementation, and therefore does not have a geographical boundary.

The background to the case, including a description of the watershed, and the environmental and socio economic issues faced by it will be described. This is followed by a brief description of the project and the main stakeholders involved. The majority of the information presented is obtained from the interviews conducted, and this is supplemented by a desktop study, as discussed in Chapter 3.

4.1 Introduction to Manitoba

Manitoba is a province in the centre of Canada, and has a land area of roughly 650,000 km^2. The capital of Manitoba is Winnipeg, which is the most densely populated part of the Province. Nearly 750,000 of the 1,200,000 inhabitants of Manitoba live in Winnipeg. The mineral-rich East and North of the Province are dominated by forests and freshwater systems, which are tapped into, for hydropower production. It is estimated that almost 1/6th of the Province is covered by around 100,000 lakes, of which Lake Winnipeg is the largest. The South consists of prairie grasslands, and extensive agriculture is practiced here. Almost 10% of Canada's agricultural production occurs here, which includes livestock rearing and the production of different types of grains and cereals. Manufacturing, mining and hydropower generation are the other major industries in the Province (Government of Manitoba, 2013).

4.2 Main Environmental and Social Issues Faced by Manitoba

The main environmental and social issues faced by Manitoba, as identified by the stakeholders interviewed is given below.

4.2.1 Nutrient Loading into Lake Winnipeg

Phosphorous levels in Lake Winnipeg have nearly doubled from 1992 to 1999, and have remained the same, ever since. This spike in nutrient concentration was followed soon after by a doubling of phytoplankton levels, dominated by communities of cyanobacteria, of the nitrogen fixing variety. Nitrogen loading has been lower than that of phosphate, which favours nitrogen fixing bacteria (Schindler et al., 2012; McCullough et al., 2012).

The increased phosphate loading is largely associated with the Red River, which originates from the US and flows into lake Winnipeg. While being one of the three major rivers that are part of the Lake's Watershed (the other two being the Assiniboine and Saskatchewan Rivers), the red River brings in 68% of the total phosphate load in the Lake, while contributing to 16% of total water flow. A map displaying the watershed of Lake Winnipeg is given in Figure 4-1.

Much of this comes from intensified agricultural practices in the basin, as well as an increase in the magnitude and frequency of Spring runoff. It is found that the increase in flooding results in more phosphorous being transferred, than the increase for human use has. The City of Winnipeg is believed to contribute towards 5% of the nutrient loading into the Lake (Schindler et al., 2012; McCullough et al., 2012).

The majority of the stakeholders (17 respondents) were of the opinion that this is the most important environmental or socio-economic issue facing the Province. The Lake is a source of commercial and recreational fishery, tourism and is widely seen as part of the image of the Province. Although less frequently mentioned, the health of the other Lakes in the area was also raised as a subject of concern.

Figure 4-1 : Water shed of Lake Winnipeg

Source: Environment Canada, 2011

4.2.2 Water Quantity Management for Flood and Drought Mitigation

While water quality is of serious concern in Manitoba, water quantity issues were the second most frequent environmental/socio-economic issue associated with Manitoba, as felt by the stakeholders interviewed (8 stakeholders). It was felt that water quantity issues could arise because of two reasons—the gradual loss of wetland cover, as a result of transformation of the landscape to one being more suitable for agriculture, and the impact of climate change into the future.

It is believed that as much as 70% of the wetland cover in the Red River Valley has been lost because of conversion to land that is suitable for agriculture, from which water is drained quickly. However, this process of draining the land, and loss of wetlands that acted as buffers and storage areas for water during floods and drought is described as being one reason for the increased magnitude of flooding, and the rapid movement of water during Spring run-off.

The second concern is regarding climate change, which is expected to increase the frequency of both flooding and droughts in the region. Certain models predict that by 2050, that precipitation in the Lake Winnipeg Watershed will increase by 5.5-7.7%compared to the values for 1980s. This is expected to result in a surge in Spring run-offs (Dibike and Shrestha, 2011). Drought is expected to increase in frequency as well. It is believed that the south-western part of Manitoba would be affected by water shortages in the future. It is also believed that the increased precipitation as a result of climate change will accelerate nutrient transfer into the Lake.

4.2.3 Concerns around Renewability of Energy Sources and Biomass

The third issue raised by the stakeholders (3 stakeholders) was that associated with the current energy portfolio of the Province, as well as utilisation of biomass without reaching the full potential for it. It is felt that Manitoba was considered a pioneer in the 1960s, when the generation of hydropower began, but that since then, no major steps have been taken towards adopting renewable sources of energy. Another stakeholder felt that the strong dependency on hydropower also brings with it many hidden costs, including the changes to the hydrological flow and the consequent impact to ecosystems, sedimentation and the other social costs of displacements during the construction of dams.

With regard to the current energy mix, the need to transition away from natural gas and coal based sources to more renewable sources was mentioned. The need to utilise more thoroughly, the diversity and abundance of biomass that the Province produced was another concern associated with this. Mainstream use of biomass in the Province is till now largely for food production, but it is felt that the potential for application in energy production as well as in other industrial applications is there and needs to be explored more.

4.2.4 Poverty of First Nations Communities

This was raised as the main social issue faced by Manitoba (2 stakeholders). There are 63 First Nations Communities in Manitoba, many of whom are impoverished economically and it is felt this is an issue that will have to be addressed. Manitoba is believed to be the Province that has the highest percentage of those of aboriginal ascent—16.7% of the Province's population identify themselves as thus. However, unemployment rates are higher among these communities, when compared to the average for the rest of the province. In addition, 62% of the children of aboriginal descent live below the poverty line (Canadian Centre for Policy Alternatives, 2013).This also impacts other aspects of social wellbeing, such as education and health, thus making this an important socio-economic issue that has to be addressed.

4.3 Introduction to the Project by IISD

The project by IISD was first conceptualised as one of the solutions to address the increasing phosphorous loading and eutrophication of Lake Winnipeg, at a summit held in 2010 to address the issue (IISD 2013). Harvesting of the cattail began at a pilot level in 2011, after which it moved to a more commercial scale in 2012. The harvesting till now has been from three locations which are,

1. **The Netley-Libay Marsh:** This expanse of wetland occurs at the mouth of the Red River, before it empties into Lake Winnipeg, covering an area of roughly 250 km^2. The Netley-Libau Marsh was once a productive wetland ecosystem, which assisted in filtering a large proportion of the nutrients brought in by the Red River. However, at present, due to large scale alterations of the wetland, this process of filtration, and other wetland functions are disrupted (IISD, 2013). Harvesting the cattail from this location is therefore considered to be an effective strategy to capture the nutrients brought in with the Red River, before they are discharged into the Lake.

2. **Pelley's Lake:** This is an area of 23,000 acres (993 km^2) and is a historical marshland that is seasonally flooded. Retention structures were put in to convert this into a retention basin, so that it could hold in water for longer periods of time. Thus, it is able to hold in the large flush of spring-run off. The area is then drained in the summer, and when it is dry enough, the cattail growing in it is harvested. This is considered to be the biggest harvesting project conducted till now, by IISD.
3. Storm water ditches found alongside the Trans-Canada Highway, have also been locations from which harvesting has been done.

From the harvesting of the cattail to its processing and final end use, and for support on various aspects of the project, different types of stakeholders work with IISD. Their association with the project is given in more detail below.

4.4 Introduction to the Stakeholders

The stakeholders associated with the project can be divided into two main categories as described in Chapter 3 — stakeholders in the 'supply chain', and stakeholders who provide support for the project. It must be noted, that this section describes the stakeholders interviewed for the purpose of the study, and that it is not a complete overview of all of the stakeholders involved with the IISD project.

4.4.1 Stakeholders in the Supply Chain

This includes individuals and organisations who collabourate with IISD on the supply chain of the project — from the harvesting of the cattail to the processing and end use. The final benefits from this process are both in the use of the cattail for various applications in the bioeconomy, as well as in the benefits arising from wetland and watershed management. Thus, the end users are those that would be the recipients of both types of benefits.

Producers: These include landowners whose land currently includes the Netley-Libau Marsh and Pelley's Lake. Three of the stakeholders interviewed also have a background in farming. In addition, to obtain the views of other farmers and landowners who may become involved with the project's bioeconomy and IWRM components in the future, representatives from Keystone Agricultural Producers (KAP) were interviewed. This organisation is a representative body for farmers in Manitoba, and is interested in concepts and practices that can support the sustainability of agriculture in Manitoba.

Processors: IISD collabourates with two organisations for the harvesting and the processing of the cattail. The first of these, the Prairie Agricultural Machinery Institute (PAMI) is a company from Manitoba that does research on different aspects of agricultural production as well as on designing and producing equipment for harvesting. PAMI has been involved in designing and providing equipment for the harvesting of the cattail, and has also provided assistance and advice on selecting suitable times and sites for harvesting, yield analysis and on further applications of the harvested cattail. Biovalco is another locally based company that designs and produces combustion equipment to produce bioenergy. In addition, Biovalco does research and collabourates with other stakeholders on further processing and production of biomass into different products.

Endusers — Bioenergy: Bioenergy is currently being utilised by certain institutions and communities in Manitoba, mainly for the purpose of space heating. Of these, Hutterite colonies are an important stakeholder group. Hutterites are small rural communities that live traditional lifestyles of self-sufficiency guided by religious beliefs. It is estimated that around 132 Hutterite colonies currently reside in Manitoba. Agriculture and manufacturing are the main sources of income for these colonies. Apart from the Hutterites, biomass burners are also used by a few institutions such as a higher education institute called Providence College, as well as The Living Prairie Museum, managed by the City of Winnipeg.

Endusers — IWRM Benefits: While the potential watershed benefits generated by the project would be felt by the entire province of Manitoba, it is certain administrative bodies which at present manage the Lake Winnipeg Watershed that would be interested in implementing these concepts. This includes both the provincial government and the City of Winnipeg. Apart from these, Conservation Districts are an important stakeholder group in this category. The Conservation Districts of Manitoba work on different aspects of land and water management, and in connection to the project, with the IWRM associated with the management of the watersheds of Manitoba. There are 18 Conservation Districts across the Province, and two—the East Interlake Conservation District and the LaSalle Redboine Conservation District contain two of the sites from which the cattail has been harvested so far, Netley-Libau Marsh and Pelley's Lake.

4.4.2 Stakeholders who Provide Support

This includes individuals and organisations who provide their expertise on various components of the project, and organisations which support the project financially through different ways. Examples of the first category are academic and other research organisations that conduct research and provide advice on processing technologies, new applications of the harvested cattail and on watershed management. As many of the stakeholders interviewed belong to both categories, they are discussed together. It must also be noted that many stakeholders discussed under those on the supply chain can also be placed under these categories.

Funding Support: Manitoba Liquor and Lotteries (MBLL) and Manitoba Hydro are both Crown Corporations (owned by the government, but managed privately). Manitoba Hydro is the sole provider of both electricity and natural gas to the Province. Both organisations have been involved with the project since its inception through the provision of funding support. Manitoba Hydro utilises Lake Winnipeg to produce hydropower, and has is therefore mandated to regulate and manage the water levels of the Lake.

Research and Development: The University of Manitoba conducts research on many aspects of watershed management, and therefore works with IISD through knowledge sharing. Other organisations have similarly been involved on topics related to applications in the bioeconomy. One of these is the Composites Innovation Centre, which studies potential applications of biomass in the production and marketing of biofibres and biocomposites, so that these can be used in other industrial applications. Stakeholders that work on bioenergy development include Manitoba Agriculture, Food and Rural Development (MAFRD) a governmental department, Climate Change Connection, a project by the Manitoba Eco Network (a not-for profit organisation working on environmental sustainability), DLF Consulting a consultancy on renewable systems and 50 by '30, a network of Manitobans who work towards increasing Manitoba's renewable energy ratio to 50 percent from the current 30 percent by 2030.

5 Analysis of the Case

The objective of this chapter is to present the case study, as well as the analysis of it. The majority of the information in this chapter is obtained from the interviews of the stakeholders, as described in Chapter 3. When the source is from elsewhere, it is indicated. The structure of this chapter closely aligns with the analytical framework presented in Chapter 3, which was also the base for analysis. The information from this chapter will provide the base for analysis of part of Chapter 6.

5.1 Bioeconomy Development

The bioeconomy discourse in Manitoba is at present largely dominated by the topic of bioenergy production. Although applications in other sectors are not unknown, much of it is still in the conceptual stage, or has been the subject of small scale commercial applications. Thus, the primary use or potential for use that biomass (and other natural material) is expected to have in Manitoba is bioenergy production, at least in the foreseeable future. The utilisation of the cattail in bioenergy production still largely remains as concepts, or in small scale experimental projects. Therefore, information on the drivers and barriers on more large scale generation of bioenergy is mostly regarding other types of biomass. For this reason, the drivers and barriers discussed below focus on those for general biomass utilisation. Drivers and barriers specific to the cattail are discussed in section 5.3.

5.1.1 Infrastructure and Supply Chain Coordination

Competition from other businesses, both at the beginning of the supply chain (competition for biomass with other industries that may utilise it as a feedstock, and at the end of the supply chain (with other sources of energy) have been described in literature as one of the most critical barriers that will have to be resolved (Roos et al.,1999). The dominant sources of energy in Manitoba are hydropower, natural gas and petroleum (for transport). The bioenergy development till now has mainly looked at the production of energy for heating, with direct combustion of either unprocessed or processed biomass being the main topic that is pursued. There is also some interest in utilising it for electricity generation, for example through cogeneration, although this is much less developed.

While a diversity and abundance of biomass that can be utilised for bioenergy production are available in Manitoba, and there is some use of it, it is not systemised and does not supply any major sector. Therefore, the dominant discourse on competition centres around the alternative sources of energy that are available in Manitoba, and not on competing sectors that use biomass s feedstock.

5.1.1.1 Competition from Alternatives: Dominance of hydropower and Natural Gas

The main sources of energy in Manitoba are natural gas (32%), petroleum mainly for transportation (40%) and electricity (26%). Manitoba Hydro is the sole supplier of both electricity and natural gas to the Province.

Natural gas is used to meet the space heating needs of the proportion of the Province that is connected to natural gas lines. The fuel is imported from Alberta where it is produced and brought into the southern part of the Province through a transmission pipeline. Around 100 communities residing in the southern end (where much of the population of Manitoba resides) are connected to the transmission lines (Manitoba Hydro, 2015a). Hydropower meets nearly all of the electricity needs of the Province. All of the hydropower is manufactured in the Province by Manitoba Hydro. The abundance of aquatic resources in the Province are tapped into for this purpose, including Lake Winnipeg.

Low Costs and Convenience to Consumer: Natural gas is considered to be a commodity that is supplied at low costs throughout North America. The cost per unit of natural gas, which is set by Manitoba in accordance with world prices, has been dropping steadily in the past years, making it a cheap source of heating fuel for users. A large proportion of the electricity that is produced within Manitoba is consumed domestically, and the price charged from consumers is set close to the cost of production, making this another cheap source of energy. The prices per unit charged from residential consumers for both electricity and natural gas is given in Appendix 4.

The University of Manitoba (the largest university in Manitoba) is considered to be one of the ten largest consumers of natural gas in the Province. In a pre-feasibility study that looked at the potential for the University to switch to bioenergy from its current utilisation of natural gas it was concluded that the current low natural gas prices would make the switch economically inefficient in terms of costs. While the price for the biomass was set assuming that it would be purchased at little or no cost (set at 1 $/GJ (EUR 0.71)[1] the low price of natural gas (set at 5 $/GJ (EUR 3.54) meant that the capital costs of switching still made the transition an unattractive option.

The variations in price of natural gas also influence the interest that would be diverted towards bioenergy development. Almost a decade ago, prices rose to around at 10 $/GJ (EUR 7.07), which is believed to have stimulated interest by the government and the business community in putting into place mechanisms for bioenergy development. However, as prices slowly fell, this momentum was lost. In fact, some of the stakeholders, particularly from the processing side were of the opinion that it is more challenging to maintain enthusiasm in bioenergy systems, in the face of such fluctuations in prices.

Apart from the competitive prices, the convenience of access to the fuel and reliability of supply were described as other advantages in using these sources of energy. A biomass burner would require the fuel to be transported to the location of energy production periodically, and would therefore be dependent on the regularity of the source of supply. This would not be the case with both natural gas and electricity however, where supply is from a centralised system, and continuous, with minimal interruptions to supply.

Lack of Connectivity to Natural Gas Lines: Accessibility to natural gas lines is mainly around the southern part of the Province, where Winnipeg is situated. The population becomes more sparsely distributed towards the North (estimated at 1 person per square mile or every 2.6 km^2), and mainly consists of rural areas. Taking into consideration this distribution, the natural gas gridline has not been extended towards the North, resulting in communities in these areas not having access to natural gas. The heating needs of these communities are met largely through the usage of coal (soon to be subjected to a coal ban), propane and electricity. However, when considering the cost per unit paid for both propane and electricity (when used for space heating) it is felt that bioenergy in such situations could become cost competitive.

[1] Exchange rate: 1 CAD=0.71 EUR (as at 15 July 2015) *Source: www.xe.com*

Export of Hydropower: Of the hydropower generated in Manitoba, nearly 32% is currently exported to other provinces in Canada, and to the US, where the price is determined by market forces. Thus, this is considered to be the main source of profit to Manitoba Hydro, as it is mandated by the government that domestic prices are set near the cost of production. Thus, it would be in the interests of Manitoba Hydro, to lower the amount of electricity consumed within the Province and increase other methods of electricity generation, particularly if the generated power can be fed back into the system. In addition, export of hydropower to the US would also result in a displacement of consumption of energy originating from coal or natural gas in the US.

While other alternative sources of energy and power are present in the Province, such as solar, wind, biogas from landfills and geothermal, their present state of development is not considered to be large enough for them to be considered as major competitors to bioenergy development.

5.1.1.2 Abundance and Availability of Biomass for Bioenergy development

The biomass that is currently available in Manitoba that can be utilised in bioenergy production originates as by-products from mainly two sectors—agriculture and forestry. It is estimated that around 15,000 to 20,000 tonnes of biomass is consumed for the utilisation of bioenergy, and that a mature industry will require around 300,000 to 400,000 tonnes.

Present Use of Biomass: The agricultural sector is the predominant user of biomass in Manitoba. After harvesting is completed, working the crop residue back into the field is not an unusual practice to increase soil fertility. It is also reported that, some of the biomass is burnt from time to time. It is generally agreed though that very little of the waste biomass leaves farming properties to be disposed in other ways, such as landfilling. Composting, and the marketing of the product as an alternative to landfilling of biomass is a practice for which the opportunity is currently being explored by the City of Winnipeg. Another important application of biomass in farming is in the use of hay as feed for livestock, and for livestock bedding.

Taking into account all of these uses, the need for recognition of the value of biomass to farmers, and the need to move away from the perception that it is a 'free resource' (having no other competing uses), was voiced strongly by the stakeholders interviewed from the agricultural/producers community.

Research on the potential for the production of biofibres and biocomposites is also currently being conducted for certain types of biomass, with the current focus being on flax and hemp. Bast fibres (fibres that help the plant to remain upright during wind) from both these plants can be mixed with thermoplastics and moulded, to produce material that can be used to manufacture interiors for the automobile industry. It is believed there is strong potential for this in markets in Europe and the USA.

A Lack of Competition from Major Industries: While both the present and potential future use of biomass is seen, apart from agriculture, there is yet no major industry that utilises biomass in a systematic and large scale manner as a feedstock for their operations. While certain industries have emerged for this purpose, they have met with limited success. The failure by these industries to sustain operations can be attributed to difficulties in maintaining both supply and demand. Wood was the biomass that was targeted by two such ventures — one that had worked on using wood stubble to produce pressure boards, and another that had produced pellets from wood for biomass burner. However, in both cases, demand had not been sufficient enough to become commercially viable.

Interchangeability of Biomass for Bioenergy Production: Perhaps the biggest strength that bioenergy development would have in terms of supply, in comparison to the experience described previously is that the production, processing and combustion of biomass could be carried out to include a variety of biomass with similar properties. This is true for both the biomass burners, which are used in Manitoba, as well as the expectations of the customer that might be interested in obtaining biomass for biofibre and biocomposite production. In both cases, it is key certain properties that are required by the customer, and the source of biomass that meets these requirements is not relevant. For bioenergy production it must be noted, that interchangeability is easier for processed biomass (e.g. pellets from different types), than it is for raw biomass (in the case of combustion without further processing). This aspect of interchangeability can be applied to promote the development of bioenergy through two approaches.

<u>Standardisation:</u> A lack of knowledge among potential users regarding the type of biomass they should select is seen as a barrier in developing confidence in bioenergy systems. This is discussed in more detail under the section 'Know-how and Institutional Capacity'. Taking this into account, and the fact that different type of biomass may have similar properties of bioenergy production, the need for a scheme of standardisation was raised by many, especially those involved actively in bioenergy development. In such a scheme, a potential user would be able to buy biomass with requirements such as heat content, moisture content and ash content, irrelevant of the type of biomass that is used. It is believed that such a scheme could help increase confidence in investing in bioenergy systems, by reducing the confusion that could arise from having too high of a variety in potential feedstock.

<u>Contracts based on needs:</u> Citing the examples from Europe and Asia, where the practice is more prevalent, a system where a long term contract would be made between the user and supplier was suggested. In such a system typically a bioenergy user would specify the needs of their system, for a certain period of time, following which a tendering process is carried out. Again, the supply could come from a variety of sources according to availability, and reduce the burden on the end user of requiring extensive knowledge of the system.

5.1.1.3 Potential to Generate Synergies

Integration with other industries in the area, and the usage of waste or byproducts as feedstock in production, is described as being one of the success factors that could drive a bioenergy system (McCormick and Kaberger, 2007).

Opportunities for this are already seen and exploited at small scales in Manitoba. The experience from pellet production as a fuel by the collabouration between Biovalco and the Greenwald Hutterite Colony is an example of this. Biovalco and the Greenwald Hutterite Colony currently collabourate on options which the colony can adopt, to move away from coal.

One of the inputs in this process of pellet production is woodchips which are sourced from a wood processor. For the wood processor, woodchips are a waste product. The woodchips are uniform in size (screened during production) and have optimal moisture content, which give them favourable properties in being used as feedstock. As they are a waste product for the producer, and will otherwise have to be disposed of, they are sold at a very economical price—$40/ per tonne (EUR 28.28 per tonne). The amount supplied is considered to be sufficient to meet the demand of 4-5 Hutterite colonies.

A similar situation faces sawdust—another type of waste from the wood industry. In the past, it was sold to the pulp and paper industry, which was used to meet the energy of its operations. However, the industry has taken a downturn in recent times. Large scale pine beetle infestation of many areas where timber is grown in British Columbia, a province which supplies a large proportion of the wood, has resulted in a shortage of supply of the main input. With many large mills closing operations as a result of this, there is a surplus of sawdust that has to be disposed of, and which can be bought at low costs.

5.1.1.4 A Fragmented Supply Chain

It is widely accepted, that while certain components of the supply chain that would provide bioenergy products exist, that they are few and far apart, with little or no integration between them. The supply chains that have come together at present mostly function on informal and opportunistic arrangements between producers of biomass and users. A lack of demand is generally agreed to be the most significant barrier against the formation of more integrated supply chains.

It is also generally accepted that for bioenergy to reach its potential as being renewable form of energy, it has to be sourced for processing or use from within a radius of 30-40 km. Beyond this, the energy used for transportation would offset the environmental and economic gains. While biomass is present in most areas, what can now be sourced is more limited in availability, and is therefore not necessarily sourced according to this rule. It is suggested in the literature that conversion to energy and transport of this instead could be a method to overcome this challenge (Dauber et al., 2012). While the usage of biomass for combustion does not allow for this, certain techniques for densification are and can be practiced. An example of this is the conversion of biomass into cubes instead of pellets which have less density. This allows for 30% more biomass to be transported.

Biomass Brokerage System: Recognising the need to close the gap of integration between the producer and user of biomass, a 'biomass brokerage system' has been created by the Providence University College & Seminary. The brokerage system designed and run by the College, is a website (www.biomassbrokerage.com) on which sellers could advertise the different kinds of biomass that they have to offer, and buyers could similarly state their requirements. This therefore brings together buyers and sellers from different parts of Manitoba (and elsewhere) and acts as a direct interface through which transactions could be made.

5.1.2 Regulatory and Financial Support

The importance of policies and instruments by the government to stimulate bioenergy development has been discussed in literature by several authors. This also includes creating a system where financial support for new projects is readily available (McCormick & Kåberger, 2007; Costello and Finnell, 1998; Rösch & Kaltschmitt, 1999)

5.1.2.1 Pricing of Alternatives that does not Recognise External Costs

One of the main barriers against bioenergy expansion into becoming a mainstream source of energy is considered to be a lack of recognition of the broader social and environmental costs associated with the use of natural gas and to a lesser degree, hydropower. At present, none of the fossil fuels utilised in Manitoba are subjected to a carbon tax.

The carbon tax implemented in British Columbia, Canada was mentioned as an example of such a taxation program. The tax, implemented in 2008, is on various fossil fuels, including natural gas. It is also described as being 'revenue neutral', since the proceeds are then recycled back into funding tax cuts for both individuals and businesses (Ministry of Finance, Province of British Columbia, 2015). It was suggested that this revenue neutrality would also make this an option that would interest the residents of Manitoba. However, when compared to other Provinces in Canada and the US it was also felt that the size and position of Manitoba in terms of economic competitiveness means that the Province will not take a leading role in such initiatives, but will follow when they become more mainstream.

5.1.2.2 Ban on Coal as a Heating Fuel

A tax that had been previously levied on coal will become a ban on the use of coal beginning from 2017, in Manitoba. The Provincial government had previously intended to implement it from 2014, but this has been delayed by a further three years. Coal and wood were the main sources of space heating, when district heating systems were more prevalent about a century ago, but these systems have gradually given way to those that used electricity, and at present natural gas.

The ban will mainly affect the part of the population that is not connected to the natural gas grid, as coal is used mainly for space heating, and for some aspects of farming. This includes mainly communities that live in rural areas, such as farming communities, Hutterite and First Nations communities and others that are remotely located. Large industries that use coal such as Manitoba Hydro, and others, such as a producer of lime (called Graymont) are, however exempt from this ban.

Ease of Transition: Of the 132 Hutterite communities that reside in Manitoba, around 60-70 are estimated to use coal, while others are connected to natural gas lines. Coal has been their source of heating fuel, since the establishment of these colonies in Manitoba, a practice which continues to the present day. The coal has been used in space heating (shops, houses, churches and barns), drying (grain drying) and for process heat for some aspects for manufacturing. As Manitoba does not produce coal, members of the Greenwald Hutterite Colony travel once a week mostly to neighbouring Saskatchewan, to haul in the coal they use, a practice shared with other communities. This was one of the advantages of switching to bioenergy systems as experienced by the colony, as the biomass needed could instead be obtained from closer distances, or delivered to them.

As described earlier, the Greenwald Colony is currently working with Biovalco, to experiment with different types of biomass to identify what would work best for the biomass burner that is currently installed in their community. The coal furnaces found in Manitoba are generally considered to be those that cannot be retrofitted and turned into one that can utilise biomass (unless it is in the form of biocoal,) necessitating completely new installations.

The capital costs of switching can be considerable. While a system that can burn coal to meet the needs of the Greenwald Colony would have cost approximately $ 100,000 (EUR 70,700), the alternative that would utilise a wide range of biomass types could cost upto $ 500,000 to 600,000 (EUR 355,000- 426,000). Limited financial assistance is available to make these transitions. However, once installed, biomass is believed to be the cheaper option when compared to coal or the other alternatives available if not connected to a natural gas line, such as propane or electricity. The price that was paid on average for a tonne of coal was $100 (EUR 71), whereas, it is expected that biomass could be obtained for as low as $40/tonne (EUR 29). The experience of moving away from coal, is also considered to be generally positive, as coal is considered to be a fuel that is abrasive to the burner, emits an unpleasant odour and particles, and leaves behind ash that could be high in heavy metals.

'Low Hanging Fruit': While the coal ban is generally welcomed as a positive move by the government, many of the stakeholders interviewed also consider it to be an easy move, as it is not one that will not affect a significant portion of the population, nor one that would be a catalyst for a large scale expansion of sources of renewable energy such as biomass. It is estimated that around 700,000 tonnes of coal are used in Manitoba, and meets about 1% of the energy needs of the Province. It is also felt that the most significant environmental impact would not be in mitigating greenhouse gas emissions, but in localised improvements in air quality.

The timing of the coal ban has also faced a lot of debate, with many in favour of it, also advocating a ban that would be implemented after a certain period of time, within which alternative systems of energy, such as bioenergy will have time to develop to meet the increased demand. This has been one of the reasons the ban has been postponed to 2017. Another reason is considered to be the lack of a system of enforcement and monitoring, which has not yet developed. The choice of economic instrument used too is the subject of split opinion. It is felt that if the price of coal is below a certain value that it would still make economic sense to pay the penalty fee, instead of switching entirely to an alternative system. It is also felt, that the previous system of taxation on coal could instead have been reworked, with an increase in the tax charged, and directing of the revenue from the taxation towards a fund that could assist those that are interested in transitioning to alternatives.

Thus, while the ban has led to a small increase in demand for bioenergy in the Province, it is not widely expected that it will by itself drive the expansion of bioenergy systems much further than this. However, there is some optimism that it could increase the familiarity and confidence that people have in such systems, as they are adopted by certain sections of the Province, which could act as an indirect driver.

5.1.2.3 Limited Availability of Economic Support

There is limited availability for economic support to make the transition to bioenergy systems. This is seen as a barrier, particularly in relation to meeting the capital costs necessary to make the switch. It is felt that the transition from systems that used wood or coal as a fuel in the past to electricity was accelerated by the provision of financial assistance to do so. At present, it is felt that the inability or unwillingness to meet capital costs, even when bioenergy becomes financially viable in terms of fuel (as was in the case of the University of Manitoba) can be overcome by a stronger push through similar assistance.

Government Funding: Such funding is available mainly through the Manitoba Biomass Energy Support Program offered by MAFRD), and offers assistance to those interested in transitioning away from systems that use coal. Capital support of up to $50,000 (EUR 35350) is provided (Government of Manitoba, 2015a) However, it is said that the funding, although announced is not yet available for application and has been stalled. Apart from this, Manitoba Hydro offers the Bioenergy Optimisation Program for a similar purpose, but with a focus on systems that utilise biomass to generate electricity.

On the availability of funding for research and development for innovation in the bioenerngy sector, it is again felt that the funding that is available comes in periodic spurts. However, funding for research and development is not seen as a major barrier in furthering bioenergy development, at least at present, as the technology to create viable systems is for the most part, already available.

Partnerships with the Public Sector: Part of the financing for the bioeconomy project by IISD has come from MBLL who offset the greenhouse gas emissions of their operations by purchasing in carbon credits generated by the project. This is done on an informal basis, and the credits are purchased at $25 (EUR 18) per tonne. It is estimated that all of the 8000 tonnes of CO_2 generated by the company's operations each year are offset by the purchase of the carbon credits.

While this transaction is on a one on one basis at the moment in Manitoba, it is hoped that this will change into the future, and that the carbon credit market will become a more formal one. At this point, this is seen as a successful arrangement of partnering with the public sector through which such initiatives can be financed. The lack of dialog between the environmental and business communities is considered to be a deterrent to the development of more partnerships such as this. It is felt that if the benefits of such projects could be communicated in more quantified terms to the business community, there would be more interest in getting involved and supporting such initiatives.

5.1.3 Know-how and Institutional Capacity

The know-how and institutional capacity surrounding bioenergy systems can be explored from three angles — the knowledge available regarding the technology itself, the knowledge that farmers have about growing the feedstock and the perception that various stakeholders have of bioenergy systems (McCormick & Kåberger, 2007).

5.1.3.1 Availability of Technology

It is generally accepted by both end users and those involved in processing that a certain level of know-how on bioenergy production already exists to meet current demand and expectations. It is also felt that further innovation can be stimulated largely by an increase in demand which would lead to more purchases and installation of bioenergy systems.

As much of the biomass that is currently utilised is already harvested and processed to some degree (residue from forestry and agriculture), any focus on the technology that can be utilised for the harvesting of biomass is for newer types of biomass, such as the cattail. In this section, the processing of biomass and combustion (energy production) technologies are discussed. The availability of technology for the harvesting of the cattail is discussed in section 5.3.2.

Processing of Biomass: The dominant method of processing biomass in Manitoba appears to be compressing it into different forms, in this case pellets, cubes and briquettes. The main reason for doing so is to increase the density of the fuel (thus increasing the amount that can be transported and stored), and to reduce the proportion of particulate matter that is released when the fuel is burnt. It is also reported that unprocessed loose material (such as sawdust) may not work with the auger systems that is used by certain systems (e.g. the biomass burner at Providence College). The choice of which shape to compress it into depends on the biomass burner used. For example, cubes have higher density than pellets, but are also more suitable for large industrial sized burners with large sized bins. A pelleting mill installed at the Greenwald Hutterite Colony is given in Figure 5-1

Figure 5-1: Equipment used to produce pellets at the Greenwald Hutterite Colony

There are also discussions of methods for processing the biomass further, for example into biochar, which has higher heat content than the forms described above. However, it is felt that this conversion may mean over processing the fuel, when considering the needs of the current bioenergy market in Manitoba, and would be costly in terms of the energy involved and finances.

Combustion of Biomass: The biomass burners that are used most commonly in Manitoba appear to be the Blueflame stoker (shown in figure 5-2), designed by the company Biovalco. This model has a 'chain grate' design, which enables it to burn fuels that have lower ash fusion temperatures. Its application is that it could burn a wider variety of biomass, when compared to similar models used elsewhere, such as in parts of Europe, which are able to burn mostly woody biomass. Manufacturing of the burner too is done in Manitoba, by the Sturgeon Creek Hutterite Colony.

The capacity of the blue flame stoker is 5 MW, but there is confidence from Biovalco that burners of larger capacity can be built. The heating needs of a Hutterite Colony can be met through the use of a 3MW system, and a 5MW system is also suitable for more large-scale purposes, such as heating an industrial sized greenhouse. For more industrial sized applications, it is also reported that operations can be designed to include a wider variety of biomass (such as biomass that has only been subjected to minimal processing, such as shredding), through the installations of walking floors. A walking floor is an automated system that would supply the system with biomass, as and when it is needed, thereby removing the need for the biomass to be fed in manually.

5.1.3.2 Unfamiliarity with Bioenergy Systems

It is generally felt that apart from some early adopters, that there is unfamiliarity about bioenergy systems. However, a more significant reason for a lack of interest is considered to be scepticism about biomass as a feedstock. The main reasons for this are, low confidence in biomass being a reliable and consistent source of supply, and confusion about the different varieties of biomass available. It is felt that there may be disruptions to supply due to various reasons, including weather conditions, and that the quality of biomass can vary greatly. The need for a system of standardisation is felt to alleviate some of these concerns. In addition, there is also the perception that biomass burners require a lot of maintenance, in terms of feeding in the biomass and cleaning out the ash. However, the

Figure 5-2: Blueflame stoker biomass burner installed at Providence biomass burner at Providence College

Director of Providence College feels that the maintenance that is needed is much less than people think is needed. At the biomass burner run at this institution, typically 3 hours of maintenance would be required per week.

The unfamiliarity with bioenergy systems also includes a lack of knowledge surrounding the regulations regarding setting up and running biomass burners. This includes a lack of knowledge by the users, as well as by health and safety inspectors that are responsible for monitoring such systems for safety risks such as the risk of fire. This lack of knowledge has resulted in confusing instructions being given to those that have set up bioenergy systems. Thus, a need to overview the associated regulatory framework, in addition to streamlining the bureaucratic process involved with setting up a bioenergy system was suggested.

The need for demonstration projects to increase confidence in the systems and for people to become more accustomed to the idea was suggested by many. In connection to this, the need for more information to be disseminated to the general public, including stories of success were expressed.

5.1.3.3 Local Champions

While there is uncertainty about the system, it was also felt during the research that there are certain individuals and institutions, including some early adopters, who are acting as 'local champions' to enable further development and penetration of bioenergy systems. These include work done by IISD and some stakeholders that work with the cattail project, such as the Greenwald Hutterite Colony/Biovalco partnership that is working on producing pellets, the Living Prairie Museum, 50 by '30, Manitoba Hydro and Providence College. These stakeholders contribute towards bioenergy development by adopting the practice, and also by experimenting with different methods that are needed to close certain gaps that exist in the supply chain, policy formulation, dissemination of knowledge and research and experimentation.

5.2 Rural Development and Decentralisation of Energy Production

The ability of bioenergy systems to contribute towards creating decentralised energy systems, and when this is done in a rural setting, to contribute to rural development and employment generation is considered to be one of the strengths of these systems (Dauber et al., 2012; Mangoyana & Smith, 2011; Raslavičius et al., 2011; Rossi & Hinrichs, 2011).

5.2.1 Decentralisation of Energy Production

The potential to contribute to decentralisation in the context of bioenergy systems in Manitoba can be looked at from two directions — through the creation of decentralised systems in rural areas, and through decentralisation by large institutions such as educational and governmental institutions installing biomass burners as the main source of energy for space heating.

5.2.1.1 Decentralisation in a Rural Setting

The communities and institutions that are not connected to the main natural gas gridline (discussed in 5.1.1) can benefit from the decentralised system that bioenergy has to offer. This includes the hutterite colonies, some schools, first nations communities, and other rural communities. It was also felt that the bioeconomy discourse at the moment is dominated largely by the perception of stakeholders from the City of Winnipeg, and that decentralisation into a rural setting can potentially change this.

The revival of heating systems similar to the district heating systems that were present in Manitoba in the past, were suggested as an example through which rural decentralisation can drive bioenergy production. An example from Denmark was discussed, where farmers create their own cooperatives to which biomass grown by them is delivered, and which then produces bioenergy which is sold to the surrounding community. It is believed that such central heating systems could benefit small rural communities in Manitoba, with potentially the same ownership as discussed above. A central heating system being developed in Gibson's Landing in British Columbia was mentioned as an example of this.

Since Manitoba has an abundance of biomass, in the rural setting, and as it is not financially or environmentally profitable to transport this across large distances (limited to 30km), a decentralised rural system of energy production would be one of the more cost-effective options for sustainable use of the biomass. This profitability would therefore be a driver to pursue this, although the small level of demand, could act as a barrier.

5.2.1.2 Decentralisation by Institutions to Support Bioenergy Development

One of the methods through which decentralisation could assist in increasing penetration of bioenergy, is if large institutions such as schools, universities, hospitals, prisons and governmental institutions (those with central heating systems) adopted it as the main source of heating. If this concept is adopted by institutions, the resulting increase in demand would help assist further development of bioenergy in the Province. At present, both the Living Prairie Museum and Providence College are examples of such institutions moving away from natural gas to bioenergy.

The government, including the Provincial Government and the City of Winnipeg is considered to be the biggest consumer of natural gas, although it is not necessarily perceived this way. The City of Winnipeg owns or leases around 700 buildings, and the number of buildings owned and leased by the Provincial Government is thought to be even higher. Therefore it is believed that if the total area of these buildings is taken together, this would be a significant potential consumer of bioenergy.

It is accepted that not all of these building are those that could accommodate a biomass burner, and that natural gas would still have to be connected to as a backup plan. Another challenge would be to transport biomass to these buildings, while maintaining environmental and financial profitability as described in the section above. However, this is seen as an important strategy that, if adopted could help in bioenergy development.

5.2.2 Rural development and Employment Generation

When compared to other forms of renewable energy systems, it is agreed that bioenergy has the potential to create both direct and indirect employment opportunities, and through this contribute to the revival of rural areas. It is felt that this could especially benefit rural communities currently undergoing decline as a result of out-migration for better economic opportunities (Domac et al., 2005; Rossi & Hinrichs, 2011.

5.2.2.1 Money Spent on the Local Economy

The Province spends a significant amount of money in the range of $3-4 billion a year (EUR 2.13-2.8 billion), on the import of natural gas from Alberta. Thus, utilising this money in the production of Manitoba's own energy needs was a concept that interested a lot of the stakeholders interviewed. Another interesting feature of utilising biomass that was pointed out was, that in Manitoba, all forms of renewable energy sources (including hydropower) as essentially local, while non-renewable forms were largely imported. However, it was felt that this would not be enough to change the inertia associated with transitioning away from the current energy mix that the Province is utilising.

The number of people that a bioenergy system would be able to employ, as opposed to other methods of energy production was pointed out as another means through which local money could remain circulated in the local economy. This was considered to be a welcome development in a setting where the size of the rural community was shrinking, one of the reasons being that agriculture was the only viable sources of revenue in rural areas. However, this was in contrast to another suggestion made about the need to mechanise bioenergy production. The use of highly mechanised systems with minimal human labour and the generation of large economies of scale was pointed out as one of the reasons for the profitability of systems that used electricity and fossil fuels. Thus, it was suggested that if bioenergy systems were to become profitable, that a similar method of production would be required.

5.2.2.2 Means of Poverty Alleviation

The potential for bioenergy systems to act as means of poverty alleviation, especially of First Nations communities was also brought up. The lower living standards faced by many of the first nations communities in Manitoba was suggested as the main socio-economic issue facing the Province. Unemployment rates among First Nations communities can be as high as 80%. A central heating system in such a community many of which are located in remote settings would be a method through which this unemployment could be addressed. The case of the Ojibways First Nations community in Quebec, which has a central heating system owned and managed entirely by the community, was suggested as an example.

With regard to Manitoba, a wetland system called St Martins, which has dried up in recent years, in which cattails grow abundantly has been suggested as a potential site for bioenergy development. This could involve a synergistic system where a First Nations community residing closeby could participate in a project utilising this cattail for fuel production which could then be sold to a lime producer called Graymont operating in the neighbourhood. However, the needs and acceptance of the First Nations communities in participating in such a project should first be examined, when assessing the viability of this idea.

5.3 The Bioeconomy and Integrated Water Resources Management

The development of the bioeconomy, and the implementation of IWRM strategies overlap when reed biomass growing in wetlands (key ecosystems in watersheds) is harvested for utilisation in the bioeconomy. In this section, the drivers and barriers faced by the utilisation of the cattail as raw material is discussed, followed by the drivers and barriers faced by the cattail project in contributing to IWRM in the Province.

5.3.1 Land Availability

The cattail, being a plant with ubiquitous distribution, shows widespread distribution across wet and low lying areas across the Province. The distribution can be divided into three broad groups—1) wetlands and marshland that is not subject to heavy cultivation, 2) small patches in mostly low lying areas adjacent to areas that are cultivated, 3) along ditches that are constructed for the purpose of flood mitigation. The first category can be land that is deliberately left uncultivated (for water retention or conservation value purposes) or land that is not financially profitable to cultivate. The latter feature is shared with the second category, where these plots are part of agricultural land, but are left as they are as they are not suitable for farming, mostly due to their nature of being low-lying areas that collect floodwater. This also overlaps with the third category, as such ditches can be part of the drainage network in the area, where these are constructed to drain water off low lying lands so that these can be cultivated.

5.3.1.1 Variability in Land that is Considered Marginal

Much of the land in all three categories (except land that is demarcated for water retention/conservation value), can be described as marginal land, as it cannot be subjected to profitable cultivation. However, it was felt by some of the stakeholders from the categories 'Producers' and 'End Users: IWRM Benefits' that such assignment of land into being marginal should be done with caution. This is because what can be considered as marginal land can change depending on many factors, including seasonal variations and other socioeconomic factors. It is felt that such variability could impact the predictability of the cattail that is harvested from such areas from season to season.

An example of seasonal variations is that land that is dry and arable during a year of low precipitation may become one that contains excessive moisture, and one that is not suitable for cultivation, the next. An example of a socioeconomic factor is the identification of the bovine sponge disease in Canada in 2005 which closed the Canadian borders to exports, resulting in many farmers in the industry moving to other sources of income. One of these was grain cultivation which led to large scale draining of land that had been previously wetland and used for grazing of cattle.

5.3.1.2 'Wetlands as Wasteland'

As the focus of cultivation is largely about maximising productivity of the land, it is said that the general focus is, on whenever possible, to drain wetland. This is a continuation of the transformation of the prairie landscape since the time of settlement in the area, into land that can be cultivated. There is currently no governmental policy or incentives given to keep aside a certain extent of land for other purposes, such as biodiversity conservation.

5.3.2 Profitability of Harvesting

The profitability of harvesting of the cattail can be determined by several factors which include the yield per unit area, the pattern of distribution of the locations in which the cattail grows, and the ease of access to equipment that can be used to harvest the cattail.

5.3.2.1 Abundant Growth in Wetlands

The cattail is described as a plant that thrives in suitable habitats which includes a wide variety of soil types and water levels. Its primary productivity is described as 'exceptional' as it grows in thick chunks of vegetation. According to one estimate, it can yield upto 14-20 tonnes of biomass per hectare (0.1 km^2). This is a higher yield, in comparison to other types of woody or grassy biomass (Appendix 4). Unlike other agricultural crops, it does not require any input in the form of fertilisers or pesticides, or working of the land for growth. Therefore, when it grows on land that is otherwise not arable, harvesting it would give an additional source of income to farmers (if markets for it exist) with minimal input from their part.

Certain locations in Manitoba were mentioned as being particularly suitable for harvesting. The common feature shared by all of these are, that they form continuous and extensive areas for cattail growth. This continuity, it is suggested is necessary to make this operation efficient in terms of resources utilised for harvesting. The extensive delta in the south end of Lake Winnipeg, which includes the Netley-Libau Marsh and retention basins similar to Pelley's Lake were mentioned as an example. Another example was the south western part of Manitoba which often experiences heavy moisture and spring rainfall, posing difficulties in cultivating this area. It was proposed that certain parts of cropland of poorer quality can be intentionally flooded to hold in floodwater, and that the owner of the farmland is then compensated for the lost productivity. If such a program materialises, it will also result in areas suitable for cattail growth.

5.3.2.2 Patchy Distribution of Marginal Land

With the exception of the continuous stretches of land as described above, it was suggested that harvesting the cattail from areas smaller in size, such as those next to farmlands will not be economically feasible. It was felt that this might change if bioenergy production became a decentralised operation, and if the transportation fell within a radius of 30 km, especially if the cattail is harvested from small extents of land, such as 5-10 acres (0.02 to 0.04 km^2). If the biomass collected is very high, another option would also be to process it into something that has a higher densified energy content, before transportation. In the current and foreseeable future though, harvesting from small patches, and transporting across long distances, is a practice that would be costly in terms of finances, as well as greenhouse gas emissions.

However, while harvesting small areas of land, or harvesting in straight lines is usually not the preferred method, if the cattail is mowed down for other reasons, this could then become a reason for transforming this practice into harvesting. Such ditch cutting is done by the municipalities along roadside ditches, but since the cattail is not harvested, it is not collected. It is suggested that this could easily be converted to a practice of collecting the cattail, thereby utilising the existing infrastructure for this purpose. While this could generate a lot of biomass collected at little cost, the downside of this is that it can also be mixed with a lot of debris, which is the solid waste that is collected in the ditches.

5.3.3 Availability of Existing Technology for Harvesting and Processing

Although specialised equipment is used in other parts of the world, for reed harvesting from wetlands, PAMI, the company that works on designing and producing equipment for harvesting, focuses on methods through which existing agricultural equipment can be adapted to harvest the cattail. This thereby reduces the barrier of having to meet additional capital costs on specialised harvesting equipment for the cattail. The equipment used for grain harvesting, and that used for forage harvesting (e.g. hay) differ, and it is the second type that is more suitable for the purpose of cattail harvesting.

Similarly, after the cattail is harvesting, equipment that is used to bale hay can be used to bale the cattail. Further, as harvesting and baling equipment will not be otherwise utilised after the crop harvest, it is suggested that not letting the equipment idle and utilising it for cattail harvesting can lead to an extended season for the farmer. This would be after the harvesting of the crops, so would be around late fall/early winter (November/December). Another advantage is that farmers would already have the know-how to utilise the equipment for the harvesting and baling.

While the utilisation of existing equipment is a driver, the most significant challenge of this is that it is heavily dependent on weather conditions, and the level of moisture in the wetlands in which the cattail grows. The ground will have to be sufficiently dry and firm for the equipment to go in, which would be a challenge during seasons of heavy precipitation and excessive moisture. The moisture content in the ground generally also coincides with the dryness of the cattail. Both of these therefore necessitate harvesting late later in the year, in the middle of fall. In winter too, as the surface is frozen, the ground would be firm enough for the equipment to go in. However, a higher yield can be obtained during seasons with higher precipitation, as the amount of biomass produced increases with the extent of wetlands created.

This issue of trade-offs is also seen when planning for the amount of time that is left for the drying of the cattail after harvesting, under natural conditions. The harvested biomass has to reach a certain level of dryness so that it can be baled, transported and stored effectively. In the case of a particularly wet season, therefore, harvesting earlier in the year may be ideal. However, since agricultural equipment cannot be operated at this time, the harvested biomass may have to be dried further artificially, which will require expenditure of extra energy.

An exception to this was suggested, which is when bioenergy is utilised for grain drying. During seasons of high precipitation, the harvest would require more drying, and therefore expenditure of energy. However, during such seasons, the amount of cattail biomass produced is also higher, which could then be utilised in the correspondingly higher production of bioenergy.

The issue of moisture levels in the ground would however not be a challenge in areas where water levels are artificially controlled, as in the case of the retention basins managed by the conservation districts. In the Pelly's Lake retention basin, the water that is stored is released and drained out during summer, so that the ground will become dry enough for harvesting equipment to navigate through it. However, this will only be possible where water levels are managed externally, as in the case of this example.

5.3.4 Characteristics of the Cattail as Feedstock for Application in the Bio-economy

The potential is seen for the utilisation of the cattail in making different product types, which have the potential to contribute towards generating a bioeconomy. A detailed description of the product types, the process followed to make them, and the expected application is given in Figure 5-3.Of these, some are still largely in the concept stage and their application mostly hypothetical, while other products have been developed further. The main categories of products that are being pursued are given below, along with the stage of developed they are in, and the potential to expand.

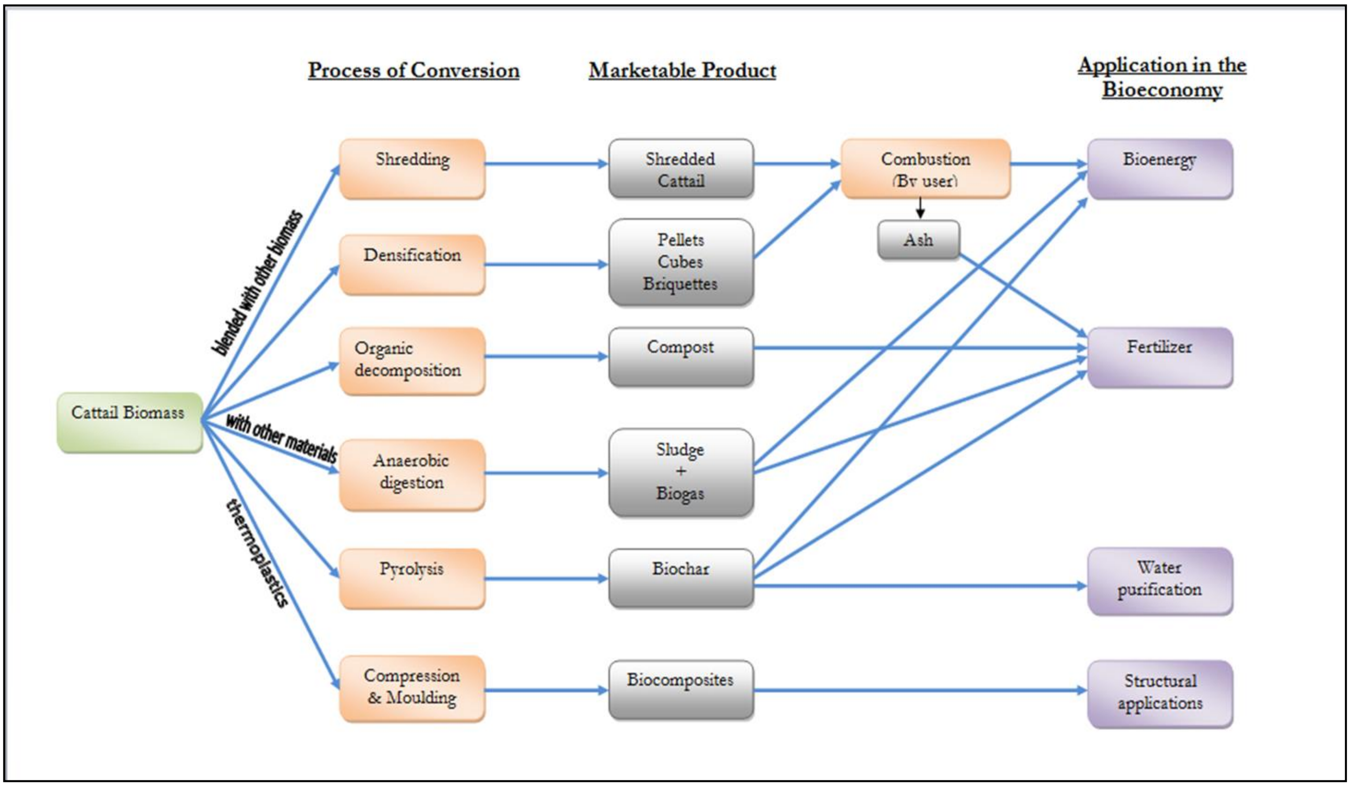

Figure 5-3: The different applications of the cattail in the bioeconomy, the process of conversion and the products generated

5.3.4.1 Production of Bioenergy

Anaerobic Digestion: The anaerobic digestion of the cattail, in a solid state anaerobic digester has been looked at by PAMI, with promising results. However, some of the other stakeholders voiced some concerns about the applicability of anaerobic digestion in Manitoba. The climatic conditions of Manitoba were one such reason, as it is not evident if the bacterial activity required for the process can be sustained through the range of temperatures experienced by the Province. It is also felt that anaerobic digestion is a process that would need a lot more study before it became feasible for large scale production of energy, as an optimal mix of cattail: other substances will have to be identified. Since the cattail, similar to wood pulp or straw, is low in nutrients, it does not digest easily, and will have to be co-digested with other materials such as sewage or manure. The third concern (one that is also shared with the concept of processing the cattail to produce biochar), is that in comparison to direct combustion, it may be over-processed, requiring more energy than is ultimately produced.

The sludge that is produced as a co-product, however, is considered to be suitable to be applied as a fertiliser. As a large proportion (75%) of the soils in Manitoba are alkaline in nature, any fertiliser that shows neutral or acidic properties would be more suitable for application in these soils. The sludge, which has a neutral pH is therefore considered to be suitable for this purpose.

Direct Combustion: Direct combustion could be either of shredded cattail (processed to a small extent) or of more densified forms such as pellets, cubes or briquettes. Shredded biomass can be utlilised by systems which have walking floors, as described earlier. Combustion could be of plain cattail, or of the cattail blended with other biomass, such as wood, straw or peat. The general consensus among the stakeholders interviewed is, that systems that can burn other types of biomass, such as the blueflame stoker, can also utilise the cattail.

With regard to the properties of the cattail for combustion, it is generally agreed that the cattail has good heat content, and can burn well. The heating value of the cattail is estimated to be 17-20 mJ/kg, which is comparable to or higher than other types of biomass (Appendix 5) The cattail is also interchangeable with straw or grass, which could contribute to a more robust supply of biomass in general, as one can replace another when shortages occur. However, it is also felt that plain cattail is not the ideal biomass for combustion, and that it should be blended with other types. This is because the cattail (like grass or straw) has a high content of silica and other minerals, which when combusted, tends to form substantial amounts of 'clinkers', which form from the ash that is left behind after combustion. This can cause obstructions in the system, which results in an inability to sustain fires.

The Greenwald Hutterite Colony, in partnership with Biovalco has been experimenting with different blends of biomass for the production of pellets, as shown in figure 5-4. They are of the opinion that a pellet that blends together the cattail with wood (woodchips) has shown very promising results for combustion. The lignin and resin in the wood helps to bind the pellet together, while the addition of the wood reduces the amount of ash, and therefore clinkers left behind in the system. Another advantage of this pellet mix is that, the ration of wood: cattail can be varied from 100% wood to 25% wood: 75% cattail, depending on the supply of the cattail. Hence, in seasons of low cattail harvest and supply, the content of wood can be increased, to keep the supply consistent. Thus, this is considered to be a product of much promise, and can be marketed at a larger scale, and it is hoped that production can start soon.

5.3.4.2 Production of Biochar through Pyrolysis

Another concept in which PAMI has collabourated with IISD, is the production of biochar, (also known as biocoal) through pyrolysis of the cattail. Pyrolysis is a process in which biomass is combusted at high temperatures, in the absence of, or with limited oxygen (Mohan et al., 2014). Biochar can be used to produce bioenergy through combustion (like regular charcoal), but higher potential is seen in its applications in functioning as a soil amendment and in water filtration. In water filtration and treatment, it is suggested that biochar due to its properties of adsorption could replace activated carbon, which is the material that is

Figure 5-4: Pellets produced by blending woodchips and shredded cattail

conventionally used (Mohan et al., 2014).

This is concept is again at the preliminary stages, but has shown promising results. The contaminant removal capacity of the biochar produced from the cattail was not as high as was expected. However, it was found that adding the biochar to the sand that is used for filtering, reduced the compaction of the sand, thus showing promise for the use of biochar as a bulking agent.

5.3.4.3 Production of Biofibres and Biocomposites

The potential for using biomass in the biofibres and biocomposites industry was discussed earlier under 5.1.1.2. The applicability of the cattail for this purpose has not been looked at yet. However, considering historical applications of the cattail, it is hypothesised that the cattail would have similar properties to flax and hemp, whose bast fibres can be separated and used for the production of interiors for the automobile industry. The usage of natural fibres for this purpose is becoming a common practice in the industry, so it is felt that viable markets can be found for this purpose.

It is felt that while direct combustion is the most efficient way to obtain energy from biomass, that it is also the least value that can be obtained in terms of money, and that other potential applications may fetch higher values. This is an opinion shared by some of the stakeholders that are actively involved in the bioenergy sector. In the case of the cattail, it is felt that the separated fibres could be utilised for structural functions, such as in the manufacturing of interiors or building components. The woody core could be utilised as reinforcement in cement blocks, and the rest pelletised for bioenergy.

An advantage that the cattail has over flax and hemp is that these are commodity products, with other competing commercial applications. This may result in higher prices being demanded to buy them for biofibre production. Therefore, if the cattail can be demonstrated to have similar properties, it would be more cost effective to choose the cattail over other sources of biofibre production.

5.3.4.4 Production of Fertiliser

The cattail is considered to be a 'luxury consumer of nutrients', with the ability to absorb nutrients (including phosphorous) over and above its needs. Thus, the harvested cattail will contain large amounts of phosphates, in the range of 10-40 kg per hectare (Appendix 4). The captured phosphates can be recycled back into the soil to increase soil fertility.

Apart from the phosphate value, the harvested cattail can also have other applications in farming, in connection to livestock rearing. The dried cattail can be used either as fodder for the animals, or as livestock bedding. However, the need to investigate the cattail for its nutrient contents, such as proteins and lipids to identify its suitability to be used as animal feed was mentioned. With such an application, the manure from the livestock can also then be used as fertiliser.

The fertiliser that can be obtained for applications in agriculture can be of three types—organic fertiliser (compost, sludge or biomass worked back into the soil), inorganic fertiliser (ash from the combustion from biomass), and liquid fertiliser (nutrients extracted from the ash). Of this, the applicability of the first two types have been considered in more detail at present, when compared to the applicability of the third type.

Expenditure on Fertiliser: The stakeholders from the 'Producers' category, were enthusiastic about the possibility of retrieving the phosphorous through the cattail, to be used as fertiliser. It was reported that a significant proportion of the expenditure in farming is attributed to fertiliser purchase and use, which can be as much as $750-1000/ (EUR 530-707)/tonne (two estimates). This can account for 35-40% of the total costs of production in a given year. Thus, the monetary value of phosphates is widely recognised. The costs associated with using fertiliser consisting of mined phosphates that are imported can be a significant driver in generating interest in using alternative sources of fertiliser.

The concern over fertiliser expenditure and the impact of its use is also said to be one of the reasons for the success of the Environmental Farm Plan, by MAFRD. The Environmental Farm Plan focuses on assisting farmers in identifying and managing agri-environmental risks, and has around 6000 producers participating, covering about 9 million acres of land (Government of Manitoba, 2015b).

Suitability of Different Types of Fertilisers: The majority of the phosphate present in the harvested cattail is retained in the ash after combustion. Thus, this is a method through which the phosphorous can be concentrated, so that it has applications as soil fertiliser. The issue of the convenience of using ash as fertiliser was raised. As ash contains particulate matter that can become airborne, it was suggested that the captured ash will have to be processed further (for example, into granules), to convert it to a usable product.

However, the more pressing concern regarding the applicability of the ash, was the presence of hydroxides, which result in the ash having an alkaline pH value. A large proportion (75%) of the soils in Manitoba (and in the Red River Valley in general) are alkaline in nature. Therefore, the concern is that the application of a fertiliser with a basic pH can have a detrimental impact on soil fertility, instead of improving it, in addition to the phosphates remaining in a largely insoluble form in the soil. On the rest of the soils that have largely neutral or acidic pHs, this form of fertiliser is suitable for application. A common practice here is to lime the soils to increase the pH, and it is thought that the hydroxides present in the ash can have the same function as the lime.

Thus, the reclaimed ash will have to be further experimented with, before it can turn into a commercially viable product. One avenue followed is acidifying the ash, which has been shown to increase phosphate solubility (Grosshans et al., 2014). The usage of sludge or composted cattails will not encounter such a problem, and can be readily applied as fertiliser. As mentioned in Section 5.1.1.2, the City of Winnipeg runs a composting facility, to recycle other types of biomass to be sold either as bulk to farmers, or in packaged forms to individual home growers. The cattail, with its high phosphate content may also be well suited for this purpose.

5.3.5 Role in Integrated Water Management/Reduced Costs of Public Services by Wetland Management

One of the most significant applications of producing bioenergy from reed harvested from marginal land is expected to be in land and water management strategies, arising from the potential to contribute to flood and drought mitigation, nutrient recycling and water purification and to the conservation of habitat for the biodiversity that reside in these systems (Kuhlman et al., 2013; Vaičekonytė et al., 2014).

5.3.5.1 Role in Phosphate Management

The role of the project as a solution that would assist in mitigating nutrient loading into Lake Winnipeg was generally accepted by all of the stakeholders interviewed. However, it was stressed that the project of harvesting the cattails should be part of a collection of solutions. The need for such end of pipe solutions to also be balanced by more initiatives that tackled nutrient loading at the source was mentioned.

Potential to Reduce Nutrient Loading: The ability of the cattail to absorb and store large amounts of phosphorous, in comparison to other types of biomass has been discussed earlier. The harvesting and removal of all types of vegetation, including the cattail also has another benefit of reducing phosphorous runoff into waterways.

Research done at the University of Manitoba has shown that much of the phosphorous, especially that from agricultural land, moves into waterways not as particulate phosphorous or due to soil and water erosion, as was previously believed, but as dissolved phosphorous from organic sources. This dissolved phosphorous is released from vegetation or vegetative residue and can account for as much as 80-90% of the phosphorous leaving a particular landscape.

In Northern climates where the ground is frozen in winter and where snow melt results in rapid runoff off of water, this practice can be especially counter-productive. When the vegetation in such climates dies in winter, it releases a large proportion of dissolved phosphorous. With spring run-off, much of this is flushed off the landscape. As 80-90% of the water runoff that occurs from these landscapes occurs during Spring (mid-March to mid-April), it can be concluded that a huge flush of nutrients occurs during this time. Therefore, while leaving vegetative residue has previously been promoted (also in the US and Canada) as a form of phosphorous management, it is recommended that the opposite should be done. The vegetation occurring in hydrologically active areas, such as ditches, wetlands and riparian areas, should be removed, to reduce dissolved phosphorous from entering common waterways.

If this concept becomes more mainstream as a management practice to prevent phosphorous loading into common waterbodies, it would necessitate the removal of vegetation (presumably from areas where the practice does not have other negative environmental consequences). Since cattail is a common occurrence in hydrologically active areas as described above, this would result in a large mass of cattail being harvested. This can then be used as a low cost feedstock for other applications.

On the topic of how this can materialise spatially, opinion was split. A system of buffers of the cattail around individual farms was suggested, so that this may assist in phosphate capture, before it enters common waterways. However, others were of the opinion that it would be challenging to obtain participation from farmers, as well as result in inefficient resource utilisation of resources while harvesting. The latter concern arises since the cattail harvesting will then have to be done from small dispersed patches of land, as opposed to large areas, resulting in more fossil fuel and equipment used and time spent. It was generally agreed that farmers would prefer not to have extensive cattail growth in their farmlands, as the thick vegetation can obstruct the smooth floor of floodwater through storm water drains, thereby interfering with rapid drainage of the land. Further, the collected water and marshy areas created could become a habitat for insect populations, some of which are said to be pests if livestock is owned. Hence, harvesting the cattail that grows in larger expanses of land was suggested, for example at the scale of Pelly's Lake.

Public Concern and Legislative Support: The pollution and eutrophication of Lake Winnipeg was the main issue that the stakeholders interviewed felt was faced by Lake Manitoba. This is also a topic that is discussed very publicly and the reason is said to be that the pollution is a very visible environmental issue, especially as Lake Winnipeg is a popular recreational and tourist area. As a result, it is felt that especially in the last ten years, steps have been taken to reduce the impact of nutrient loading on the Lake.

This has also motivated discussions in political circles, and an Act known as the 'Save Lake Winnipeg Act' was assented to in 2011 by the Provincial Government. The Act recognises that the nutrients that result in the algal bloom of Lake Winnipeg originates from both urban and rural sources and from changes in environmental systems. The need for further environmental protection measures, including high standards to reduce nutrient loading, and the expectation of working with upstream stakeholders to obtain the same is stated. The Act amends previously existing legislation on the subject, including The Crowns Land Act, The Environment Act and The Water Protection Act. (The Save Lake Winnipeg Act, 2011)

Many of the stakeholders felt that the existing efforts to reduce nutrient loading can be complemented by the cattail harvesting project by IISD. Thus, the existing pressure to implement measures to reduce nutrient loading can be an important driver, in securing governmental funding for the expansion of the project.

Disagreement about Source of Phosphate Loading: It was noticed that there was significant disagreement about which practices lead to a higher release of phosphorous into common waterways. Opinion was split among whether it came from rural or urban sources, with those from the farming community stating that the City of Winnipeg is responsible for a large proportion of the nutrients being released, both as remnants in treated wastewater as well as from storm water runoff. However, this opinion is countered by other stakeholders who state that this view stems from the fact that the phosphorous being released from the City can be measured, whereas there is less information about phosphorous runoff from agricultural use, as it is from non-point sources.

Therefore, while all of the stakeholders were united on the agreement that more effort has to be put into reducing the nutrient loading, there is no consensus on which stakeholder group should play a bigger part in this endeavour. While this is unlikely to be a significant barrier for any initiatives related to the cattail project specifically, a certain stakeholder group may feel antagonistic about some initiatives that may arise from it. For example, a program to set aside a certain portion of land for flood mitigation and nutrient management, may meet opposition from the farming community.

5.3.5.2 Potential Application in Flood Mitigation

While the condition of Lake Winnipeg was the most frequent issue raised by stakeholders as a pressing environmental or socio-economic issue faced by Manitoba, the management of water, with regard to flooding and drought was also brought up often.

Increase in the Magnitude and Severity of Flooding: It seems to be the general perception among the stakeholders interviewed, that flooding is becoming a more frequent phenomenon in Manitoba, along with an increase in its magnitude. In addition, along with the manifestation of climate change, droughts are expected to become more of a concern in the future. It was felt that the Province is less prepared for the occurrence of droughts, as this has been a less serious issue in the past.

These concerns are also felt by the general public. In a study done by the Royal Bank of Canada, it was found that 57% of those living in Winnipeg felt that they were living in an area vulnerable to flooding, while 24% felt the same about drought (Royal Bank of Canada, 2015). According to the view of farmers, the year to year wet and dry cycle that they have been accustomed to is slowly changing, with a wet or dry season lasting for longer periods of time.

The costs of flood damages have been significant. A large scale flood event in 2011 led to the displacement of almost 3600 people from their homes, with the damages to infrastructure estimated to amount to $200 million (EUR 141.4 million) (excluding damage to agricultural land). The floods in the summer of 2014 resulted in losses to agricultural revenue, which is estimated to be as high as $ 1 billion (0.71 billion) (CBC News, 2011; Metro News, 2014). Significant costs have been incurred by the Provincial government, both in meeting damage to infrastructure, as well as insurance payments for damages to property.

Therefore, it is agreed that the provincial government would be interested in initiatives that would work towards mitigating and controlling large scale flooding, as it would ultimately lead to less costs in damage payments. Thus, this could be a method of financing for the project, as payments would be made for the maintenance of green infrastructure, which in this case are water retention areas.

Potential to Contribute to Flood and Drought Mitigation: There is expectation that if the project on generating bioeconomies can be scaled up, that along with the ecosystem service of removal of excess nutrients flood mitigation benefits can also be achieved. This benefit would be through wetland areas in which cattails grow naturally (or are grown for this purpose), which could hold in floodwater during peak flow, and release it after excess flow subsides. It was also suggested that the benefits will materialise significantly, if this could be implemented in upland areas. The project at Pelly's Lake, managed by the La Salle Red-boine Conservation District, with support from organisations such as IISD and Manitoba Habitat Heritage Corporation is considered to be a representative model by many stakeholders, on how this could be done. While other retention basins are managed by the Conservation District, this is the largest in terms of area, and complex in terms of ability to manage water levels.

This project is generally considered to be successful in achieving the different objectives of flood mitigation, nutrient recovery and stimulation of a bieconomy. It is therefore considered to be a demonstration project of similar projects that could be implemented elsewhere to achieve, in combination, more large scale benefits. The implementation of such retention sites upstream, near tributaries and creeks, before water flows into the main stem of the river was suggested as a method through which smaller sized projects such as this could have a significant impact.

The need to control and manage water levels was pointed out as a key feature that would help in achieving flood mitigation as an important benefit, along with that of the bioeconomy. If the water that is held back during Spring can be drained out during summer, equipment that is used to harvest forage crops in agriculture would be able to operate in the area. Thus, as with any cropping systems, the need to manage water levels would help in reducing the uncertainty associated with when the water levels will be low enough to harvest.

The ownership of most of the land is private—half of it is owned by a Hutterite Colony residing nearby, while the other half is divided among four individuals. As it is considered to be marginal land, due to its nature of being a marshland, it did not have other prior uses, for example, in agriculture. Thus, it did not have any competing value. However, there is a lot of focus on draining land in order to maximise productivity, as was described earlier, in Section

5.3.1.2 Stakeholders interviewed from the 'Producers' category expressed a lack of interest, in the process of draining the landscape being reversed, as it meant a loss of land that had value for agriculture.

Hence, while the concept had potential, identifying areas that would be suitable may pose a challenge. One suggestion made was that incentives could be targeted at farmers who have cropland on which lower quality crops are grown, if such land is found on locations suitable for the application of this concept. The incentives may then be closer in value to the profits from cultivation that the farmer will have to forego.

The Need for Quantified Benefits and Demonstration Projects: The need for the benefits that the project could generate in terms of nutrient removal and flood mitigation to be quantified were expressed very frequently. This was felt as necessary to generate attention from government officials, as well as from the business community, as these stakeholders would be more willing to invest in the project if the projected results were made more tangible and translated to economic terms. As an application of this, the expected benefits in flood mitigation can then be converted to actuarial values, which could lead to a premium being established that could, for example, be paid to farmers upland to set aside certain extents of land for flood storage.

5.3.5.3 Potential to Contribute towards Control of Invasiveness

The cattail being a part of wetland habitat provides certain services for the resident biodiversity, such as being cover for nesting birds and providing food for animals such as muskrats. However the cattail also displays extensive growth, which makes it an ideal candidate for bioenergy systems. This is particularly seen of the hybrid varieties between the native broad leaved cattail, and the non-native narrow leaf cattail. These varieties show tendencies of invasiveness, and in certain places, such as in the US require external management through removal of patches of vegetation. This maintenance is done by creating 'hemi-marshes', where patches of the cattail are left with open spaces between them. However, this is not considered an issue in Manitoba, and the cattail varieties found here are considered to be less prolific in terms of growth.

The usage of heavy machinery for harvesting may create considerable impact in pristine wetland habitats with native seed banks. However, it is thought that much of the wetlands in Manitoba have suffered some form of alteration at given point, and that harvesting here will have little impact. The function of creating habitat for biodiversity is more of a concern, but it is believed that harvesting when the nesting birds have left, and more ideally when the ground is frozen are practices that could be done to minimise impact.

5.4 Integrated Water Resources Management

Apart from the ecosystem services that the IISD project has the potential to generate in wetlands and watersheds, other elements of the IWRM framework which are in place, have the potential to support the project, and thereby act as drivers. In the context of watershed management in Manitoba, a large proportion the work is done by conservation districts. Therefore, the elements of the IWRM framework are looked at through the structure, responsibilities and functioning of the conservation districts.

5.4.1 Management at Watershed Level

The 18 conservation districts manage watersheds and sub watersheds, with management work taking place at the watershed level. Each conservation district is tasked with leading the development of an Integrated Watershed Management Plan. The objectives of this plan are to identify issues of importance in the watershed, come up with policies and projects that would help in addressing these issues, and to determine how these programs could be implemented cooperatively within the Watershed (Manitoba Conservation Districts Association, 2015)

As each conservation district is set up by a municipality, not all of the individual conservation district fall within a given watershed boundary. Some may fall within watershed boundaries, while others within Municipal boundaries instead. When conservation districts share watersheds, it is said that they develop partnerships to manage the watershed on a joint basis, and that such collabourations have mostly been successful.

It is felt that the fact that the administrative structure does not always occur within a watershed is not necessarily an impediment to carry out operations, although it would make them easier. Therefore, while this is not a significant barrier, management of individual watersheds or sub watersheds would certainly assist in refining operations. This may be of particular value, if more retention basins need to be setup managed in upland watersheds.

5.4.2 Role of Government: Decentralisation and Active Role in Certain Services

The Conservation Districts are considered to be a decentralised method of governance, through which water resources are managed in Manitoba. Conservation districts have autonomy in designing and implementing watershed management plans within their administrative boundaries, and are run by a board appointed by the Municipality. The concept is supported by legislation, through the Conservation Districts Act. The Act focuses on managing land and water resources in private land, and therefore excludes both First Nations and Crown (Public) Land.

With regard to the activities and programs carried out the by the conservation districts, most have a similar project portfolio. Many carry out abandoned well sealing, erosion control, improving surface water quality and ground water quality (source of drinking water for some areas of Manitoba) and increasing naturalised vegetation cover at the watershed scale. Most conservation districts also carry out water retention projects, to reduce peak flow during flooding. However, with regard to providing public services such as flood control, the Provincial Government retains the responsibility of constructing and maintaining built infrastructure. Thus, certain key services, which would also require higher investments, are still provided by the provincial Government, as suggested by the IWRM framework.

This decentralisation would be of benefit in designing and implementing localised solutions with regard to flood mitigation, especially in connection to the application of the concept of retention basins for this purpose. In addition, it would reduce the time and effort spent on navigating more complex bureaucratic processes, which are an inevitable part of larger government structures. This would enable any initiative that is implemented in partnership with the conservation district to operationalise effectively in terms of time and other resources.

However, the Provincial government also plays a key role in providing certain key services such as flood mitigation. Large flood infrastructure, such as dams, dykes, spillways and flood diversion channels are constructed by the government. Examples of these would be the

Winnipeg Floodway, Portage Diversion and the Shellmouth Dam. Much of this infrastructure is associated with the major rivers, while the conservation districts focus on smaller waterbodies such as creeks and streams. Therefore, at present, the Provincial Government still remains largely responsible flood mitigation in the Province.

5.4.3 Financial Support

The funding for the conservation districts comes from both the Provincial and Municipal budgets, at a ratio of 3: 1 (Province: Municipality). This is said to account for 60-70% of annual funding, while the rest is made up by funds obtained externally. While certain projects can be implemented though the funding received, it was felt that the amount of core funding obtained was a challenge in setting out projects beyond a certain magnitude. On the topic of retention basins, it was said that generally more money was spent on these projects although these were fewer in number, in comparison to the other projects run by the conservation districts. Therefore the extent of funding received may be a shortcoming in further expansion of these projects.

5.4.4 Multi-sectorial/Multi-stakeholder participation

The Conservation districts are structures that ensure multi stakeholder participation from within the conservation district at many levels. The Board of Directors that run a conservation district is appointed by the Municipality in the district, and those appointed are local residents who own land within the conservation district. The input of the residents is also obtained in designing the roadmap for a plan for the actions taken every year. Open houses are held to obtain the views of local stakeholders on what issues should take priority, in becoming part of the plan. The Project Management Team that is responsible for actioning these programs too comprises of residents of the watershed and other parties of interest.

Perhaps the biggest contribution to the bioeconomy project from this culture of stakeholder participation is the integration of private landowners. The conservation districts are set on private land, mostly agricultural, and integration of these farmers/landowners has been described as a challenge that initiatives on flood mitigation could face. The involvement of such stakeholders is done through the provision of design assistance for projects, as well as financial assistance. Thus, this involvement can be described as incentive-based. This has created positive relationships, and it is said that many landowners who have erosion or water related issues in their lands now approach the conservation districts to obtain assistance with implementing a project, or with its funding. This includes the management of the retention basins.

Thus the conservation districts can be an important avenue through which these stakeholders are communicated with about the project, and integrated in its implementation. This is especially possible as those from the farming community also make up members of the Board of Directors. It is felt that this could be achieved by setting up educational campaigns, and workshops through which information about the project is delivered. Further, the expertise of the conservation districts on the local watershed can be utilised in identifying potential locations for inclusion in the retention area network.

6 Transferability of the Project

This section continues from the analysis done in Chapter 5, to understand how the existing status of the system and the drivers and barriers experienced by the IISD project could influence which of the benefits are more significant to the stakeholders involved with the project. First, the significance of the socioeconomic drivers and barriers identified in Chapter 5 is discussed. Following this, the private and public benefits that the project could generate are looked at, along with the relative importance given to them by the stakeholders involved.

A comparative case study from another case also from the Red River Basin, is then introduced to understand how this relative importance could be influenced, and could change by the existing status of the system and the socioeconomic drivers and barriers that the project could face in the two different contexts.

6.1 Significance of the Socioeconomic Drivers and Barriers

Of the different socioeconomic drivers and barriers identified in the case study in Chapter 5, certain drivers and barriers were mentioned with higher frequency, with many of the stakeholders interviewed also stressing their importance towards either hindering or advancing the project, when compared to the other factors discussed. On the topic of the bioeconomy, the majority of the barriers and drivers are associated with the use of biomass (which is not always specific to the cattail, as discussed in Chapter 5) to generate bioenergy, and not with other applications in the bioeconomy.

The barriers that were given the highest significance were those associated with the dominance of the alternative energy sources currently available in Manitoba. The drivers that were given the highest significance were those that were associated with the project's potential role in mitigating the impact of flooding and the eutrophication of Lake Winnipeg.

The low prices and convenience of access that natural gas and electricity afford to consumers was one of the barriers mentioned that were of high importance. It was felt that the prices of both which have remained vastly affordable, and have continued to fall in recent times provide stiff competition to alternative sources of energy becoming more widely used in the Province. Related to this, a regulatory environment that does not intervene to facilitate fossil fuels being priced so that they recognise broader environmental costs or put into place policies that provide substantial inducement for more renewable sources of energy to thrive was mentioned as another barrier of significance. While it is agreed that the coal ban is a good start, it is not expected that it would provide a strong enough push for bioenergy systems to expand significantly.

This is in agreement with what is discussed in existing literature, where competition with existing businesses, either at the beginning or end of the supply chain, is considered to be one of the most critical barriers to be resolved when developing bioenergy systems. In the case of bioenergy development in Manitoba, competition at the beginning of the supply chain cannot be described as a serious deterrent, as current use of biomass by other sectors is very limited. However, competition from the alternatives at the end of the supply chain still remains a critical barrier that will have to be resolved either by market forces or through regulatory intervention. On the topic of regulatory intervention the need for policies and instruments that provide sources of financing to support bioenergy systems was also mentioned, an argument that is also supported by existing literature. The sources of financing available now are described as being very few in number or not continuous in availability.

Other barriers that are described in literature and which can be said to be of importance in this case study are a fragmented supply chain, with little interaction between the actors involved and a lack of understanding and trust about bioenergy systems. However, it was not felt that these are as significant in hindering the development of bioenergy as the other barriers described above.

The ability of bioenergy systems when compared to other energy systems, to enhance socioeconomic development is widely discussed in literature. However, it was interesting to note that many of the stakeholders interviewed were not convinced that this was one of the stronger drivers in helping to advance bioenergy systems in Manitoba. Some of the stakeholders felt that such decentralisation could be indeed be a favourable direction in which the advancement of bioenergy systems could proceed, but were not optimistic that it would necessarily materialise that way. Thus, in contrast to the emphasis that is placed on rural development as an important driver in the literature surveyed, it was felt that this was of less significance in this case.

Other drivers for bioenergy development that were felt were stronger in their potential to help bioenergy to expand were the availability of technology for the processing and combustion of biomass, and in the case of the cattail, for the harvesting as well. The interchangeability of the different types of biomass in the production and combustion of the fuel (an attribute also shared by the cattail) was also felt to be another strength of the bioenergy systems in Manitoba.

However, while the availability of technology is also discussed in literature as an important factor, less emphasis is placed on the interchangeability of biomass. While the need to integrate with existing industries in the area and to create synergies and through this make bioenergy systems competitive is argued for widely in the literature surveyed, tapping into the diversity of sources that could supply biomass is not discussed as much.

A possible explanation for this could lie in the fact that in Manitoba, there is a certain amount of hesitancy regarding the regularity of supply of the fuel if someone made the switch to bioenergy systems. This arises partly from the fact that the bioenergy industry is still very young, with much of the biomass being traded through a rather informal market. In addition, when the volumes being traded are small, the regularity of their supply can be susceptible to external conditions, such as the weather. Therefore, in the absence of a mature industry that can guarantee a constant volume of biomass being supplied, this interchangeability becomes a strength in developing bioenergy systems. In more mature industries, this may not be as important.

The drivers that were considered as being the most significant in helping to drive the IISD project come from the benefits created related to wetland and watershed management. The potential of the project to create green infrastructure that could generate ecosystem services such as water quality improvements and flood and drought buffering is widely accepted. The increased need for these services in recent years, taking into account the more frequent flooding events and the eutrophication of Lake Winnipeg, and pressure on the government to act on these issues are viewed as important drivers in generating funding support for the project and through this, contribute to its viability into the future. This also verifies what is suggested in literature, that the greatest potential of the use of reed harvested from wetlands is in an integrated approach to land and water management strategies.

A lack of concrete, quantified information regarding how such a project could contribute towards providing these services, is not mentioned in the literature as a barrier to the development of such strategies. A possible reason for this could be that this concept is still not widespread in its implementation for this gap to be felt. However, in the case of Manitoba, the absence of such quantified information is seen as barrier towards generating confidence in the project and towards attracting both government and private funding.

On the topic of IWRM, the presence of conservation districts fulfil many of the elements described in the framework, including management at watershed level, decentralisation of this function and comprehensive multi stakeholder participation. Thus, these elements already being in place are also a driver of some significance in that they could aid the project in further development.

6.2 Public and Private Benefits from the Project

If the socioeconomic drivers provide enough of a push, and if the barriers are resolved successfully, the bioeconomy project at the watershed level can be expected to generate a collection of both private and public benefits. In contrast to the drivers and barriers, which are a reflection based on the existing status of the system, the benefits generated are more hypothetical and future-oriented. Thus, the discussion of the bioeconomy focuses more on the use of the cattail in a variety of applications, as opposed to the use of general biomass in generating bioenergy.

The private benefits can be expected to be generated in two layers. As the first layer, a set of private benefits can be expected to materialise through the different products that can be produced from the harvested cattail. Thus, these would materialise as private benefits to those involved, in the form of profits generated through the production of different applications of the bioeconomy.

As the next phase of development of the project, it is expected that the benefits of flood and drought mitigation are added to the current assemblage of bioenergy production and nutrient recovery. This would then necessitate the planned designation of certain parts of the landscape that are maintained as wetland habitats. These habitats will be able to store and release water during periods of excess flooding and drought, and will also function as harvesting sites for the cattail. Such areas could be both private and public land.

On private land, this may necessitate a system where the individuals or institutions that own the land are incentivised or compensated, if this land can instead be subjected to other uses, for example agriculture. If the profitability of utilising the cattail for bioenergy production reaches values high enough to equate the profitability from other uses, the need for such incentives/compensation would be less. Through a similar process of development, another avenue through which financing can be obtained could materialise— the generation of carbon credits or water quality credits. Although here it is an ecosystem service that is quantified and is the unit of transaction, it would again necessitate the maintenance of wetland habitats, which would be areas of cattail growth, in the context of the project.

Thus, both of these would be a second layer of private benefits that the project can generate.

Taken together with the first layer, these private benefits would then indirectly lead to the development of a wide range of public benefits. These public benefits would be associated with the maintenance of wetland habitats from which the cattail is harvested (flood and drought mitigation, water quality improvement), harvesting of the cattail as a form of habitat preservation, the production of bioenergy as a form of renewable energy, the recycling of nutrients, and rural development through the bio economy.

The private and public benefits are interconnected in many ways, thus making this an integrated system of benefits. One benefit would need to have strong linkages to other benefits in order to materialise. The interconnections between the different private and public benefits that the project can be expected to generate are given in Figure 6-1.

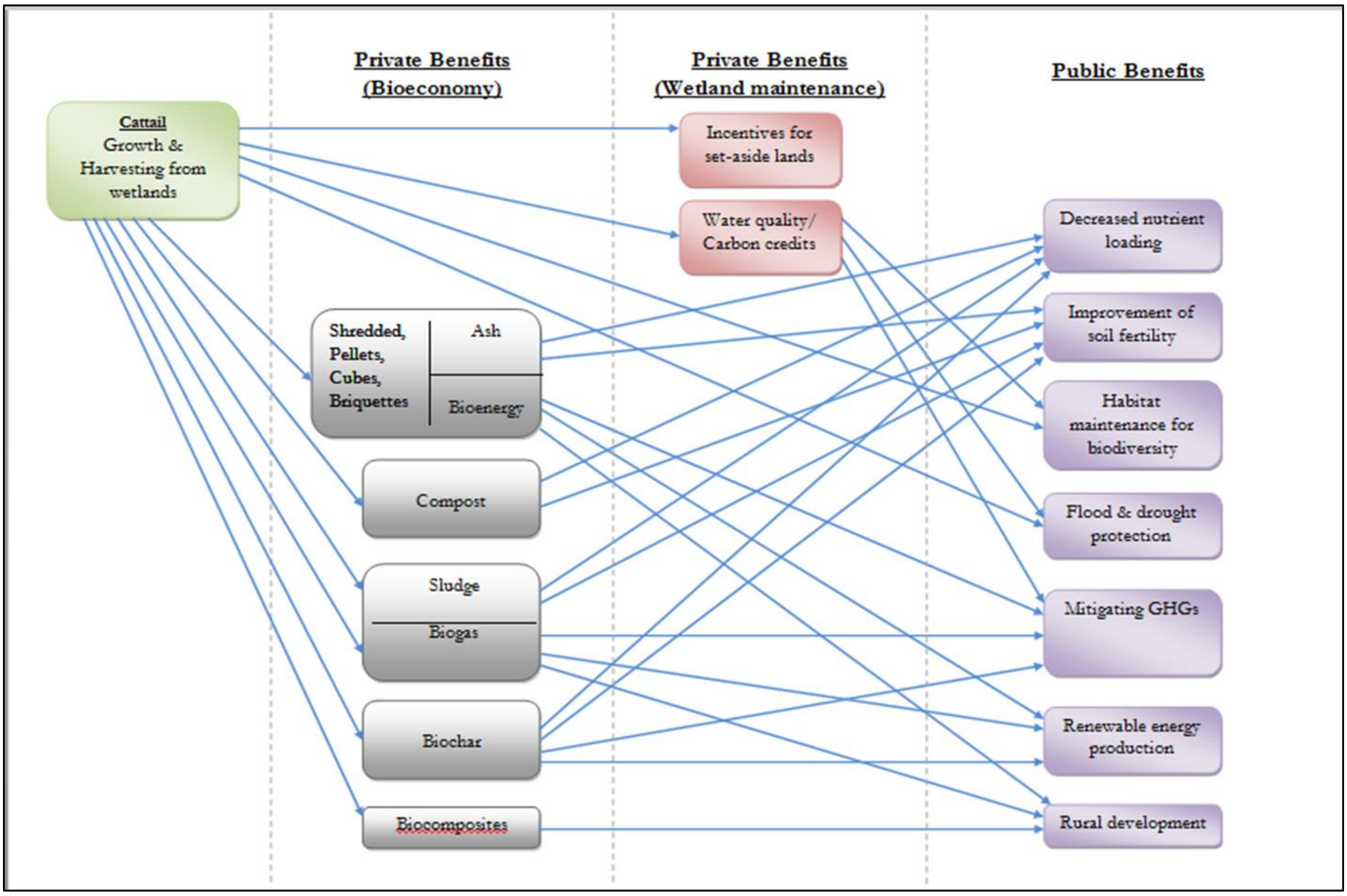

Figure 6-1: The interconnections between the different layers of private and public benefits occurring from the utilisation of the cattail in the bioeconomy

6.3 Relative Importance of Benefits to Stakeholders

While the benefits that the project can generate are many, and often interconnected, different benefits would be of importance to different stakeholder groups. To evaluate which aspects of the project are of value to the different stakeholders involved with the project, the interviewees were asked to rank the benefits in terms of importance. This importance would depend on importance to their private self, or importance to meet the needs of the Province, or both. However, in most cases, these were considered as the same, a fact that could be attributed to the infancy of the project. As tangible benefits are not yet generated, it could be unclear how the benefits from the project can affect a particular stakeholder's personal interests.

In addition to the public and private benefits being discussed in the thesis, other benefits were brought up, that the stakeholders felt that the project could generate. These included 1) self-sufficiency for Manitoba and the ability to utilise its own resources to meet its needs 2) diversification of agriculture, with the introduction of a new type of crop that farmers could cultivate, and 3) an improved image for the cities located near Lake Winnipeg, as a result of the Lake's potential environmental improvement.

The nature of the project to produce a bundle of private and public benefits was reflected in what the different stakeholders considered to be the benefit that is of importance. Many (12 stakeholders) felt that it is the integrated nature of the project that would be of importance to the Province. The argument was that a ranking of benefits or the identification of one key benefit could not be done, as the bundle of benefits could not be separated from each other. Even amongst those that selected a key benefit as being of more value to them or to the Province, it was acknowledged that this should be part of a larger collection of benefits, to drive the success of the project, as well as be of significant value to the province.

The perception of which benefits were of more value (apart from an integrated system) was in some cases similar between a certain stakeholder groups.

6.3.1 Flood and Drought Mitigation Benefits

All of the stakeholders in the 'Endusers: IWRM Benefits' (and a total of 5 stakeholders from all categories) group felt that the ability of the project to contribute towards flood and drought mitigation was the most important benefit that it could generate. It was felt that this could create interest in the value that wetlands have for the economy, and even reverse the trend of draining, to attain other uses from the landscape. Another co-benefit that is hoped will be created is an awareness about the value/dollar that would be obtained especially with regard to flood mitigations strategies, when projects such as these are invested in.

It must also be noted that awareness about how the project could contribute to flood and drought mitigation, was lacking in some of the members from other stakeholder groups. The initial focus of the project has been on stimulating a bioeconomy as a possible answer to reduce nutrient loading in the Lake. This may have meant that information about flood mitigation being an important benefit that is currently being pursued has not been imparted to some of the stakeholders. It could also mean that the connection of the project to this benefit is not immediately evident.

6.3.2 Nutrient Recycling and Impact on Lake Winnipeg

This was the predominant benefit that was hoped would be generated by the project from the 'Producers' group. In total, 5 stakeholders mentioned this as the most important benefit that the project could generate. This could be attributed to two reasons. One is that, those in the agricultural sector feel that they are considered responsible for the nutrient loading, when they feel that other stakeholders also play a part. Thus, the topic of nutrient loading would be one that is of immediate interest to the farming community. Secondly, the significant expenditure incurred for the usage of inorganic fertiliser would mean that there is considerable interest in examining the possibility of alternatives to this.

An interesting observation is that, despite nutrient loading into Lake Winnipeg being considered by most of the stakeholders as the most important issues facing Manitoba, the reduction of nutrient loading is given less significance as the benefit that would be of most value to the stakeholders and to Manitoba. While this benefit was named as one of the benefits among the integrated system that the project could create, another explanation for this discrepancy could be that, it is not expected that this project can play a significant role in nutrient reduction. It was stressed by many stakeholders, that this project can play a part in solving the issue, but that it will be one of many solutions that would do so.

6.3.3 Generation of a Bioeconomy

Despite the focus on utilising the cattail for bioenergy production, few of the stakeholders (2 stakeholders) felt that this is the benefit that would be of importance to them. This included those in the 'Producers' and 'Processors' categories, as well as those from 'Research and Development' who worked on issues strongly associated with this topic. As with the topic on nutrient loading, this was mentioned as one of the benefits that would be part of an integrated system. Another possible explanation is, that as many of the applications of the bioeconomy are still in the conceptual phase, that most stakeholders (with the exception of a few) do not quite know what role they would play if it were to expand into the future. Finally, the significant barriers faced by bioenergy development may have contributed to this, as has been discussed in section 6.1.

6.3.4 An Integrated System of Benefits

From the bundle of private and public benefits that an integrated system would have, it was felt that a certain type of benefit had a stronger potential for materialising first, mainly as it would develop into a concept that would be supported by the larger environment. This support was due to some of the socioeconomic drivers that the project faces in its expansion. Conversely, a benefit was considered weaker in gathering support if it was thought to face certain barriers that would not be resolved in the foreseeable future.

The potential for bioenergy systems to develop in the short term, when compared to systems that would generate benefits of flood and drought mitigation, was a reason that some of the stakeholders felt the bioeconomy (and particularly bioenergy) would be the benefit that would materialise first, and stimulate the development of the other benefits. The large amounts of investments as well as a strong backing by the government that would be needed for the water management benefits to materialise was the main argument behind this. However, in the long run, it was felt that the water management benefits have the potential to become the stronger component of the project in attracting financial support.

As an approach to initiating an integrated approach was that the needs of a particular context should be judged, and the system be modified to generate those benefits, even within a particular geographic location/watershed/political boundary, such as Manitoba. This concept will be examined later in section 6.5.

6.4 The Existence of Trade-offs

The integrated system of a bundle of benefits is what is considered to be the key strength of the project. However, within this system, not all of the benefits complement each other, and it would not be possible to optimise the system so that all of the benefits that the can be generated are maximised. There, trade-offs are inevitable, and a system of decision making is needed to evaluate which benefits need to be maximised to tackle the socio-economic and environmental issues faced by the system. Some of the trade-offs that can be expected to occur are discussed below.

6.4.1 Trade-offs between Maintaining a Robust Bioeconomy/Obtaining Ecological Benefits

A well-functioning bioeconomy would inevitably require a constant and reliable supply of the raw material that feeds it. As was discussed earlier, this was a concern that many stakeholders had regarding the suitability of bioenergy for their energy needs. If the cattail is considered, this would necessitate predictable harvesting times, and designated areas from which it is harvested. Thus, it would be closer to a cultivated system than a natural one.

Taking into consideration that the generation of the bioeconomy is a benefit that will have to be balanced with several others, such a cultivated system may not be the most suitable. Many of the other benefits such as flood and drought mitigation and habitat creation, are dependent on many environmental variables, which would require an enormous amount of information for prediction and control. Thus, it would not be feasible to generate both sets of benefits at optimal levels — a focus on generating the ecosystem services associated with the project will mean that the supply of the harvested cattail each year could fluctuate.

Thus, the utilisation of the cattail in a thriving bioeconomy will depend largely on its interchangeability with other types of biomass for different applications. If this can be ensured, the tradeoff between the need for more control of the system vs the materialisation of the other benefits can be balanced, to a certain extent.

6.4.2 Trade-offs between Optimal Times for Harvesting

A more complicated system of trade-offs however, ensues in determining the most suitable timing of harvesting of the cattail. There is very little overlap between the periods of time that are optimal for the different benefits.

Trade-off between flood/drought mitigation and nutrient management: This arises, because vegetation and vegetative residue in standing water, leads to the formation of organic phosphorous that is highly soluble in water, and therefore can be flushed off a landscape, when water drains from it. This phenomenon is particularly pronounced during the rapid flow of water during Spring floods. However, even during other seasons, holding in water in an area that has dense vegetation, and allowing it to drain away, can have the same impact, if the system is not controlled to some extent.

In the case of the cattail, this control should coincide with the lifecycle of the plant. The majority of the phosphates will be found in the above ground biomass, from mid-August to early September. Therefore, harvesting the cattail during this time will result in a removal of a large proportion of the phosphorous. After this period, the plant pulls the phosphates into the rhizomes, which cannot be harvested.

If a system is managed so that water levels can be manipulated externally it would be possible to drop the water levels before this occurs, so that the ground would become dry enough for harvesting equipment to go in. However, for a natural wetland system that is used for water buffering, the storage and draining of water in the system will not necessarily coincide with the lifecycle of the cattail. In such a natural setting, therefore, flood and drought mitigation will not necessarily complement nutrient removal through the harvesting of the cattail.

Trade-off between nutrient removal/ profitable harvesting: As described above, in order to use equipment that is used for agricultural purposes, the ground must be dry enough for the equipment to navigate through it. Further, the harvesting and baling equipment is in use by farmers till the beginning of November, after which it is left to idle. Therefore, this is a more optimal time to utilise this equipment to harvest the cattail.

Further, the level of moisture in the ground also corresponds to the level of moisture in the harvested cattail biomass. Harvesting later in the season would result in less need for the cattail to be dried artificially. However, the time of the year that is most suitable to ensure profitable harvesting is much later than when maximum nutrient removal can be achieved, as described in the previous section.

Trade-off between nutrient management and wildlife conservation: The harvesting of the cattail, so that minimal damage occurs to wildlife, does not also coincide with the most optimal timing of phosphorous removal. The habitat is used by nesting birds from June to the beginning of August. Following this, most of the young birds would have left their nests, although some birds such as ducks, herons and egrets and mammals such as the muskrats will utilise the habitat for a slightly longer period. Therefore, from the point of view of harvesting with minimal impact to the resident wildlife, once again, October, and the months after that will be more suitable.

6.4.3 Balancing Trade-offs

Two strategies were put forward as possible methods through which an attempt could be made to balance the generation of the different benefits. One of these is to select a timing for the harvesting so that all of the benefits could be realised to some extent, but not fully. As one stakeholder stated, "No one should get what they want". The middle of August was suggested as a suitable time for this. The other suggestion was that, the collection of benefits that are most needed in a certain context should be identified, and the timing of the harvesting decided to maximise these. A visualisation of this is given in Figure 6-2.

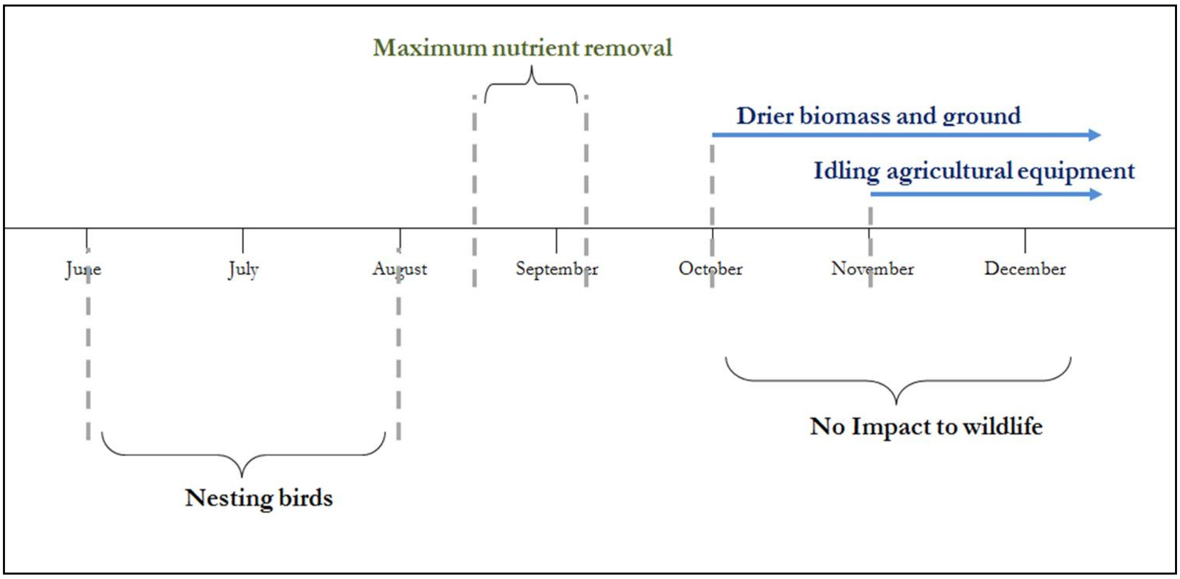

Figure 6-2: Balancing the different trade-offs in harvesting of the cattail

6.5 Implementing and Integrated System of Benefits

Taking into account the different types of environmental and socioeconomic issues faced by the Province, and the different drivers and barriers faced by the project, the integrated system of benefits that the project has the potential to generate is also viewed by the stakeholders as the most important group of benefits that would be of importance. This is summarised in Figure 6-3.

It was felt, that bioenergy development has the potential to help the project advance in the beginning, but that the benefits associated with the generation of ecosystem services could account for a major proportion of the support for the project in the long run. However, for this to materialise, many of the stakeholders felt that stronger demonstration of the benefits associated with the project is needed.

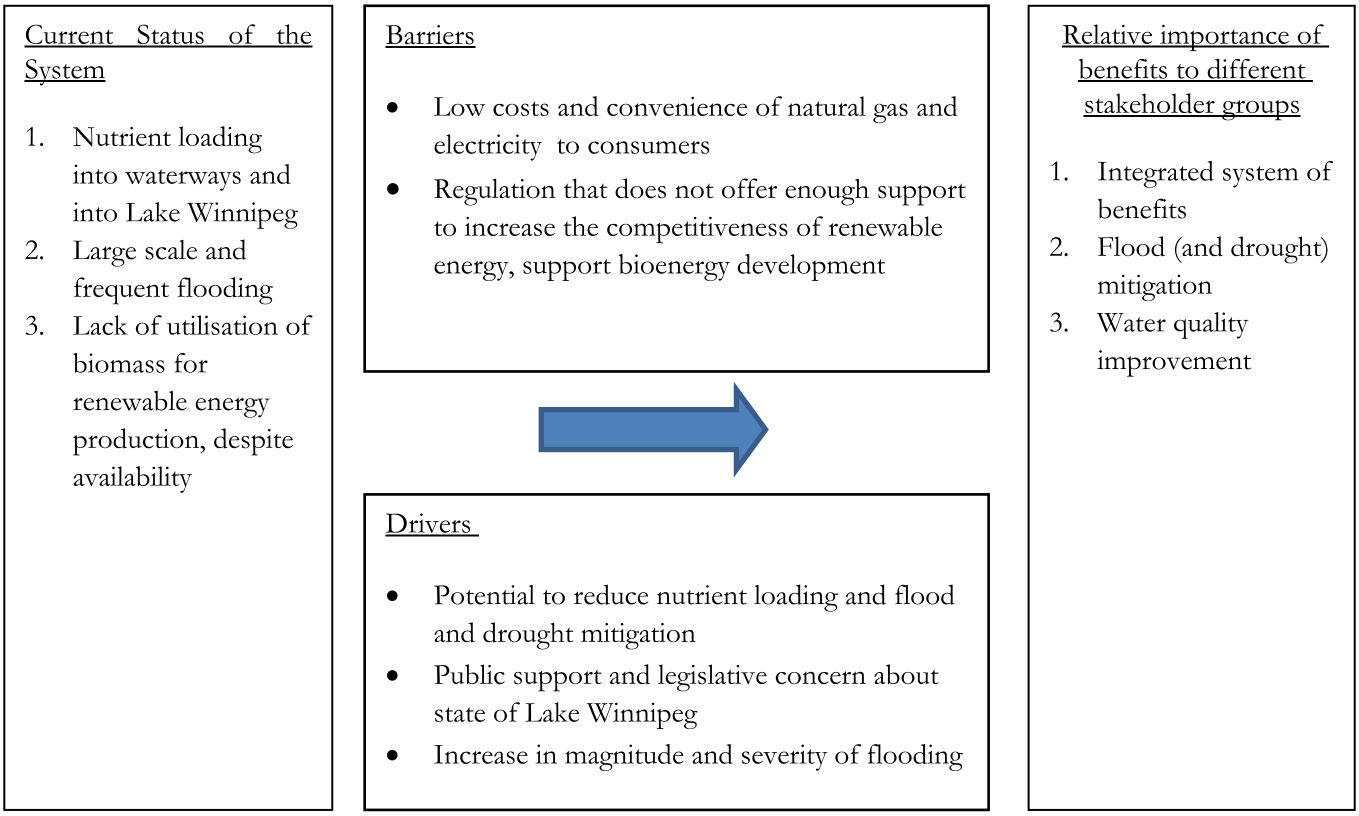

Figure 6-3: Relationship between current status of the system, drivers and barriers and importance of benefits to stakeholders

Demonstration projects of a larger scale were one of the solutions suggested to rectify this. On the bioenergy side, the installation of a biomass burner at a few large institutions in order to validate the benefits and to create confidence in utilising such a system was proposed. On the water management side, the need for the small scale pilot projects that are in existence at the moment to transition towards a demonstration project that is bigger in both magnitude and duration was expressed.

Secondly, the need for quantification of the benefits generated, so that they can be communicated in more concrete terms to create confidence among different stakeholders including the government, as well as from sections of the private sector that would be interested in investing in sections of the project was pointed out. Further, it was stressed that the interconnections between these benefits and how they fit into the needs of Manitoba should be communicated suitably, so that they could reach those outside of the scientific community. As an example of this gap, the association between the IISD project and flood and drought mitigation was not immediately apparent to many of the stakeholders outside of the category of 'Endusers: IWRM Benefits'.

In addition, while the results for certain aspects of the project have been quantified, many of the stakeholders were of the opinion that a better understanding of the project could be conveyed by providing quantified information on the integrated system of benefits that the project hopes to generate. This is also needed to identify how the expected benefits balance against other, and how much of each benefit can be generated under an integrated system. Another advantage of this would be to identify nexus points in the system, so that the generation of the different types of benefits can be maximised.

At present, it is felt that the Government of Manitoba is looking into options to transition away from being solely dependent on built infrastructure for flood and drought mitigation, to also incorporating more natural solutions into their strategy. The Province recently released 'Manitoba's Surface Water Management Strategy' which calls for the implementation of multi-purpose water storage strategies, both engineered and natural, to generate both water buffering and other ecosystem services. This includes increasing water retention on crown land, working with conservation districts and farmers to achieve the same and storm water management in urban areas through the use of retention ponds. The use of these retention areas for multiple purposes such as water quality improvement through biomass (e.g. cattail) harvesting is also recommended (Manitoba Conservation and Water Stewardship, 2015).

These concepts are very much in line with what the IISD project hopes to achieve, and where it could fit in as it develops further. Therefore, demonstration of how it could be implemented in more large scaled settings, as well as more concrete information on the magnitude of benefits that it can generate would assist in creating confidence among the stakeholders involved and others, regarding its potential

6.6 The North Ottawa Project: A Comparative Case study

The relative importance of the project's benefits to the project's benefits to the stakeholders in Manitoba, is very much context-specific. To analyse how this ranking of benefits might change in another context, the North Ottawa Project by the Red River Basin Commission was looked at. The North Ottawa Project is a system of flood storage areas and is located in the Red River Valley, in Minnesota in the USA.

6.6.1 The Red River basin Commission

The Red River Basin Commission (RRBC) is a small not-for-profit water planning organisation that works on water planning and management of the Red River Basin. The main role of the organisation is to facilitate dialogue and discussion between the various entities involved with the Red River Basin, and further practices to improve water management in the basin. These include the three states and one province from the US and Canada which jointly share the basin—Minnesota, North Dakota, South Dakota and Manitoba. While the RRBC does not have intergovernmental jurisdiction, it has close ties with the different governments in the three states and one province and their municipalities, with its 42 member board consisting of representatives from these governments. The base funding for the RRBC's work too, comes from various sources from the provinces, states and municipalities.

All of the work by the RRBC centres on the Natural Resource Framework Plan, which consists of thirteen goals, including flood mitigation, flood response and recovery, flood forecasting, drainage and water quality (Red River Basin Commission, 2015). A large proportion of the Commission's work is on reducing flood damages, while it is said that improving water quality through the reduction of nutrient loading is a second area of priority. In 2011, as part of this Plan, the Long Term Flood Solutions plan was designed, in an effort to reduce flood related damages in Minnesota. The North Ottawa Project was a result of this initiative.

6.6.2 Main Environmental and Socio-economic Issues faced by Minnesota

The main challenges in Minnesota are centred on agriculture. Almost 80-90% of the watershed here is associated with agricultural production, much of it cropland. Therefore the focus has been very much on draining water away from the landscape, as rapidly as possible, often through the usage of tile drainage, ditches and other engineering systems. However, this has resulted in flooding downstream, with the frequency of large scale flooding increasing over time. Another environmental impact associated with agriculture is nutrient loading into waterways, and the impact this practice has on more downstream waterways has been recognised.

6.6.3 The North Ottawa Project

The Long Term Flood Solutions Plan included goals for level of protection that municipalities should have against flooding, flood plain management and a goal to try and reduce the frequency of hundred year flood (a term for a flood of large magnitude that has a 1% probability of occurring in a particular year) by 20%. It was decided that this goal would be achieved through the construction of flood storage areas (Figure 6-4), known as distributed storage plants. Each sub watershed that was a part of this plan was tasked with identifying areas that would meet this goal.

While ten of such retention areas exist at the moment, the North Ottawa Project, completed in 2012 is considered to be the most comprehensive in terms of control of water flow and water levels. The Project is by the Bois de Sioux watershed district (similar to conservation districts in the case of Manitoba), and the retention areas (or impoundments as they are known) drain about 194, 250 km^2 (75000 square miles) of agricultural land, and it is felt that this improves production both upstream and downstream the impoundment. More projects of this type are planned for the Red River Basin.

Figure 6-4: Flood storage area, North Ottawa Project Image source : J.Lewis, personal communication, June 2nd, 2015

6.6.4 Socio-economic Drivers and Barriers

The North Ottawa Project can be associated with two types of benefit—the realised potential for flood mitigation, and those that can be potentially generated. The drivers and barriers faced by the two types of benefits are discussed below.

6.6.4.1 Realised Potential for Flood mitigation: Drivers and Barriers

Demonstrated Benefits: The goal to reduce the 100 year flood by 20% is being met mostly or entirely, through the construction of similar retention areas. The North Ottawa Project is one of two projects by the Bois de Sioux watershed district. It is estimated that both of these projects will assist in meeting all of the flood contribution by this watershed. Thus, the contribution that this strategy can play to flood mitigation has been known and expressed in quantified terms. Around 10 such structures have been built in the Red River Basin to meet the 20% flood reduction goal. It is estimated that a total of 100-200 of such sites will be constructed in the next 20 years to achieve this goal.

Financial Support by the Government: The cost for the project was shared between the Bois de Sioux watershed and by the Red River Watershed Management Board, and funded entirely through government funding, both local and federal. The land on which the retention basins are built was formerly private land, and was bought by the watershed district. The case for the construction basin was made largely by showing the potential for generating flood mitigation benefits, as well as for, through this, improving the productivity of agricultural land above and below the retention area. It can be concluded that obtaining funding at such a scale was a significant driver in pushing this concept forward.

6.6.4.2 Potential Benefits: Drivers and Barriers

Impact on Nutrient Loading Downstream: The RRBC works closely with entities in Manitoba, and the contribution by the US and Canadian sections of the Red River to the nutrient loading into Lake Winnipeg is treated as an issue of importance. Hence, following flooding, water quality and nutrient buildup is treated as the next biggest issue of importance. A goal that attempts to reduce the phosphorous loading into the Lake by 50% has been adopted by the Government of Manitoba, and the RRBC is exploring ways through which work in the Red River Basin an contribute towards this.

Therefore, the impoundments are focused on strategies on how this can be achieved. Following collabourations with IISD the application of the harvesting of the cattail (which grows abundantly in the impoundments) to contributing towards nutrient reduction have been explored. To facilitate this, the North Ottawa impoundment will be subdivided into smaller treatment cells, and will function very much like a water treatment plant.

Costs of Management of Vegetation: The storage impoundments, being areas that contained standing water, became areas in which the cattail thrived. The cattails found in Minnesota are mostly varieties of hybrids between the native, broadleaved cattail and non-native narrow leaf cattail and show properties of invasiveness. The excessive growth in the vegetation has interfered with the functioning of the impoundment, and controlling it has become an issue. Typical methods of control till now have been the use of herbicides, as well as using farm machinery to mow it down. In both cases, the cattail is not removed from the system. Further, the use of herbicides has resulted in the release of the chemicals to downstream waters.

Harvesting the cattail and using it for different applications is therefore a method through which more a reduction of nutrient loading is achieved as a co-benefit. Further, potential profits from this strategy would give it a competitive advantage over the previous methods of control.

Market for Applications of the Bioeconomy: Different market applications of the harvested cattail are being pursued. It is expected that the pilot harvest will be done in August/September this year. Some of the options are similar to those pursued by IISD—applications in bioenergy and fertiliser production.

With regard to bioenergy, Minnesota has the same cheap access to natural gas that Manitoba does. In addition, coal is a big component of the energy mix, as Minnesota produces its own coal. Therefore it is not clear yet if there will be any applications in the bioenergy market. With regard to fertiliser production, the potential to produce green manure is looked at, as well as the application of the ash produced in generating bioenergy. However, the suitability of these options to Minnesota have not been explored. Like in Manitoba, much of the soil in Minnesota too is neutral to alkaline. And fertiliser produced from ash may not be the most suitable for application here.

An application that is believed to show potential is the usage the pelleted form of the cattail to produce adsorbents for usage by the oil industry in North Dakota. Such adsorbents are used to clean up oil spills from the mining and extraction process. In comparison to other materials, it has been shown that cattail has superior adsorbent properties when pelleted, and it is believed that the value can be increased by 5 or 10 times with a value of 200 dollars (142 euros)/tonne.

6.6.4.3 Reduced Extent of Trade-offs

While the issue of trade-offs is high in the case of achieving both flood mitigation and nutrient reduction in Manitoba, this is seen as being a less of an issue in the North Ottawa Project. This is due to the nature of this impoundment being a confined system, and the ability to manage water levels, in a highly controlled setting.

The impoundment will be subdivided into smaller retention areas, in which water levels can be manipulated. The system will function very much like a two way water treatment structure, where water is passed from a primary treatment area, to a secondary one. In the secondary area, water levels will be dropped down, enabling the cattail to be harvested. Nutrient monitoring will be done of the water that enters the impoundment, of the soils and vegetation in the impoundment and of the water that is discharged from the impoundment.

The finely controlled system will therefore enable the monitoring of the phosphates when the highest amounts are stored in the above ground biomass, so that it can be harvested before the nutrients are drawn back down and released into the water. Thus, both benefits can be achieved in tandem in this scenario.

6.7 Comparison between Ranking of Benefits in the Two Case Studies

The two case studies have contexts that share a lot of similarities, as both are located in the Red River Basin. Many of the issues that are common to the basin are thus found in both cases. One of these is the occurrence of large scale flooding, with extensive damages mainly to agricultural land. It is also feared that the incidence of flooding will become more frequent and severe over time, along with the impacts of climate change. Thus, it can be concluded that both cases will be affected in similar ways.

The second issue faced by the two cases is that of phosphate or nutrient loading into waterways, as a heavy dependency is seen on agriculture in both situations. However, in the case of Minnesota, the nutrient loading is to more downstream areas, and therefore largely away from the State. In contrast, Manitoba is the recipient of this water, and the impact of the nutrient flow into the largest lake in the Province is very visible, and is an issue the Province is very keen to address.

The two economies have different energy mixes. Both utilise natural gas. However, Minnesota produces its own coal, and therefore would have little incentive to move away from the utilisation of this source of fuel. In contrast, coal is imported to Manitoba, and used by a small proportion of the population. Therefore a transition away from coal would require less resistance from the socioeconomic system. As alternative sources of fuel, and considering the abundance of biomass in Manitoba, this is expected to open up a small niche market for the use of this fuel. In Minnesota however, the applications of the cattail would be different. The thriving oil industry in a neighbouring State opens up a new driver for application in the adsorbent market.

When taking into consideration the issues surrounding the cattail, it is generally felt that the varieties seen in Manitoba show less invasive tendencies, when compared to its neighbours in Minnesota. In addition, the cattail in Manitoba grows largely in marginal land that is not subjected to any use. Therefore, its presence is not considered an issue of ecological management. In contrast, the cattail in Minnesota is a serious problem to the functioning of the retention basins, which are finely controlled structures that would require minimal interference with the system. As a result, the issue of the cattail in Minnesota is largely about the management of the vegetation, as opposed to the reasons for the focus on the cattail in Manitoba –its ability for nutrient capture, and bioenergy production. Thus, in Minnesota, nutrient management becomes a secondary focus.

Therefore, it can be concluded, that for Manitoba, the range of benefits that the project can generate —flood and drought mitigation, ability to reduce nutrient loading and application in the bioeconomy would all be important. Thus, an integrated approach was felt by the stakeholders as the most important benefit that the project could generate.

If the bundle is taken apart, and the individual benefits are considered, the water management benefits are given higher priority to the bioeconomy benefit. One potential reason for this could be the drivers and barriers faced by the system. The increased urgency of both flood mitigation and nutrient load reduction in the eyes of all of the stakeholders, including the government, gives higher momentum for these benefits to materialise. In contrast, the low prices and convenience that natural gas and hydropower have in the province and an unfavourable regulatory environment for bioenergy development would give the concept of the bioeconomy less scope to expand, from its current niche status.

If the drivers and barriers for Minnesota are considered, the proven potential for flood mitigation by the retention basins, give it the highest priority in terms of the most important benefit the project could generate. In addition, the other benefits would be of less important when taking into account the needs of the Province. The impact of the nutrient loading is not as visible as it is in Manitoba, and the management of the cattail is a localised issue to the impoundments. Therefore the need to bundle the benefits together doesn't arise. Flood mitigation is given the highest priority, followed by reduced nutrient loading and reduced expenditure on vegetative management.

In conclusion, this makes a clear case that given the same set of benefits, the current pressures on the system, and the drivers and barriers that a bioeconomy project at the watershed level may face, the menu of benefits that would become important in different contexts change.

This then becomes an important consideration in project design. The project design should be customised to according to the context of the system, to generate the most optimal level of benefits. This is conceptualised in figures 6-5 (Manitoba) and 6-6 (Minnesota).

Standard list of benefits

- Flood (and drought) mitigation
- Water quality improvement
- Generation of a bioeconomy
- Integrated system of benefits
- Reduced costs of IWRM Operations

→

Relative importance of benefits to different stakeholder groups

- Integrated system of benefits
- Flood (and drought) mitigation
- Water quality improvement

Current Status of the System

- Nutrient loading into waterways and into Lake Winnipeg
- Large scale and frequent flooding
- Lack of utilisation of biomass for renewable energy production, despite availability

Drivers and Barriers

- Low costs and convenience of natural gas and electricity to consumers
- Regulation that does not offer enough support to increase the competitiveness of renewable energy, support bioenergy development
- Potential to reduce nutrient loading and flood and drought mitigation
- Public support and legislative concern about state of Lake Winnipeg

Figure 6-6: Reclassification of benefits according to the needs of the system and drivers and barriers faced — Manitoba

Standard list of benefits

- Flood (and drought) mitigation
- Water quality improvement
- Generation of a bioeconomy
- Integrated system of benefits
- Reduced costs of IWRM Operations

→

Relative importance of benefits to different stakeholder groups

- Flood (and drought) mitigation
- Water quality improvement
- Reduced costs of IWRM Operations

Current Status of the System

1. Large scale flooding in the Red River Valley
2. Impact of nutrient loading on downstream users
3. Costs of controlling the cattail

Drivers and Barriers

- Demonstrated benefits of flood mitigation and financial support
- Impact of nutrient loading downstream
- Costs of management of vegetation

Figure 6-5Reclassification of benefits according to the needs of the system and drivers and barriers faced — Minnesota

7 Conclusions and Recommendations

This research consisted of a study of a project by IISD on creating a bioeconomy at the watershed scale in the Lake Winnipeg watershed in order to achieve the following objectives.

- Conduct a case study to reflect upon the socioeconomic sustainability of the project.
- Evaluate the transferability of the project to other contexts.

This section will revisit the research objectives to reflect on the understanding obtained from each of them. Further, recommendations will be made about the project and further directions in which the study can be taken. This is of particular importance as only the first steps to assess the portability of the study have been analysed in this study.

The case study that was chosen is set in Manitoba, Canada. This province faces quite a few environmental issues, including large scale flooding and potentially drought into the future, brought about by both climate change and widespread conversion of a landscape that was once dominated by prairie grass and wetlands. The threat of flooding and drought is of special concern as Manitoba is heavily dependent on agriculture. However, this resultant manifestation of intensive agriculture in the area has also resulted in a transfer of nutrients, mainly phosphates into the waterways, with an ultimate discharge into Lake Winnipeg. This is further aggravated by an influx of nutrients from the US, brought in by the Red River which empties into the Lake.

Apart from these two issues which are felt to be the most important facing the Province, a dependency on fossil fuels to meet part of the energy needs of the Province with a lack of initiatives to utilise the abundance of biomass available in Manitoba, and the economic impoverishment of the many First Nations Communities residing in the Province were felt to be other important socioeconomic issues.

The project by IISD, initiated to tackle the issue of nutrient loading into Lake Winnipeg is now in its third year of operations. The project aims to create a bioeconomy at the watershed level, focusing on the common cattail. The opportunity to generate a bioeconomy arises from the variety of applications that could be pursued using the cattail, including the production of bioenergy, fertiliser and biofibres. The project is also unique in that, along with a bioeconomy, broader ecosystem services can also be generated. The ability of the cattail to absorb in large amounts of phosphorous into its biomass, makes it an excellent means thorough which the phosphate could be mined from the system. Patches of cattail are associated with wetlands, and the maintenance of wetlands can contribute to flood and drought mitigation through buffering of water levels, provide habitat for wildlife and other ecosystem services.

The project is still at a pilot phase, with harvesting having being done from three main areas—the Netley-Libau Marsh, found at the mouth of the Red River before it empties into Lake Winnipeg, Pelley's Lake, a retention site used to hold in water during seasons of flooding and from storm water ditches. From the harvesting of the cattail to its processing and final end use, and for support on various aspects of the project, different types of stakeholders work with IISD. These include landowners from whose properties the cattail could be harvested and organisations such as PAMI that work with IISD on harvesting and processing the biomass and on further applications and Biovalco that in association with Hutterite colonies also works on processing of the harvested biomass as well as on producing the most prevalent biomass burner used in Manitoba.

This also includes end users of the benefits that the project could generate which are of two types — end users of biomass such as institutions that have installed biomass burners and end users of the watershed management benefits, such as the conservation districts and the government. Further, supporting structures to the project include those that provide funding through various means and individuals and organisations that conduct research and provide their expertise of various aspects of the project.

The project faces a variety of socioeconomic drivers and barriers as it develops further into the future. On the topic of bioenergy generation, the dominance of natural gas and hydropower to meet the energy needs of Manitoba remains one of the strongest barriers to overcome. Hydropower is generated in the Province, and meets most of the electricity needs of the Province, while natural gas brought in from Alberta, and accounts for much of the heating needs. The low costs and convenience of accessing these fuels and a regulatory environment that does not mandate the inclusion of external public costs (particularly with regard to natural gas) continue to give these alternatives a strong competitive edge. A ban on the use of coal for space heating that will be implemented from 2017 is viewed as a positive start to promote the expansion of bioenergy, but there is little optimism that this is a strong enough driver to create strong, viable markets. The ban is expected to affect roughly 1% of the energy used in the province mainly by users who are not connected to natural gas lines and the Hutterite colonies who live a lifestyle of self-sufficiency.

The abundance and variety of biomass found in the Province, a lack of major industries utilising it and most importantly, the interchangeability of the different types of biomass, either when processing it into different products (e.g pellets, cubes and briquettes) or when burning it to produce bioenergy are viewed as another driver. The supply chain for bioenergy production that is in existence at the moment is highly fragmented, and there is a certain degree of scepticism among the public about bioenergy systems. However, certain stakeholders and institutions act as 'local champions' to overcome this gap, pushing further development of bioenergy systems in the Province. While one of the most important strengths of bioenergy systems elsewhere is considered to be their potential contribution to rural development and poverty alleviation, this was not seen as a particularly strong driver in the case of Manitoba.

With regard to the use of the cattail, the technological infrastructure that is needed to harvest, process and burn it already exist from that used for other types of biomass. For example, agricultural equipment used for the harvesting and baling of forage crops can be utilised to harvest the cattail. The cattail, being similar to other grassy biomass has a high mineral content, which can interfere with its usage as a feedstock for biomass. However, blending the cattail with wood has been found to help overcome this. Other applications of the cattail that are being currently looked at also include the production of fertiliser from the ash that remains from combusting it for bioenergy production. However, it has been pointed out that much of the soils in Manitoba are alkaline in nature, and would be detrimentally impacted by the addition of ash, as it contains a high amount of hydroxides.

There was considerable interest among the stakeholders regarding the potential of the project to generate ecosystem services mainly with regard to flood and drought mitigation and water quality improvement. Recent research has shown that much of the phosphorous leaving agricultural systems comes in dissolved form from vegetative cover. This is especially a problem in temperate climates when vegetation is left under snow cover which rapidly melts in spring. The rapid spring runoff results in much of this phosphorous being flushed off the landscapes and often into waterbodies such as Lake Winnipeg. Therefore, removing the vegetation, such as through the harvesting of the cattail can act as a mitigatory measure against this phenomenon. In addition, the phosphate loading into Lake Winnipeg has been the topic of a lot of public concern and legislative action, resulting in both of these being significant drivers in supporting the project.

The magnitude and severity of flooding in Manitoba has increased in recent times with the Provincial government incurring significant costs in meeting damages and in insurance payments. Further, with the incidence of climate change droughts are expected to become more common in certain parts of Manitoba resulting in the need for strategies for water storage. Retention basins by conservation districts, such as Pelley's Lake have shown potential as one of the solutions to address this.

Therefore, the most significant drivers were associated with the generation of the above ecosystem services. Further, conservation districts fulfil many of the elements described in the IWRM framework, including management at watershed level, decentralisation of this function and comprehensive multi stakeholder participation. These elements already being in place are also a driver of some significance in that they could aid in operationalising the project.

This collection of drivers and barriers was also reflected in what stakeholders thought would be the benefits that can be generated that would be of most importance to Manitoba. Flood and drought mitigation was mentioned frequently, followed by the potential to contribute to nutrient loading, and finally application in the bioeconomy. However, the majority of the stakeholders felt that it is the integrated nature of the benefits that would be created, that would be of most importance to the Province.

Within the integrated system it was felt that the development of the project in the short term would be led by the development of bioenergy (and potentially other applications of the bioeconomy), as it was felt that this could occur without the substantial amount of investments that would be required to generate the water management benefits. However, in the long run, if support especially from the government could be attracted, it was felt that the water management benefits would be the stronger component of the project.

Many stakeholders were of the view that any initiative that attempt to modify natural gas prices to recognise broader environmental costs will not be initiated by Manitoba, but that the Province will follow suit if this became a more common practice in Canada. Natural gas prices, one of the biggest barriers to bioenergy development (the other being hydropower) is therefore subjected to political, social and economic developments in other parts of Canada and in North America. Local initiatives to change this can only be expected to have limited impact, making this a stiff barrier to overcome. Therefore, under the current system, bioenergy (currently the strongest component of the bioeconomy aspect) can be expected to expand, but not to a significant extent.

On the contrary, the Government of Manitoba is at present looking at ways to incorporate green infrastructure into its water management strategy, and the project by IISD fits in well into this plan. Therefore, this aspect of the project has the potential to develop through initiatives within Manitoba, and attract funding and other support for development in the long run. Further, under this scenario, if fossil fuel prices are also regulated in the future (e.g. through a carbon tax), large amounts of cattail would then be available for bioenergy development that is more price competitive, when compared to the alternatives. This focus on the cattail could also assist in accelerating the use of it in other applications in the bioeconomy.

While the need for an integrated system aligns well with the objectives of the project to create multiple benefits, it must be noted that within this system, not all of the benefits complement each other, and it would not be possible to optimise the system so that all of the benefits that the can be generated are maximised. An example of this is the determination of the optimal harvesting time for the cattail. The optimal time is different for the different benefits such as flood and drought mitigation/ maximum nutrient removal, maximum/nutrient removal/profitable harvesting and wildlife management/maximum nutrient removal. To overcome this, the design of the system could either be that none of the benefits are generated at the maximum amount possible or that the benefit most desired in a particular context is chosen and maximised.

An integrated system being the benefit that is most needed by the Province and the stakeholders involved is however, was not seen in the comparative case study from Minnesota. In the North Ottawa Project, a system that was in many ways similar to Manitoba was observed. Flooding was of equally high concern in the basin. Agricultural discharge led to nutrient loading into common waterways. The cattail, which has higher invasive tendencies had to be managed, incurring additional costs.

The potential for flood mitigation had been quantified and used as a means to justify the construction of the retention basins. Thus, this was a realised benefit, and was considered to be the most important benefit that the project could generate. While nutrient loading was a problem, it was largely to water bodies downstream, and was therefore given second highest priority. While the management of the cattail has resulted in high costs, the abundance of cheap coal in the Province did not make the alternative of bioenergy an option that has potential for development. Finally, a system of bundling was not suggested, given the dominance that flood mitigation had over the other benefits

Thus, it can be concluded, that given a standard set of benefits that the drivers and barriers, and the existing status of the system would lead to a reclassification of the benefits in different contexts. This is also the case when the contexts share many similarities such as the two case studies compared, both of which were set in the Red River Basin. This makes a clear case that the project should to be adapted to generate the benefits considered important in a particular system. As this ranking of benefits is also influenced by the socioeconomic drivers and barriers faced by the system in that context, this would have a bearing in its long term sustainability.

It is also recommended that the following are addressed as next steps as the project develops further.

- There is a need for demonstration projects, where the current pilot level phase is scaled up to show conclusively the benefits the project has the potential to demonstrate, and to create confidence about it among stakeholders involved.

- The need for a quantification of the benefits associated with the system, taking into account an integrated approach, demonstrating how the different benefits balance each other out, where the nexus points are and how the trade-offs between them can be resolved.

- The study of similar concepts on other watersheds is needed to understand the relationships between the existing pressure and drivers and barriers faced by the system and the relative importance of benefits to identify common similarities and patterns

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Appendix 1: How to Implement IWRM

How to implement IWRM

<u>The enabling environment</u>

- The role of government
- Water legislation
- The cross-sectoral and upstream-downstream dialogue
- Financing structures and investment allocations for water resources infrastructure
- Co-operation within international river basins

<u>Institutional roles</u>

- Roles and functions of organisations at different levels
- Institutional capacity building

<u>Management instruments</u>

- Water resources assessment: availability and demand
- Communication and information systems
- Water allocation and conflict resolution
- Regulatory instruments
- Direct controls
- Economic instruments
- Encouraged self-regulation
- Technology

Data source: Gobal Water Partnership (2000)

Appendix 2: List of Stakeholders interviewed and occupations/areas of expertise

Supporting Organisations	
Tim Feduniw	Senior Manager, Economic Development, Economic Development Winnipeg
Rick Lawford	Chair, Scientific Committee for the Integrated Global Water Cycle , IISD Associate
Nazim Cicek	Professor and Acting Head, Biosystems Engineering, University of Manitoba
Joe Ackerman	Researcher, University of Manitoba, Dept. Biosystems Engineering
Sean McKay	President and CEO, Composites Innovation Centre (CIC)
Darryl Domitruk	Director - AgriFood Innovation and Adaptation, Manitoba Agriculture Food and Rural Development (MAFRD)
Tim Sopuck	Chief Executive Officer, Manitoba Habitat Heritage Corporation (MHHC)
Ian Hall	University of Manitoba, Director - Office of Sustainability
Curt Hull	Project Manager, www.climatechangeconnection.org
Daniel Lepp Friesen	Owner, DLF Consulting
David Lobb	Senior Research Chair, Watershed Systems Research Program Professor, Landscape Ecology Department of Soil Science, Faculty of Agricultural and Food Sciences University of Manitoba
Deny St. George	Sr. Biosystems Engineer, Manitoba Hydro
Jeremy Langner	Renewable Energy Engineer, Manitoba Hydro
Bruce Duggan	Director, Buller Centre for Business, Providence University College & Seminary
Dan Svedarsky	Professor, University of Minnesota, Crookston, USA

Donna Dagg	Manager, Sustainable Development, Manitoba Liquor and Lotteries (MBLL)
Processors	
Joy Agnew	Project Manager, Agricultural Research Services, Prairie Agricultural Machinery Institute (PAMI)
Stephane Gauthier	Partner, Biovalco
Lorne Grieger	Assistant Vice President Manitoba Operations, Manager – Agricultural Research & Development Services, Prairie Agricultural Machinery Institute (PAMI)
Eugene Gala	Partner, Biovalco
Uses: IWRM Benefits	
Armand Belanger	District Manager, East Interlake Conservation District
Justin Reid	District Manager, LaSalle Redboine Conservation District
Producers	
James Battershill	General Manager, Keystone Agricultural Producers (KAP)
Dan Mazier	President, Keystone Agricultural Producers (KAP)
Harvey Chorney	Landowner
Curtis McCrae	Landowner
Dennis Anderson	Landowner, Netley-Libau Marsh
End users: Bioenergy	
Will Hofer	Greenwald Hutterite Colony
Rodney Penner	Naturalist, City of Winnipeg
Representatives from the Red River Basin Commission	
Joe Corneya	Red River Basin Commission (RRBC)
Jeff Lewis	Red River Basin Commission (RRBC)

Appendix 3: Grouping of Analytical Framework between stakeholder groups

<table>
<tr>
<td>Landowners

• Income/Profitability
• Government policies around land-use planning
• Perception: Feedstock, Technology, Supply Chain
• Costs of controlling invasiveness</td>
<td>Processors

1. Income/Profitability
2. Economic Support for bioenergy projects: Government-Grants, Subsidies, Private financing
3. Employment Generation
4. Extent of knowledge/experience
5. Extent of existing infrastructure/expertise from other sectors

Scale effeLandowners

• Income/Profitability</td>
</tr>
<tr>
<td colspan="2">1. Social Benefits: Rural Development, Decentralisation
2. Environmental Benefits: Flood mitigation, Water quality improvement, Habitat maintenance, Other benefits</td>
</tr>
<tr>
<td colspan="2">End users</td>
</tr>
<tr>
<td>Bioenergy

• Profitability
• Government policy on energy: Taxes, Subsidies
• Perception of fuel, technology
• Infrastructure: Accessibility to fuel, Convenience
• Costs and convenience of switching</td>
<td>Flood Control/Water management

• Water Legislation
• Costs associated with land and water management: Damages by flooding and flood prevention, Water quality maintenance, Habitat maintenance, Control of invasiveness
• Role of government and support
• Financial support for watershed management
• Potential to improve multi stakeholder/sectoral participation in watershed management</td>
</tr>
</table>

Appendix 4: Natural gas and electricity prices for Manitoba

		Month Fixed Charge	Rate per Unit
Current Electricity Charges	Not Exceeding 200 Amps $ (€)	7.28 (5.17)	7.38 (5.24) cents / kWh
	Exceeding 200 Amps $ (€)	14.56 (10.34)	
Natural Gas Charges	Primary Gas $ (€)	14 (9.94)	27.63 (19.62) cents / m^3
	Supplementary Gas $ (€)		31.85 (22.62) cents / m^3

Data source: Manitoba Hydro (2015)

Appendix 5: Comparison of different properties of biomass

Raw Plant Material	Average Yield (tonnes /hectare)	Heating Value (mj /kg)	Time to Maturity	Phosphorus Capture (kg / hectare)
Cattail	14 – 20	17 – 20	90 days	10 – 40
Wheat Straw	1 – 3	13 – 18	90 – 100 days	0.1 – 2
Switchgrass	9 – 14	17 – 19	3 years	-
Miscanthus	6 – 48	17 – 19	3 – 5 years	-
Willow	7 – 10	10 – 12	3 years	-
Poplar	7 – 10	10 – 12	6 – 12 years	`-
Corn stover	5 – 6	17 – 18	110 – 120 days	-

Data source: Zubrycki et al., 2014