DECISION-MAKING IN LOCAL AGRICULTURAL COMMUNITIES FOR SUSTAINABLE UTILIZATION OF BIOMASS RESOURCES

by

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ABSTRACT

Agricultural biomass fulfils several important functions essential for the sustenance of human societies; it is used for the production of food, feed, biomaterials and bioenergy. Although biomass is renewable, there is finite land available for its production. Thus, it is imperative that the production and consumption of biomass is governed appropriately to avoid unsustainable social, economic and environmental consequences at all scales of development. This thesis addresses the issue of decision-making for sustainable management of biomass resources in local agricultural communities. This is accomplished in two parts. Firstly, sustainable resource management strategies aligned with the understanding of agricultural systems as complex social-ecological systems are explored. Secondly, the viability of the application of the identified strategies is assessed by studying the decision-making processes regarding effective resource utilization of small farmers in India and Canada. This two-part research process offers insight into the operationalization of resource management practices that can enable the pursuit of sustainable development in local agricultural communities.

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CHAPTER 1: INTRODUCTION

1.1 Research background

The steady rise in global population and the concurrent quest for economic growth is occurring in a manner that is coupled with rapid and deleterious natural resource consumption (Broman & Robèrt, 2017). The industrial production necessary to support the increasing standards of living of this growing populations threatens the exhaustion of many natural resources (Wasiak, 2017). Moreover, this industrial production relies heavily on the availability of energy traditionally provided by fossil-based resources resulting in increased carbon emissions that have negatively impacted the state of natural ecosystems (Wasiak, 2017). There is now an urgent need to implement the idea of sustainable development to pave way for stable economic growth and social resilience that operates within ecological boundaries (Holden et al., 2016). A crucial step towards sustainability implies operationalizing the shift away from fossil-based energy resources towards renewable ones such as bio-fuels sustainably derived from resources harvested from agricultural land (Wasiak, 2017). However, it is important to ensure that agricultural production for bio-fuels does not interfere with other important functions of agricultural land such as food and feed production (Bird et al, 2013).

Agriculture plays an indispensable role in the sustainable development agenda as it provides livelihood to 2.5 billion people worldwide (FAO, 2016). As a direct result of the growing population and levels of affluence, more pressure is exerted on agriculture and natural systems that are not only expected to fulfil our food requirements but also provide services such as employment, energy generation, biodiversity conservation among others (Kanter et al., 2016). In this scenario, it is imperative that we effectively manage the potential benefits and trade-offs associated with the varied functions of biomass resources and agricultural land-use for the sustainable management of these respective resources (Kanter et al., 2016). Agricultural biomass systems like all other natural resource systems occur at the intersection of complex environmental and social sub-systems requiring novel and integrative governance approaches that respect such complexity (Virapongse et al., 2016). The transition towards sustainable systems and societies requires collaborative efforts across multiple disciplines and actors for generating effective decision-making strategies for resource management (Broman & Robèrt, 2017; Charnley et al., 2017).

1.2 Research aim and objectives

This thesis has evolved within the context of complex agricultural biomass systems and the need for sustainable decision-making for effective resource utilization. The primary aim of this thesis is to understand and support decision-making in local agricultural communities for effective agricultural biomass resource utilization in a sustainable manner, i.e., not only economically profitable but socially equitable and environmentally progressive.

To fulfil the primary research aim, this thesis seeks to achieve the following research objectives and sub-objectives;

1. To propose strategies for the sustainable utilization of agricultural biomass resources in local agricultural communities.

   i. To understand sustainable resource management as a complex social-ecological system.

2. To explore the implementation of identified strategies (objective 1) in local agricultural contexts for sustainable development.

i. To establish the relationship between biomass utilization and the rural economy.
ii. To better understand the decision-making process of small farmers undertaking on-farm diversification activities.

1.3 Methodological and analytical approach

This study employs a range of qualitative methods to effectively fulfill the research objectives presented in §1.3. These methods are discussed individually in the following sections.

1.4.1 Case studies

The case study methodology is mostly used to study contextualized phenomenon (Baxter & Jack, 2008). In this thesis, the case study approach was employed to study the decision-making process of small-scale farmers when seeking to operationalize value addition from a value chain perspective in two different geographic contexts. For this purpose, two case study sites were chosen; one in Puthar, India and the other in Port Hood, Canada. Specifically, the case studies were considered to describe the 'why' and 'how' of the decision-making phenomenon employed by small farmers in their respective contexts. The multiple case study approach, as applied in this study, can be used to compare, replicate and extend the findings of the studied phenomenon (Eisenhardt & Graebner, 2007). The criteria for selection and the profile of the participants for the case study analysis are discussed in detail in Chapter 3 (§3.3.1).

1.4.2 Data collection

For the purpose of collecting data, semi-structured interviews and focus groups were conducted with farmers in both case study sites.

1.4.2.1 Semi-structured interview

Semi-structured interviews are a useful methodological tool used to gain in-depth insights into a particular subject matter (Karali et al., 2014). Semi-structured interviews are partially structured and include open-ended questions that encourage a conversational flow of information exchange between the interviewer and the interviewee (Longhurst, 2003). This format was used to gather information from small farmers in Puthar and Port Hood regarding their decision-making process for effective agricultural resource use practices. The details of data collection using this approach are discussed in detail in Chapter 3 (§3.3.2).

1.4.2.2 Focus group

In addition to the semi-structured interviews, data was collected by conducting a focus group in Puthar. This method was used to corroborate the information collected and analyzed from the interviews. The focus group methodology was ideal for this purpose as a focus group discussion allows several people to clarify their opinions and ideas in a manner that is often not possible in a personal interview (Kitzinger, 1995). Additionally, focus groups are helpful in generating discussion and group consensus over complex stakeholder-driven issues (Reed et al., 2009). The details of data collection using this approach are discussed in detail in Chapter 3 (§3.3.2).

1.4.3 Data analysis

The analysis of the acquired data was conducted by two analytical methods of content analysis and thematic coding that are discussed below.

1.4.3.1 Content analysis

Content analysis can be defined as a method "for making replicable and valid inferences from data to their context, with the purpose of providing knowledge, new insights, a representation of facts and a practical guide to action" (Elo & Kyngäs, 2008, p. 108). This thesis employs an inductive approach to content analysis which implies searching for patterns in any kind of textual data or content (Graneheim et al., 2017; Bengtsson, 2016). Specifically, this method is used in this thesis for exploring strategies for sustainable utilization of agricultural biomass resources in local agricultural communities. For this purpose, qualitative data acquired from a variety of literature sources was organized followed by the process of open coding which involves generating notes and headings that describe all aspects of the content (Elo & Kyngäs, 2008). Using this method to analyse literature sources yielded an understanding of critical processes and generated knowledge ((Elo & Kyngäs, 2008) around the complex nature of agricultural systems.

1.4.3.2 Thematic coding

The primary data collected through interviews and focus group was analyzed using the thematic coding analysis process to understand the decision-making mechanisms of small farmers regarding effective on-farm resource management. Thematic analysis can be described as the "search for themes that emerge as being important to the description of the phenomenon" (Fereday & Muir-Cochrane, 2006, p. 82). This coding process is used to identify patterns in the data that are grouped as themes for further analysis (Fereday & Muir-Cochrane, 2006). Finding themes is often a challenging process and requires generating codes that "captures the qualitative richness of the phenomenon" in question (Fereday & Muir-Cochrane, 2006, p. 83). Therefore, this thesis employed the four-stage data analysis and coding process identified by Bengtsson (2016); the stages being decontextualization, recontextualization, categorization and compilation. The details of thematic analysis process through these four stages is discussed in detail in Chapter 3 (§3.3.3).

1.4.4 Ethical considerations

This primarily qualitative research study was conducted as per the guidelines of the Social Sciences and Humanities Research Ethics Board of Dalhousie University, Canada. Participants in the two case study sites (Puthar, India and Port Hood, Canada) were recruited (Appendix C & D) after the Ethics Board granted permission to commence the study. Prior to the collection of data through interviews and focus group, the consent of all participants was sought in both case study sites (Appendix E, F & G). Subsequently, the consent documents were provided to the participants were discussed to provide the context of the study design and purpose of the research making them fully aware of the intent of the research. The participants were then alerted to the procedures, tasks and activities in which they were involved, and the risks and potential benefits offered by the research. They were also informed of their rights with respect to the voluntariness of participation and that their right to withdraw at any given time without any penalty. All the data in the form of audio recordings, notes and transcripts was secured to prevent unauthorized assess. The principles of anonymity and confidentiality, central to the research process, were maintained throughout the data collection, analysis and reporting stages.

1.4 Thesis organization

This thesis is organized in four chapters. The present chapter (Chapter One) provides the preliminary context to the research being undertaken and gives a snapshot of the aim and objectives of this thesis. It also delves into the methods of data collection and analysis used for conducting research. The bulk of the research is expatiated in chapters Two and Three which are prepared as stand-alone manuscripts intended for publication.

Chapter Two is primarily occupied with the discussion around sustainable natural resource management practices, particularly, with regard to agricultural biomass resources, and their alignment with the idea of sustainable development. Additionally, this chapter critically assesses this relationship and proceeds to develop the triple-axis model of sustainable development which is used to introduce strategies that can serve the dual objectives of sustainable resource management and development. These strategies form an innovative way to deal with the growing challenges of land-use for biomass debate also discussed in the chapter.

Chapter Three proceeds to deal with the application of the strategies discussed in Chapter Two by studying the decision-making processes of farmers who are the primary stakeholders present at the intersection of agricultural biomass use and social development. Accordingly, this chapter outlines the opportunities and barriers that farmers face when making decisions around sustainable resource use providing insight into the operationalization of resource management practices that push the agenda for sustainable development.

Chapter Four summarizes the research findings and their relevance to current literature, and presents the concluding thoughts of the thesis. Additionally, the chapter discusses the need and opportunities for future research in the direction set by this thesis.

CHAPTER 2: A CONCEPTUAL FRAMEWORK FOR THE SUSTAINABLE MANAGEMENT OF AGRICULTURAL BIOMASS

2.1 Abstract

Biomass serves many purposes for the sustenance of human societies as is evident in its varied uses as food, feed, biomaterials and bioenergy. However, the increasing demand of different biomass types along with transitioning of traditional agricultural or forested land has increased the competition over available land resources resulting in negative environmental and socio-economic outcomes. Conventional resource management practices have been unable to adequately address such challenges in part due to a limited understanding of complex resource-use systems, which interact at multiple scales. To try and better address this, a triple-axis model of sustainable development is presented in this chapter and used as a template for exploring strategies that can accommodate the complexity of biomass systems for sustainable development.

2.2 Introduction

The present state of the environment characterized by growing resource constraints threatens to disrupt human well-being by limiting economic growth and development (Ringler et al., 2013). Improving the long-term sustainable management of the various renewable natural resources can provide one of the ways to offset this challenge. Agricultural biomass, an example of a renewable resource, forms the bedrock of human society in its use as food, feed, fuel and fiber (Müller et al., 2015). Fulfilling the increasing demands of the growing population will require us to expand biomass production across its varied uses. However, the land available for expansion to accommodate growing biomass needs is finite (Chamberlin et al., 2014). This is further exacerbated given that land is utilized for varied functions such as forest cover, urban infrastructure and conservation of species; all uses that serve other important environmental and socio-economic functions (Foley et al., 2005). As such, the expansion of biomass production for more novel biomass uses presents its own set of challenges as it sometimes competes with alternative land use thereby creating unsustainable outcomes (Endres, 2011). Biomass production can impact human well-being by disrupting the efficacy of complex socio-environmental processes occurring at diverse geographic and temporal scales(Rodrigo et al., 2015).

The transition towards sustainable development is therefore linked strongly with the way we manage natural resources such as biomass (Rammel et al., 2007). As such, natural resource management systems need to reflect and adapt to the complexity of socio-ecological systems that are characterized by non-linearity, diversity and uncertainty in the multi-scale interactions of spatial, temporal and social dimensions (Grashof-Bokdam et al., 2017; Rammel et al., 2007; Levin, 1998). However, current decision-making systems for resource management do not embody these aspects. In this regard, there is a need to reinvent holistic biomass management systems by introducing strategies that reflect the understanding of sustainability as a complex evolving process that operates at the junction of multiple scales and actors (Rasch et al., 2017; Chattopadhyay, 2015).

This chapter deals with the above aspects and is structured as follows: section 2.3 discusses the complexities associated with biomass production and consumption and the impacts associated with the unsustainable production of biomass. Following this, section 2.4 provides an overview of decision-making systems that are currently in use for the management of biomass resources. Furthermore, this section delves into the limitations that challenge the utility of these management systems from a social-ecological systems perspective. The next section (§ 2.5) explores the need for reassessing sustainable development as a concept working at multiple scales adding to the complexity of its application. Specifically, a new conceptual approach to sustainable development is presented in this section. This renewed understanding of sustainable development paves way for discussing innovative strategies (§2.6) that could be employed for management of biomass resources in a way that is holistic and sustainable. Section 2.7 presents the conclusions for this component of the research.

2.3 Unravelling the land-use competition debate

2.3.1 Multiple uses of biomass

Biomass can be characterized as organic material, waste or residue derived from activities such as agriculture, fisheries and forestry (Müller et al., 2015). However, in this context the focus will be agricultural biomass, which is used as and for the production of food, feed, biomaterials and bioenergy (Müller et al., 2015). Although, biomass is overwhelmingly consumed as food and feed globally, the demand for biomass destined for other purposes is steadily growing as well (Guillou & Matheron, 2014; Wirsenius, 2007). The increasing rate of biomass production and consumption is influenced by many socio-economic trends linked to population growth, rise in income levels in developing countries, and increased demands for bio-based 'green' products designed to replace those derived from less sustainable supply-chains such as fossil fuels (Vasilica et al., 2014; Kampman et al., 2008).

Population growth translates to the requirement to feed more than 9 billion mouths, primarily by bridging an estimated 70 percent crop calorie deficit by 2050

(Searchinger & Heimlich, 2015). On the other hand, successes in economic growth and development have led to changing dietary patterns - away from cereal crops and towards more protein-rich foods like meat and dairy. This is linked to more than an 80 percent increase in demands for the same between 2006 and 2050 (Müller et al., 2015; Searchinger & Heimlich, 2015). Additionally, the modern energy landscape is increasingly turning to bioenergy; currently 10 percent of the world's total primary energy supply is derived from biomass (Singh, 2017). The targets for bioenergy production are set to increase against the backdrop of growing global energy needs, projected to increase by 37 percent by 2040 (IEA, 2014). The utility of bioenergy has generated worldwide interest largely due to the concerns around declining fossil reserves, climate change, the consequent need to cut carbon emissions and the perceived 'carbon neutrality' of bioenergy (Müller et al., 2015).

It is evident that supporting the needs of the growing population will require prioritizing the development of different biomass types. Up until now, meeting these increased demands has largely meant land expansion and intensification of agricultural production to increase biomass yields (Schmitz et al., 2014); this response is no longer a valid option.

2.3.2 Complexities associated with land-use for biomass production

With the increase in demand for agricultural biomass, land cover patterns are bound to transform at the expense of existing uses of land (Bird et al., 2013; Kampman et al., 2008). Land is a finite resource that serves many purposes; its use and development have significant implications for environmental and societal well-being (Haberl et al., 2014). Primary land-use include: conservation of natural ecosystems responsible for non-provisioning ecosystem services; built environment linked to urban settlements and infrastructure; and (obviously) the production of provisioning goods mainly derived from agriculture and forestry (Haberl et al., 2014). Increasing population has required us to preserve and expand all functions of land causing competition over the finite land-based resources available (Haberl et al., 2014). Unfortunately, future projection models devised by FAO and IAASTD (see Alexandratos & Bruinsma, 2012 and van Vuuren et al., 2009 respectively) advocating for the expansion of arable land for food and feed production do not necessarily consider how land is currently being used and governed (Müller et al., 2015). If not sustainably governed, competing land uses could have severe implications on our collective environmental and socio-economic well-being.

2.3.3 Implications of biomass production

2.3.3.1 Environmental impacts

Natural ecosystem conservation (as a form of land-use) provide us with essential ecosystem services such as biodiversity preservation, carbon sequestration and water purification among others (Haberl et al., 2014). The large-scale conversion of natural ecosystems to agricultural land to meet growing biomass demands will lead to deforestation; the potential degradation would have significant impacts on the condition of these ecosystem services (Müller et al., 2015). Furthermore, degradation caused by intensive agricultural activities can lead to decreased land productivity and nutrient loss, causing lower biomass yields and resultant cropland expansion (Gasparatos et al., 2011). Such land cover changes, mainly in the form of agricultural land expansion, can alter the micro-climate contributing to climate change and increased greenhouse gas emissions, functionally countering the very intention of utilizing biomass-based fuels – for example

- as an emissions-neutral alternative for conventional energy sources (Müller et al., 2015).

2.3.3.2 Socio-institutional impacts

With 805 million people hungry worldwide, the most severe implication of prioritizing land for purposes other than food production is food security (Müller et al., 2015; FAO, 2014). It is a known fact that global hunger can be tackled by developing the capacity of small farmers (FAO, 2014). However, using large amounts of land to produce biomass as fuel and material can displace marginalized farmers who are doubly affected by the loss of access to land (Müller et al., 2015). The competing demands of different biomass types can concentrate power in the hands of a few actors negatively impacting marginalized and vulnerable groups and their dependence on land for securing livelihood and sustenance (German et al., 2013). The use of land for biomass production is not only influenced by its finite availability but also on the complexity surrounding land accessibility issues.

2.3.3.3 Economic impacts

The decision to use land for the production of one type of biomass over others may also lead to micro- and macro-economic risks. Countries pursuing production of biomass for non-food purposes may rely too heavily on food imports which can cause trading imbalances in times of crisis (Müller et al., 2015). Alternatively, focus on large scale biomass production for exports may result in risks associated with volatile global market prices (Müller et al., 2015). For instance, the cost of maize prices substantially shot up in the international market in response to the allocation of a significant amount of corn crop for fuel in the United States of America (Haberl et al., 2014). The debate around using land for food or fuel is further exacerbated as grain commodity prices have risen and grain per capita production costs have plummeted (Kiers et al., 2008). Evidence suggests that it may seem counter intuitive to pursue a certain course of biomass production over another given the socio-economic and ecological dynamic at play in connection with land-based resources.

2.3.4 Multi-scale trade-offs

Socio-ecological implications associated with the current biomass use trends can cause situational conflict occurring at micro-macro scales and in between scales (Colvin et al., 2015; Grimble & Wellard, 1997). Land-use change usually occurs at the local scale but can have much wider and global benefits or repercussions (Foley et al., 2005). Where at the local level, biomass production can increase economic productivity, food productivity and energy independence, at the same time, it can also exacerbate challenges associated with competing demands among different land uses and reducing land access for local stakeholders (Müller et al., 2015). Certain studies show that at the global level there may not be any shortage in terms of land and water availability for necessary food production (see Kampman et al., 2008). However, the same cannot be said for the regional level given that, for example, 94 percent of the available agricultural land in South Asia is already in use and little land is left for expansion in regions like North Africa and Japan (Kampman et al., 2008). Another instance that illustrates the multi-scale dynamic of biomass production is the Chaco soybean example. The largely subsidized maize ethanol production in the United States Midwest resulted in the decrease of soybean production. This influenced a boom in soybean production in the South

American Chaco region to cater for the fodder demands in Asia linked to increased meat consumption (Haberl et al., 2014).

There is a need to employ governance strategies that promote socio-ecological development while limiting the negative externalities associated with the multiple uses of land. These decision-making strategies span socio-political, economic and environmental dimensions and arch over multiple geographic scales from global to local (Foley et al., 2005). However, these scales of governance when operating in isolation without accounting for the applicability of strategies unique to each level tend to deepen the gaps they intend to fill (Müller et al., 2015).

An instance of this dissonance is reflected in the Sustainable Development Goals (SDGs) developed by the United Nations. The SDGs were developed as a collective of goals to push for a global sustainable development agenda in the fields of environmental, societal and economic progress (Sachs, 2012). Several of the goals (shown in Table 1) have direct relevance with the issue of sustainable production and consumption of biomass (Müller et al., 2015). With one in every nine people undernourished globally, SDG 2 is specifically directed towards food security and production of food through sustainable agriculture (UNDP, 2017). Goals 7 and 13 address the issues of energy generation and access and the impact of energy on climate change given that energy production makes up for 6o percent of global greenhouse gas emissions (UNDP, 2017). This is relevant to the debate given that 10 percent of the annual global primary energy is derived from biomass which is considered the most significant renewable energy source (Dornburg et al., 2008). Additionally, Goal 15 calls for the protection of the natural environment by tackling issues of biodiversity loss, land degradation, desertification among others (UNDP, 2017). The integrity of the services provided by natural ecosystems is in jeopardy in the context of the competing uses of land.

Table 1: SDGs relevant for biomass production and consumption (adapted from Muller et al., 2015)

SDG 2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
SDG 7	Ensure access to affordable, reliable, sustainable, and modern energy for all
SDG 9	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
SDG 12	Ensure sustainable consumption and production patterns
SDG 13	Take urgent action to combat climate change and its impacts
SDG 15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

However, the multi-scale complexities inherent in the competing demands of biomass resources are unaccounted for in the SDG framework of decision-making, unintentionally aggravating negative impacts and trade-offs associated with unsustainable and mismanaged resource use. For example, investment in technology and infrastructure (SDG 9) by focusing on agricultural intensification and land expansion can affect land productivity and availability eventually making land unfit for future use (Müller et al., 2015). The production of bioenergy is intended to neutralize the effects of rising greenhouse gas emissions while providing clean energy to all (SDG 7) while its generation requires large-scale production on land obtained by deforestation and land cover change further exacerbating impacts associated with climate change (SDG 13) (Fargione et al., 2008). As a result, the exercise of global goal setting for sustainable development has gone amiss as the trade-offs resulting from biomass use have been unaccounted for in the global managerial space.

2.4 Current state of biomass resource management

The challenge presented by the land-use debate specifically in the context of biomass production is the balancing of environmental sustainability with growth and development (Sachs, 2012). Given the highly uneven international patterns of development, trade flows, market conditions, policy and social circumstances, the governance of biomass requires management practices that are specific to the local context (Dunenage et al., 2013). Subsequently, in addition to the global assessment models (see Schmitz et al., 2014) which are useful when seeking to understand large-scale trends associated with changing land-use systems, local case-specific management tools are needed to understand attributes necessary for resolving complexities and impacts associated with biomass use (Haberl et al., 2014).

Some of the popular decision-making tools for sustainable resource management are indicator systems which have risen to prominence in terms of assessing agricultural sustainability (Van Asselt et al., 2014; Reed et al., 2006). Indicator systems can be valuable decision-making tools as they "can provide a representative picture and describe the components or processes of the system studied in all of its relevant aspects (natural, economic, social and ecological)" (Geng et al., 2014, p. 44). Sustainability indicators can largely be characterized as top-down and expert-led, or bottom-up and community-driven (Reed et al., 2006). There are several examples of top-down indicator systems that exist for guidance regarding the use of biomass at the regional level. Specifically, several studies focus on generation of sustainability indicators for land-bioenergy systems (e.g., Corbière-Nicollier et al., 2011) for socio-economic (e.g., Dale et al., 2013) and environmental (e.g., McBride et al., 2011) dimensions. However, none of these decision-support tools model for the complexities inherent in the competing demands of different biomass types. Moreover, these systems tend to focus on a singular aspect of sustainability, i.e. social, environmental or economic (van Asselt et al., 2014). Additionally, sustainability frameworks such as these provide inadequate coverage over spatial and temporal scales resulting in decision systems that fail to understand and integrate multi-scale dimensions that characterize biomass systems (Arodudu et al., 2017).

Indicator systems consist of numerical measures like many other computational natural resource management tools (Liu, 2014; Veleva et al., 2001). This poses other limitations around the complexity and utility of such tools. Single-use biomass resource management systems tend to be computationally complex and not very compatible with the end-user experience (Basco-Carrera et al., 2017; Jakeman et al., 2006). Consequently, such tools do not often resonate with local communities whose engagement is central to increasing understanding of complex resource issues (Turucu, 2013; Reed et al., 2006). Adequate management of natural resources calls for the accommodation of diverse resource user experiences within decision-making systems to account for sustainable development issues at the local level (Colvin et al., 2015; Reed et al., 2006).

To address such development, there is a need to adopt community-driven/stakeholder-based/bottom-up approaches for sustainable resource use management (Vaidya & Mayer, 2014). Adopting such an approach is essential to the creation of integrated resource management systems that employ cross-disciplinary thinking and broadly consider trade-offs and multi-scale interactions of complex biomass use systems for enhanced decision-making (Virapongse et al., 2016; Pahl-Wostl, 2007).

2.5 A New Conceptual Framework for Supporting Sustainable Development

To align the principles of natural resource management with the ideals of sustainable development requires shifting the focus from a compartmentalized view of the different dimensions of sustainability towards a more integrative one (van Kerkhoff, 2014; Rammel et al., 2007). The ability to manage natural resources is strongly linked with the accommodation of the ideals of sustainable development as suggested by Rammel et al. (2007),

> …natural resource management as a regulation system that links (at diverse scales) two sub-systems: human societies on the one hand and bio-physical systems on the other. We call the whole co-evolving system "human–nature-system" which expresses the characteristics of social–ecological systems. In general, co-evolving "human–nature-systems" contain a high level of inevitable complexity in terms of dynamic, cross-scale and interdependent interactions between particular sub-systems of natural resource management, which must be considered simultaneously when aiming for sustainable development. (p. 13)

As noted in §2.4, current natural resource management practices do not adequately accommodate the dynamic nature of our complex socio-ecological systems. The tendency to focus on the unidimensional approach of juxtaposing economic models and static approaches to justify decisions regarding issues such as the land-use/biomass production debate form the central core of this chapter. It is evident that in order to create lasting solutions for this crisis, we need to move towards approaches that can accommodate evolving socio-ecological systems and build resiliency within them by voicing the complexity of such dynamic systems. The degree of complexity present within socio-ecological systems is a function of multi-scale interactions of different temporal, spatial and developmental scales and the uncertainty inherent within these dynamic interactions (Berkes et al., 2008).

To address this, a triple-axis model for sustainable development (Figure 1) is presented - to aid in conceptualizing the integration of the different scales at which socio-ecological systems function. The intention to better assess and/or understand the interactions that need to be addressed when seeking to manage natural resources such as land and biomass from a sustainable development viewpoint. This model represents the three-dimensional visualization of the spatial, temporal and developmental scales at which sustainable development takes place. Natural resources, such as land and biomass, are interlinked with complex socio-ecological systems that simultaneously function and interact on these scales. The different dimensions and features of this model are explained below for visualizing the multi-scale dynamics of sustainable development which are central to the reinvention of holistic natural resource management techniques.

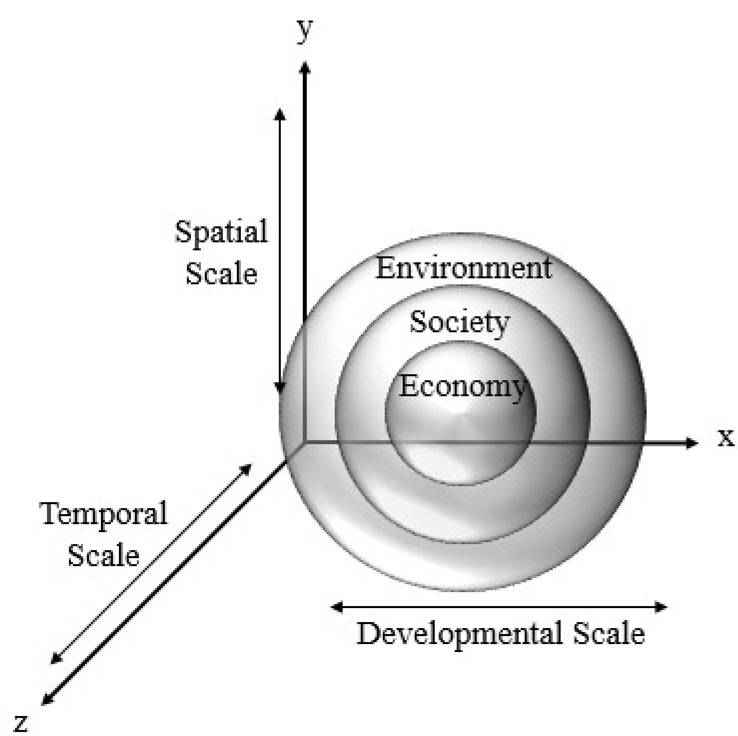

Figure 1: Triple-Axis Model of Sustainable Development

2.5.1 Developmental dimension

The x-axis of the proposed model comprises of the developmental dimension of sustainable development. Sustainable development is represented traditionally by the three interlinked rings of profit, people and planet (Figure 2a) (Kuhlman & Farrington, 2010; Giddings et al., 2002). Such a representation often encourages straightforward analysis by encouraging balance between the three pillars of environment, society and economy which are understood as equally important (Imran et al., 2014; Giddings et al., 2002). However, such a representation has many limitations as it underplays the interconnectedness of these pillars, thereby, legitimizing the conflicts and trade-offs implicit in this design (Imran et al., 2014; Giddings et al., 2002). The separation of these three dimensions gives credence to the notion that the balance of the three pillars necessitates the substitution of one aspect over the other, for e.g. it supports weak sustainability by implying that the health of the natural environment is at odds and can be replaced by economic capital (Helne & Hirvilammi, 2015; Kuhlman & Farrington, 2010). This notion does not sit well with the material reality of socio-ecological systems which point toward the dependence of the economy on the society and environment (Imran et al., 2014; Giddings et al., 2002). In this regard, a need has been identified that requires the pursuit of a more critical examination of the interlinked model, which tends to promote technical fixes to a nested model that accommodates the fundamental complexity inherent in the dynamic of the three normative dimensions of sustainable development (Griggs, 2013).

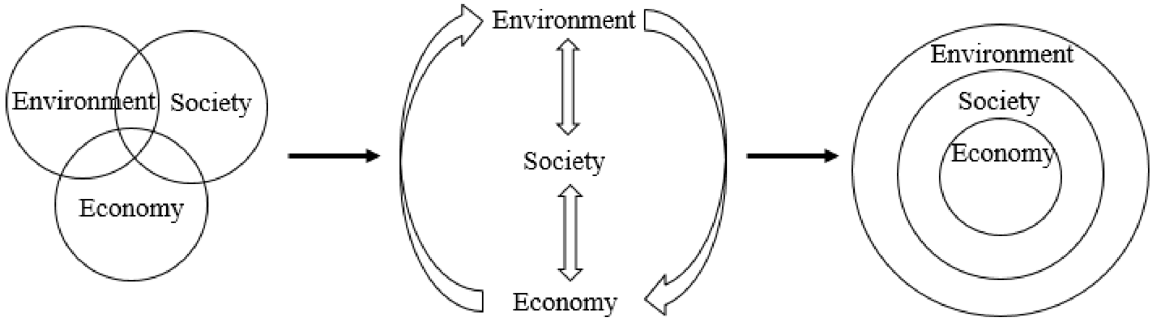

Figure 2: Transition of the idea of sustainable development as interlinked rings of environment, society and economy (2a) to understanding the utility of environment and economy driven by societal needs (2b) to understanding the three dimensions in a nested hierarchy (2c)

The nested approach to sustainable development (Figure 2c) puts forward the idea of embeddedness in which the economy is nested in society and the society is nested in the environment depicting the hierarchy of dependence of the economy on the society and the dependence of society and economy on the environment (Griggs, 2013). The placement of the economy within the core of this model does by no means imply the supremacy of this dimension that should drive all developmental efforts, but rather the role of all three dimensions as drivers of socio-ecological systems (Figure 2b) (Longo et al., 2016; Giddings et al., 2002). This dynamic of mutual dependence of the three dimensions is particularly noteworthy when understanding and managing natural resources such as land and biomass in agricultural systems. The dependence on agriculture as a society primarily drives the use of the natural environment for the creation of a bio-based economy, which in turn drives the sustainable use of the natural resources at our disposal. In examining the transition of the nested concept of sustainable development (as shown in Figure 2) our efforts at natural resource management can be greatly benefitted.

2.5.2 Spatial dimension

Another aspect that requires attention when dealing with complex socio-ecological systems is the spatial dimension. In response, the y-axis of the proposed triple-axis model is denoted by the spatial scale. The sustainability of socio-ecological systems that utilize natural resources spans the scale simultaneously from global to local influencing development at these scales of action (Häyhä et al., 2016; Wilbanks & Kates, 1999). Scale is especially important when discussing sustainable development because the distribution of natural, social and economic capital is highly varied and heterogenous throughout the global landscape in different spatial units from nation-states to local communities (Swyngedouw, 2010; Grainger, 1999). Traditional systems of resource management do not accommodate scalar complexities when seeking solutions to natural resource issues (§2.4.2). In management systems, scale is accommodated either in a top-down manner without realizing local change (e.g. in the case of SDGs) or in a bottom-up approach without adequately addressing phenomenon that have global consequences (e.g. in the case of local indicator systems) (Häyhä et al., 2016; Wilbanks & Kates, 1999). Thus, there is a need to pursue development and resource management through a lens encompassing the geographic and political reach of scalar units.

2.5.3 Temporal dimension

The dynamic between the environment, society and economy has an added dimension of distinct temporalities which form the z-axis of the triple-axis model of sustainable development model. The temporal aspect is not often the included in the discussion around sustainable development. However, it is central to understanding the linkages between the dimensions of environment, society and economy (Weiser et al., 2017; Held, 2001).

Modern analytical systems have treated time as a "monolithic concept ignoring the diversity of temporal aspects" (Held, 2001, p. 354). Time is most commonly expressed in terms of economics implying that it is linear, homogenous and reversible (Held, 2001). However, it is important to note that all three environmental, social and economic aspects are linked to distinct and dynamic temporal rhythms. The natural environment which forms the back drop of the land-biomass debate has larger ecological implications as the current global production and consumption patterns of agricultural biomass impact the time scales for processes such as land degradation, biodiversity loss and climate change (Weiser et al., 2017). These processes are often not reversible and homogenous contradicting the pace of economic time (Weiser et al, 2017; Held, 2001). Furthermore, the societal sphere of sustainable development is governed by the principles of inter- and intra-generational equity which forms another time-scape spanning temporal aspects of population and generational age growth periods (Pahl et al., 2014). Lastly, the time-scape associated with the economy within agricultural systems is distinct and artificial in nature considering the fluctuations inherent in global and local markets and the uneven geography of development in different parts of the globe which may affect the temporality of the economic dimension (Weiser et al., 2017). It is, therefore, important to incorporate the temporal scale when talking about sustainable development and managing complex socio-ecological systems.

2.6 Emergent Themes and Strategies for Sustainable Resource Management

The role of innovation in the context of socio-ecological systems utilizing natural resources is crucial if we intend to formulate creative solutions to understand and manage such systems. So far, in the context of land-use/biomass resource management, efforts have been directed towards a technical approach which has taken place in isolation. Innovation demands integration of technology with various networks, institutions and partners (Kiers et al., 2008). In isolation, natural resource management practices present "blunt tools for social change" (Lilja & Dixon, 2008, p. 9). In this regard, the triple-axis model of sustainable development can be used to discuss strategies which can be employed in consonance with the traditional practices of natural resource management for managing the growing land-biomass production crisis. Presented below are few of the concepts that are relevant for the development and operationalization of holistic natural resource management practices specific to the land/biomass conundrum.

2.6.1 Multifunctional Agriculture

As discussed in the previous sections, managing the critical trends of agricultural biomass production and consumption will require us to reassess the current agricultural production paradigm which encourages the intensive mono-functional use of agricultural landscapes in the process eroding many non-provisioning ecosystem services (Haberl et al., 2014). Agriculture today faces far greater challenges; feeding the hungry across the globe whilst maintaining the quality of our collective natural resource base (Shen et al., 2013). Therefore, to realize sustainable development within natural resource use systems, there is a need to move towards multifunctional agricultural landscapes that provide provisioning goods without compromising the quality of ecosystem services (Haberl et al.

2014). Given that 75 percent of global agricultural land is operated by more than 570 million family farms worldwide, an explicit the link can be drawn between agricultural and rural development (Lowder, Skoet & Raney, 2016; Rodríguez-Pose & Hardy, 2015). Therefore, adopting multifunctional agriculture as a wider practice will help boost rural development while maintaining ecological integrity, essentially “killing two birds with one stone”.

Multifunctional agriculture as a concept lends itself to the commodity as well as non-commodity aspects of agricultural activities (Morgan et al., 2010; OECD, 2003); the role of agricultural goes beyond the production of food and fiber and includes the protection and management of environmental resources and landscapes, and focuses on enhancing the socio-economic viability of rural communities (Renting et al. 2009). Farmers feature prominently in this understanding of multifunctional agriculture given their role as stewards managing agriculture-based natural resources (Marsden & Sonnino, 2008). According to Marsden and Sonnino (2008), agricultural activities can assume multifunctionality if they add employment opportunities to the agriculture sector, create new agricultural sectors that align with societal needs and utilize resources in new ways that move beyond on-farm operations. As such, strong multifunctionality promotes the sustainability of rural livelihoods by catering to the economic, social and environmental dimensions of agriculture dependent rural communities (Morgan et al., 2010).

Multifunctionality in agriculture manifests itself in a number of diversification activities extending from on-farm value adding to off-farm ventures (Akimowicz et al., 2016). The pursuit of such activities will lead to rural development by promoting and strengthening local value chains as farmers seek more economic forums to expand their operations (Marsden & Sonnino, 2008). Alternatively, better infrastructure and supply chain governance will provide incentive to farmers for delving into different modes of diversification activities (Marsden & Sonnino, 2008). In the context of this research, multifunctionality in agriculture can present avenues for the holistic development of all dimensions of sustainable development by boosting socio-economic value of communities that are majorly responsible for the production of agricultural biomass while maintaining the environmental integrity of the available natural resources.

2.6.2 Value-chain thinking and business modelling

Natural resource management carried out at the local level does not consider the spatial linkages implicit in the biomass production debate that span local and global imaginaries (§2.4.2); the employment of value-chain thinking within the agricultural sector can be used to combat this limitation. Value chains are linked together with different actor groups of producers, traders, consumers, etc. that act cooperatively to enhance the productivity and resilience of a chain that supports value added activities at each or several linkages (Chen et al., 2015; Riisgard & Ponte, 2011). Thereby, value chains enable sustainable business environments and foster effective decision-making and resource allocation by virtue of their collaborative structure (Fearne et al., 2012). They rely on partnerships and knowledge sharing among different chain actors and organizations to create systems and products (Fearne et al., 2012).

Value chains assume a more holistic perspective when they lend themselves to the development of sustainable ventures. In the agricultural sector, diversification options extended by multifunctional agriculture (§2.6.1) constitute sustainable ventures that utilize opportunities for the improvement of socio-economic well-being while contributing to environmental sustainability (Gradl et al., 2011). However, managing these ventures can be challenging as the alignment of their multiple goals necessitates the development of appropriate business models (Gradl et al., 2011). These needs can be fulfilled by inclusive business models which work at the intersection of development and business and focus on socio-ecological sustainability while driving innovation from a pro-rural perspective (Gradl & Knobloch, 2010). There are many variations of the inclusive business model concept which are discussed in literature as sustainable business models (e.g., Breuer & Lüdeke-Freund, 2014; Høgevold et al., 2014; Stubbs & Cocklin, 2008), hybrid business models (e.g., Hahn & Spieth, 2014) and value co-creation business models (e.g., Nenonen & Storbacka, 2010) The need and nature of such business models are discussed in literature (Carayannis, Sindakis & Walter, 2015) and applied in real-world circumstances such as the wood product industry (Maunula, 2014).

The development of inclusive business model can enhance and benefit local agricultural value chains by providing guidance for building stable and meaningful relationships between different chain actors and encouraging flow of knowledge and innovation (Riisgard & Ponte, 2011). This approach can strengthen rural economies that are agriculture dependent and promote rural development by pulling rural communities into the larger spatial context of global development via stronger value chains.

2.6.3 Stakeholder engagement

Natural resource use problems occurring within social-ecological systems are expressed on multiple scales and affect different groups of actors (Charnley et al., 2017; Reynolds et al., 2014). Decision-making for effective resource management needs to be adaptive to changing circumstances and inclusive of varied values and experiences

(Fazey et al., 2014; Reed, 2008). Current strategies for resource management underplay the complexity and uncertainty inherent in natural resource use by assuming a technical top-down approach to decision-making that excludes the knowledge and concerns of the people affected by these issues (Lynam et al., 2007). Although top-down approaches employ rigor and reveal trends that may not be otherwise visible on casual scrutiny, these approaches are not normally rooted in the reality of local socio-ecological contexts (de Vente et al., 2016; Reed et al., 2006). To ensure a collective effort towards sustainability, there is a growing need to engage local communities by adopting bottom-up approaches in natural resource management (de Vente et al., 2016; Reed et al., 2006). Linked to this is the fact that the concept of stakeholder analysis is gaining traction as a way to enable decision-making that is holistic and participatory in nature (de Vente et al., 2016).

The application of stakeholder analysis is particularly noteworthy when seeking to operationalize value chain thinking and multifunctionality in agriculture for the sustainable use of biomass. The nature of value chain development is participatory as it tries to match developmental opportunities with the needs of the communities and other stakeholders (UNIDO, 2011). The key and oft-neglected stakeholders in rural value chains specializing in agricultural biomass are small-scale farmers and producers (Boateng, 2006; Grimble & Wellard, 1997). Thereafter, promoting sustainable biomass resource management requires us to enhance decision-making capacity at the farm level by engaging local farmers (Akimowicz et al., 2016). Engaging key stakeholders to create bottom-up approaches combined with the traditional top-down decision-making strategies can enable interdisciplinary resource management that is aimed at sustainable development (Reynolds et al., 2014; Reed et al., 2006).

2.7 Concluding Remarks

Producing biomass to fulfil human needs is wrought with complexities given that land used for its cultivation has many other diverse uses which need to be preserved if we intend to develop sustainably. Furthermore, the competing land-use demands generate impacts that have severe environmental, social and economic repercussions. Natural resource management systems have a big role to play when dealing with these complexities and impacts. However, the lack of adequate decision-making systems further aggravates unsustainable outcomes. This is in part due to the misrepresentation of the idea of sustainable development that forms the goal of resource management. Sustainable development is a complex process that operates at multiple developmental, spatial and temporal scales that cross-interact to increase the complexity of resource-use systems. This chapter has introduced the triple-axis model of sustainable development to correct this representation; this model is used here as a conceptual framework to explore strategies such as multifunctional agriculture, value chain thinking and stakeholder engagement as ways to promote holistic biomass management systems. The next chapter seeks to operationalize the application of these strategies.

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CHAPTER 3: UNDERSTANDING FARMERS' DECISION-MAKING PROCESS FOR VALUE ADDITION FROM A VALUE CHAIN PERSPECTIVE

3.1 Abstract

Small farms around the world fulfil majority of the global biomass demands; the sustainable development of the largely agriculture-driven rural economy is directly linked to the sustainable management of agricultural biomass resources. To accomplish this, it is necessary to visualize agricultural systems as complex entities that are driven by multi-scale and multi-actor interactions. In this regard, innovative resource management practices such as on-farm diversification and value chain thinking can be employed to fulfil the sustainable resource use agenda. The implementation of such practices requires an understanding of the decision-making processes of small farmers who are the key actors involved in rural agricultural systems. This study makes an attempt in this direction and employs a case study approach to explore the decision-making process of farmers contemplating value addition as a diversification activity from a value chain perspective. The study results reveal that farmers in both study areas (Puthar, India and Port Hood, Canada) consider nine identified variables to explore the feasibility of the value addition activity. Additionally, farmers in both case sites experience interpersonal and institutional barriers that hinder the undertaking of the diversification activity which influence farmers' motives for making such complex decisions. The implication of these study results can enable the implementation of innovative strategies that aspire for sustainable agriculture.

3.2 Introduction

More than 500 million small farms around the world fulfil the majority of our food requirements by working 75 percent of total global agricultural farmland (Lowder, Skoet & Raney, 2016). More than 90 percent of these farms are primarily owned by an individual and utilize family labour to perform on-farm operational activities (FAO, 2014a). These small family farms form the backbone of the rural economy and are largely dependent on agriculture for their livelihood and sustenance (Rodriguez-Pose & Hardy, 2015). The resolution of the intensifying debate around sustainable production and consumption of agricultural biomass across its varied uses is strongly interlinked with the sustainable development of the agriculture-driven rural economy and vice versa (Koopmans et al., 2017; Zasada et al., 2017; Dent et al., 2013). Furthermore, the pursuit of sustainable agricultural practices largely depends on how we develop and utilize biomass at the local rural level (Rodríguez-Pose & Hardy, 2015).

The sustainable management of biomass resources can be envisaged in the development of a rural bio-based economy that "encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bio energy" (European Commission, 2012, p. 3). The development of such an economy is reflected in the principles of multifunctional agriculture that stresses diversification strategies for resource utilization in new and commercial ways (Hansson et al., 2013). This requires access to new markets by rural producers emphasizing a value chain perspective to diversification activities for boosting the rural economy (Lopolito et al., 2015; Albu & Griffith, 2006). A value chain can be described as a "range of activities required to bring a product or service from production through to final consumption" (Lowitt et al., 2015). Specifically, the value chain concept seeks to understand interactions of multiple actors with economic phenomenon having widespread implications for rural agricultural development (Lowitt et al., 2015).

The effective application of innovative concepts such as on-farm multifunctionality and value chain development is further enabled by the understanding of agricultural systems as complex systems conceptualized at multiple scales and levels, and being influenced by a wide range of actors (Feola & Binder, 2010; Wilson, 2008). Concurrently, the employment of farm-based multifunctionality requires an understanding of farmers' motivations and behaviours as they form the key stakeholder group functioning within rural agricultural systems (Feola & Binder, 2010; Wilson, 2008). In this regard, there is a growing body of literature that seeks to understand the decision-making process of farmers as they play a crucial role in the implementation of sustainable resource management and agricultural practices (for example, Lopolito et al., 2015; Karali et al., 2014; Hansson et al., 2013; Northcote & Alonso, 2011; Vik & McElwee, 2011; Feola & Binder, 2010; Maye et al., 2009; Darnhofer et al., 2008; Macé et al., 2007; Alsos et al., 2003; Willock, Deary, McGregor et al., 1999). However, farmer decision-making around multifunctionality from a value chain perspective remains largely underexplored.

Given this context, this chapter presents the findings intended to improve the understanding of the decision-making processes of small farmers for on-farm diversification activities through a value-chain lens. The key elements examined include: a) factors that require farmer consideration when making these decisions; b) barriers that impact farmers' decision-making process; and c) motivations that drive farmers to take such decisions. This chapter attempts to examine these issues by adopting a case study methodology which is outlined in section 3.3. Furthermore, section 3.3 discusses the methodologies of data collection and analysis that accompany the chosen case studies. The results are presented and discussed in section 3.4 followed up by a concluding piece found in section 3.5.

3.3 Methods

3.3.1 Case study methodology

This work primarily employed a case study approach to address the research questions presented in this chapter. The case study methodology is exceptionally handy when seeking to explore complex processes within a particular context (Baxter & Jack, 2008). Yin (2013) classifies case studies as explanatory, exploratory or descriptive in nature; this study employs a multiple case study design by studying two cases to explore these functions. The multiple case study design enables the researcher to make comparisons and study differences within and between case studies (Baxter & Jack, 2008). Additionally, this allows for the replication of results through a more robust grounding in varied empirical theory and evidence (Eisenhardt & Graebner, 2007).

This study explores two cases; one in Puthar, India and the other in Port Hood, Canada. These two case studies were selected by theoretical sampling to serve functions of “revelation of an unusual phenomenon, replication of findings from other cases, contrary replication, elimination of alternative explanations, and elaboration of the emergent theory” (Eisenhardt & Graebner, 2007, p. 27). This implies choosing case studies carefully to predict similar or dissimilar results across cases based on a theory (Yin, 2013). Accordingly, the two case studies for this research were small farm-based where on-farm diversification activities were being executed or proposed as a means of creating and adding value to waste agricultural biomass and related residuals. The two case studies provided distinct regional and cultural contexts for studying decision-making regarding the optimal utilization of agricultural land-based resources for value addition from a value-chain development standpoint.

3.3.1.1 Puthar case study

Puthar is a small village located in Panipat district in the province of Haryana in northern India (Figure 3). In Puthar, the focus of the inquiry is the practice of mushroom cultivation which is done to utilize waste paddy straw generated on-farm as a residual by-product from paddy cultivation. For the data collection phase, four farmers were interviewed in Puthar. Farmers were related to one another and worked on the same family owned farm. In the case of the Puthar farm, it was owned by two related individuals. These farms were worked by these farmers as well as their sons. The age of the farmers who were interviewed ranged between 60 years for the older farmers and 30 years for the younger farmers. During the interviews, the female family members of the farmers were also present. The female family members also actively took part in farm operations as labour which is characteristic of family farms.

For the interviews held in Puthar, the interactions were held in the farmers' house. Later, the farmers showed us the mushroom farms where the conversations continued. The mushroom farms were near their home on a small plot where other members of the village also conducted their mushroom operations. In Puthar, mushroom cultivation was performed by utilizing waste paddy straw produced from rice cultivation which was the primary production activity being pursued in Puthar.

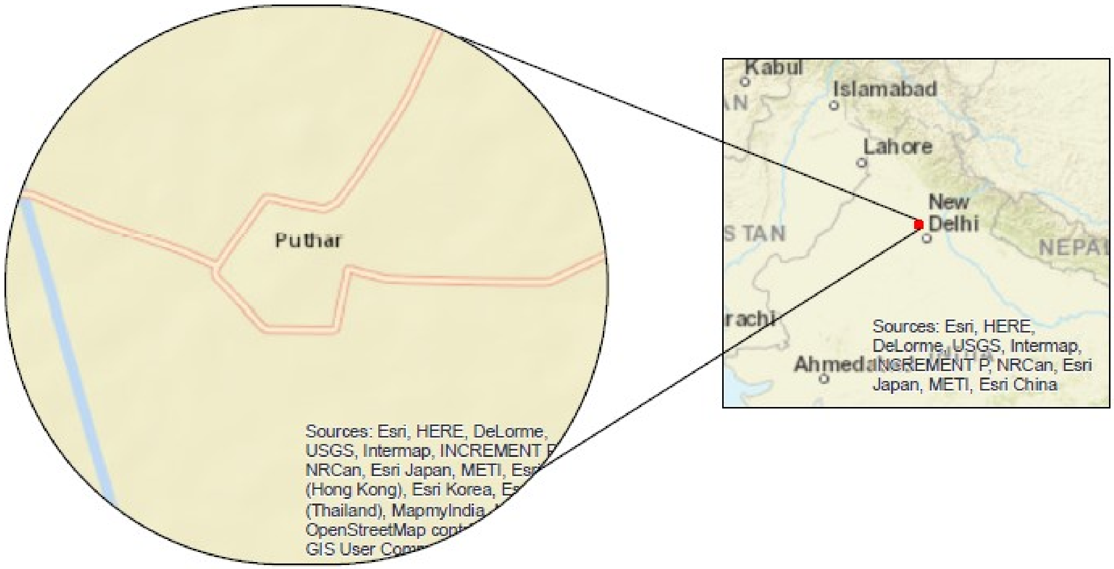

Figure 3: Locator map for Puthar, India

3.3.1.2 Port Hood case study

Port Hood is a small town located in Inverness county in the province of Nova Scotia in Canada (Figure 4). In Port Hood, farmers are contemplating the development of a community anaerobic digestor to produce biogas by utilizing excess manure from the dairy farm and wild grasses growing in the adjoining fields. For the data collection phase, two farmers were interviewed in Port Hood. The farm in Port Hood was owned by one individual. The age of the farmers who were interviewed ranged between 50 years for the older farmer and 30 years for the younger farmer. During the interview period, the female family members of the farmers were also present who also actively took part in farm operations as labour which is a characteristic of family farms.

In Port Hood, the interview started when the farmers took us to their dairy farm and then the conversation continued at their home. The dairy farm had hundred cows.

The farmers in Port Hood were contemplating the production of biogas by utilizing waste manure produced as an outcome of the dairy operations.

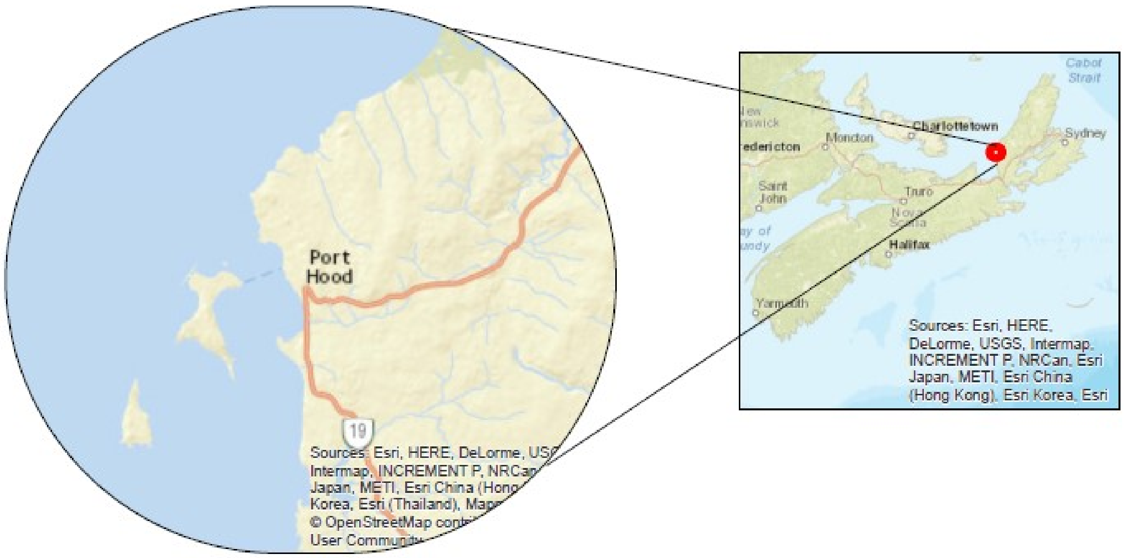

Figure 4: Locator map for Port Hood, Canada

3.3.2 Data collection

Case studies are often complemented with multiple sources of data including documentation, interviews and participant-observations among others (Baxter & Jack, 2008; Eisenhardt & Graebner, 2007). In this instance, data collection was achieved by conducting semi-structured interviews and focus groups with small farmers who comprised the study population in both case sites. Semi-structured interviews are laid out in an open-ended format allowing the respondents to express their own opinions without directing them towards predefined answers (Karali et al., 2014). This open and conversational mode of communication is useful in unearthing rich empirical data where emergent themes can be adequately explored (Karali et al., 2014; Eisenhardt & Graebner, 2007). A total of six interviews were conducted, each running for an average of two hours. The questionnaire (Appendix A) prepared for the interviews delved into the operational components that link an agricultural value chain (UNIDO, 2011; Appendix B). The questions explore both the general and specific contexts of the farmer's endeavour to implement diversification activities that add value at various points along the value-chain, i.e. introduction of new strategies or technologies, new crops, new markets, or uses for existing crops and valorization of waste and/or residuals.

Once this first round of data were analysed (discussed in section 3.3.3), a second phase of data collection was employed by conducting a focus group in Puthar. The focus group methodology forms a type of group interview that capitalises on participant interaction to explore and clarify complex issues that warrant consensual discussion for increased understanding (Reed et al., 2009; Kitzinger, 1995). This approach was primarily used to corroborate the analysed information received from the interviews. The focus group comprised of 12 farmers who were recruited by convenience sampling methods. The intention was to gain an in-depth understanding of the motivations that drive decision-making process (presented in §3.4.3) and to explore the implications of this process for the identification and implementation of successful value addition activities that could enhance sustainable development specifically in Puthar.

In addition to the interviews and focus group as means of data collection, extensive observatory notes were compiled and transcribed to serve as additional data for analysis throughout the research process. These constitute important primary data and were used to supplement the qualitative data obtained during the data collection period (Baxter & Jack, 2008).

3.3.3 Data analysis

The data collection and analysis phases occur simultaneously as per current practices in qualitative research (Baxter & Jack, 2008). The interviews and focus group were audio-recorded with the permission of the participants and were later transcribed for analysis. The primary method undertaken for analysis was thematic coding which is defined as “a form of pattern recognition within the data, where emerging themes become the categories for analysis” (Fereday & Muir-Cochrane, 2006, p. 82). This mode of analysis mainly took an inductive approach for the identification of themes and thereby relied on the principles of grounded theory to guide that process (Karali et al., 2014; Glaser & Strauss, 1967). This study employs analysis in the four stages of decontextualization, recontextualization, categorization and compilation as described by Bengtsson (2016). In the first phase, the transcribed text was read and portions of text having significant insights were loosely gathered in meaning units and were labelled as codes in an open coding process (Bengtsson, 2016; Berg, 2004). For the purpose of this study, the meaning units were related to the operational components of the value chain that the farmers discussed in relation to their pursuit of value addition activities. In the recontextualization phase, it was made sure that all meaning units were covered keeping this aim of the coding process in mind (Bengtsson, 2016). In the next stage of categorisation, themes and categories were identified that gave insight into the decision-making process of farmers. In qualitative research, themes are presented as “a unifying ‘red thread’ running through several categories that brings meaning to a recurrent topic or experiences and its various manifestations” (Graneheim et al., 2017, p. 32). These themes were then manually formed into relevant clusters in the compilation stage (Bengtsson, 2016). The emerging themes are presented below, in the context of the relationship to relevant literature in order to verify their efficacy and significance (Bengtsson, 2016).

3.4 Results and discussion

The interviews and focus group yielded several points of discussion. In particular, the farmers talked about several variables that they considered when pursuing their respective value additive activity. Additionally, they discussed the presence of barriers that they faced when operationalizing diversification activities. The conversations held in both places depict similarities in terms of the responses and concerns shared by the farmers despite the contrasting cultural contexts of the two study sites. These discussion points are presented below as themes that stood out in conversations with the farmers. Additionally, this presentation of results is accompanied by appropriate remarks from the farmers themselves which are presented here as quotes. The quotes are attributed to the respective farmers by referencing them as PU-1, 2, 3, 4 for the farmers in Puthar and PH-1,2 for the farmers in Port Hood.

3.4.1 Factors for assessing feasibility of value addition

Nine factors were identified that influence decision-making of farmers when choosing the various strategies for value addition within their respective farming context (Figure 5). These factors are multi-dimensional and are represented in four categories mimicking the four indicators of sustainability, namely, social, economic, environmental and institutional, as developed by the Commission on Sustainable Development (UNDPCSD, 1995).

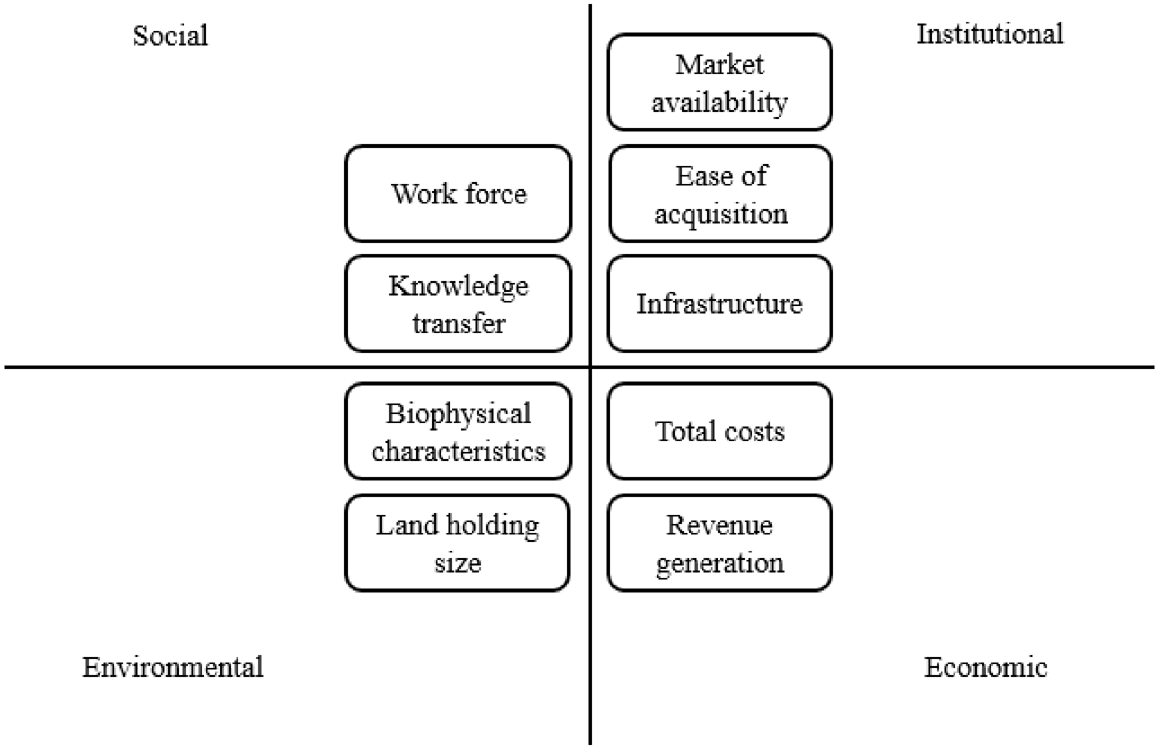

Figure 5: A schematic representation of the factors that drive decision-making for assessing the feasibility of on-farm value addition activities

3.4.1.1 Biophysical characteristics

During the interviews, farmers responded that the conditions of the natural environment was imperative for pursuing value addition activities. Factors such as water availability, soil quality, climatic conditions, etc. were listed as paramount when looking to operationalize the value additive activity from an environmental perspective. For example, in Puthar, where farmers were cultivating mushrooms on paddy straw, it was essential to maintain the temperature close to 25 degree Celsius to ensure an optimum growth environment for the various mushroom species of interest (Colavolpe & Albertó, 2014). As one farmer remarked, "with mushroom cultivation, controlling temperatures is key." (PU-4). Due to the rudimentary nature of the mushroom bed infrastructure, cultivation could only be done over four months in the winter when the temperatures dropped to an average of 20-25 degree Celsius, therefore providing the necessary conditions for mushroom cultivation. In Port Hood, the choice of energy crop production was linked to environmental factors such as land availability, soil quality, water availability and nutrient requirements (Zhu et al., 2017); biophysical factors formed an important consideration for farmers when deciding to perform agricultural value addition activities (Karali et al., 2014).

3.4.1.2 Land holding size

The amount and availability of land was another consideration for assessing the feasibility of particular value addition strategies. In Puthar, the average parcel of land owned by the farmers was less than 10 acres; this was in contrast to the situation in Port Hood where farm size ranged between 300-1000 acres. Accordingly, the amount of arable land available greatly influenced the type of value addition activities in both places (FAO, 2014a). The decision to grow mushrooms in Puthar was driven by the small amount of land available as the cultivation of mushrooms is not a space-intensive activity and is usually done indoors on vertically stacked trays (Easin et al., 2017; Celik & Peker, 2009). On the other hand, the vast amounts of farmland available in Port Hood led to the decision to cultivate energy crops to justify commercial-scale bioenergy production. However, even at this scale the literature suggests that there is some debate regarding the economic viability of such operations, noting that small-scale digestors still often do not pan out in the North American context (Costa, 2014). This scale issue was a driving factor for farmers in Port Hood to want to develop a community digestor model that could also utilize raw material (manure and crops) from surrounding dairy farms to justify the expansion of biogas production operations (Werblow, 2017). About the scalability of operations, a farmer in Port Hood had said, “It is not new technology and well the other thing they say is is it scalable. Well of course it is scalable. There are villagers that are doing this out of 45 gallon drums and hole on the floor and you can scale it right upto these massive levels. So it is scalable, it is not new, there are 8,000-10,000 of these digestors in Germany alone, Holland, you know all these European countries are being regulated to put them in and being forced to put them in, so we are just trying to come about it from another perspective in that- hey, we want to get ahead of the game” (PH-1).

3.4.1.3 Work force

Farmers in both places reported the availability of trained labour was another important consideration when deciding the viability of value addition. In both places, the farmer’s family members helped out with the agricultural activities as is a characteristic of family farms (Akimowicz et al., 2016; FAO, 2014a). However, with the inclusion of value addition activities, the necessity of specific labour requirements were reported by farmers in both places. Expansion of production operations in Puthar relied on how well the labour was trained to handle the complexity associated with mushroom harvesting. Commenting on the barriers for obtaining the right kind of labour, a farmer in Puthar said, “labour also we can get easily but they aren’t trained” (PU-4). Farmers in Puthar reported many instances of harvest spoilage due to operational mismanagement on the part of by the hired labour. Similarly, in Port Hood, successfully establishing a biogas digestor would necessitate the inclusion of a skilled personnel to run the operation; personnel who had a sound knowledge of the technology and its operation. When asked about day to day work requirements at the dairy farm in Port Hood, a farmer said, "so its myself, my son; its a family farm so we don't have any extra labour. In some odd time we will hire somebody to up and give a hand but only for a day or two. It is myself and my son that are providing 90 percent of the labour and my wife and our daughter support us" (PH-2).

3.4.1.4 Knowledge transfer

Knowledge transfer was another key factor influencing decision-making. Farmers in Puthar said that the idea of cultivating mushrooms on waste paddy straw arrived in their village via word of mouth from nearby villages roughly ten years ago. The knowledge around the technology and requirements for the successful set-up of value addition from waste agricultural biomass was an outcome of innovative thinking driven by need and effective communication. This was acknowledged in the comment, "firstly, there is lack of knowledge, the knowledge of the possibility that this too can happen" (PU-3). Specifically in Port Hood, the awareness and knowledge around community biogas digestor models communicated from other members of the farming community led to the idea of producing biogas to utilize on-farm waste such as manure and under-utilized field outgrowths. Many sources of knowledge transfer were noted by the farmers including other farmers and farming knowledge, formal institutions of knowledge such as universities and research institutes (Bonfiglio et al., 2017; Šūmane et al. (2017). However, exchange of information between farming colleagues and counterparts was most trusted as these sources displayed local experience which was highly relevant to the lived circumstances of the farmers (Šūmane et al., 2017). Another aspect of knowledge transfer, which was discussed by the farmers was the dissemination of accumulated knowledge for the effective training of individuals acting as work force, thereby, setting up informal structures for passing on knowledge to relevant members of the agricultural community.

3.4.1.5 Market availability

Farmers in both places said that an important component for evaluating feasibility of the planned value addition activity was the suitability of current market conditions; creating a value-added product was dependent on the supply and demand dynamic in the market for that product. Adequate supply to meet that demand and distance to the market were identified as crucial factors within this theme, “Our biggest advantage is that we are next to Delhi. We have done everything but finally we need to sell and the market is available to do that” (PU-1). Akimowicz et al. (2016) stated market conditions as a crucial factor for farm investment. Return-on-investment by means of profitable sales and distribution of the value-added product thereby justifying the value addition activity itself depended on conditions of market access and suitability. Accordingly, mushroom cultivation in Puthar directly catered to the nearest market about 70-80 kilometres away in New Delhi (capital of India) with enormous demands for packaged mushrooms through wholesale or retail marketing. In Port Hood, the justification for commercial biogas production depended on the utilization of generated biogas for meeting on-farm operational energy needs and the economic returns from the sale of digestate, the product of the anaerobic digestion process. Consequently, market conditions posed an important consideration for pursuing value addition. Alternatively, an undefined market could lead to considerable risk when pursuing a path of value addition causing undesirable socio-economic consequences (FAO, 2014a).

3.4.1.6 Infrastructure

The piece around infrastructure is one of the key considerations in determining the viability and development of value addition of agricultural biomass. Agricultural value chains revolve around varied aspects of infrastructure in terms of institutional access to markets and finances, for trading and communication, and physical infrastructure (FAO, 2014a). In this light, the primary consideration of farmers for value addition were in terms of physical infrastructure requirements; in these cases, this referred to the construction of the mushroom culture house and biogas digestor plant in Puthar and Port Hood respectively. In Port Hood, a farmer remarked, "the biggest piece of the puzzle is the infrastructure" (PH-1). Infrastructural capacity also included means of transportation of externally sourced raw materials and relevant machinery to the agricultural sites and the distribution of the value-added product for end-market use. To this end, broader infrastructural requirements such as feeder roads, access to electricity, etc. were also discussed as concerns central to the process of deciding the pursuit of value addition (Akimowicz et al., 2016; Kiers et al., 2008). Consequently, maintenance and handling of infrastructural elements after the initial set-up was deemed crucial in both places for facilitating resource-efficient operations; "what you need is expertise and hard work in setting up the infrastructure" (PU-2).

3.4.1.7 Ease of acquisition

Procurement of input supplies was another factor noted by the farmers for carrying out value addition. The availability of raw materials for infrastructural needs and agricultural biomass for creating value added products were the main talking points within this theme. Easy access to the relevant raw materials posed a challenge as some inputs were sourced from off-farm and required transportation thereby increasing the costs of procurement. The main raw materials for mushroom cultivation in Puthar included waste agricultural biomass such as waste paddy straw and tempered animal manure for mushroom culture substrate; both these raw materials were locally sourced from nearby farms. Additionally, spawn packets for seeding were sourced from private enterprises in New Delhi. On the other hand, raw materials for biogas production in Port Hood required consistent supply of waste manure and harvested energy crops from the immediate and neighbouring farms in the county. Additionally, the culture house for mushroom cultivation was made with bamboos which along with other accessories were added infrastructural requirements. Similarly, in Port Hood, the farmers were concerned with the acquisition of machinery for setting up the anaerobic digestor for biogas generation which comprises of bulky machinery (Werblow, 2017).

3.4.1.8 Total costs

Economic viability was the foremost parameter evaluated by the farmers before considering value addition as a unique proposition. In Puthar, financial investment was needed to justify the operating costs of the value addition activity associated with the infrastructural set-up, hired labour, procurement and transportation of raw materials from upstream, distribution and sales of the value-added product downstream (Easin et al., 2017). A similar proposition held true in Port Hood. However, since the costs associated with installation of machinery, transportation and maintenance of the digestor itself required a significant capital investment, the economics for this were justified only on the basis of expansion of raw material procurement (Werblow, 2017). This was an added consideration for farmers in Port Hood who wished to acquire a profitable return on investment for pursuing community-based biogas generation. As a farmer rightly said, "the downstream traffic would become massive if you start with more inputs into the digestor which will lead to multiplying revenue streams and cost structures" (PH-2).

3.4.1.9 Revenue generation

Another key consideration when deciding to pursue value addition was the percentage of revenue generated. Given that agriculture as a profession is fraught with risks and threatened by unpredictable environmental and socio-institutional circumstances, it was important to the farmers that their diversification undertaking yielded guaranteed economic returns (Rodríguez-Pose & Hardy, 2015). The revenue generated depends on many factors such as length and actors involved in the value chain of the value-added product, market price volatility, etc. (UNIDO, 2011). In Puthar, revenue was primarily generated from the sale of mushrooms through retail or wholesale marketing. Alternatively, in Port Hood, revenue was generated from the sale of excess biogas, heat and processed digestate; end-products of the biogas generation process. In the case of biogas production, the gas is typically converted to heat and electricity which is used to offset fuel costs and/or sold to the grid; leftover liquid produced as digestate after the anaerobic digestion process in the digestor can be sold for land application as fertilizer or used by the participating farmers to offset their own fertilizer purchases (Werblow, 2017).

3.4.2 Barriers for operationalizing value addition

So far, we have identified factors that need consideration when farmers decide to innovate, outlining their motivations and attitudes towards decision-making in the process of adding value to available resources. However, operationalizing the process of innovation by carrying out on-farm value addition activities is not a straightforward process. Farmers in both places reported barriers for pursuing value addition such as inadequate market conditions, regulatory environment, lack of knowledge and skills among others (FAO, 2014a). These variables were cited as constraints that deterred farmers from utilizing residual agricultural biomass in profitable and innovative ways. These barriers are primarily interpersonal and institutional in their nature and are discussed as such.

3.4.2.1 Interpersonal barriers

Farmers reported abilities associated with risk-taking and knowledge transfer as primarily interpersonal in nature that affected uptake of innovation. Agriculture is regarded as a high-risk business owing to environmental and institutional uncertainty associated with this profession (Rodriguez-Pose & Hardy, 2015; Willock et al., 1999). Alternatively, uptake of innovation is related to attitudes of risk which is largely a function of entrepreneurial behaviour. Such entrepreneurial tendencies are prominent in farmers pursuing on-farm diversification activities (Vesala & Vesala, 2010). The farmers reported that pursuing innovation and seeking new business propositions that support value creation was fraught with risks. When asked about the market opportunities of other possible value-added products, a sixty-year old farmer in Puthar replied, "younger folk have to take this (entrepreneurial activities) up. You can't expect people at our age to take such risks" (PU-2). Such sentiments were reflected among the older interviewees and resonate in literature; older farmers are ofttimes found to be more averse to risk-taking as they seek stability in their profession (Morgan et al., 2010). However, individual farmers perceive risk differently and the ability to take well-calculated risks serves their entrepreneurial efforts deemed necessary to innovate (Karali et al., 2014).

Additionally, farmers also reported that they were not very aware of the opportunities available to them when seeking to create value added products. For example, farmers in Puthar stated that there were no organized channels of information that could be used to update their knowledge about mushroom farming. They received largely anecdotal information regarding the cultivation of better and more suitable types of mushrooms from newspaper articles or through their peers. A farmer in Puthar remarked, "we can only do the things that we know about" (PU-4); "we have found use for waste paddy straw, like that there are many things which get wasted and can be utilized if only we can acquire the right knowledge" (PU-1). Similarly, in Port Hood, the farmers stated that the technology of anaerobic digestion used to produce biogas was a very well explored technology but for them and farmers from neighbouring farms it seemed like a novel and risky approach to biomass use as they were not very aware of the implications of developing and utilizing that technology for their own benefit. Concerning this, a farmer in Port Hood said, "…as soon as you mention the digestors here they (other farmers in the community) all go its new technology. No, it is not new technology. It's been going on. I mean India has been doing this for hundreds of years" (PH-1). Access to the sufficient and right information required interpersonal skills associated with effective communication and collaboration by building knowledge networks (see Šūmane et al., 2017).

Innovation and reorganization of resources for creating and adding value is thereby linked with entrepreneurial ability which requires interpersonal skills such as the ability to take risks, ability to innovate and adapt to changing circumstances, bridging knowledge gaps through collaboration and communication among others (Šūmane et al., 2017; Morgan et al., 2010). These skills stand out on the personal front and are central to the farmer's ability to pursue value addition and on-farm diversification. Alternatively, the absence of such entrepreneurial skills posed as barriers for effectively carrying out innovation and value addition leading farmers to lose out on business opportunities that maximize economic benefit and improve their livelihoods.

3.4.2.2 Institutional barriers

The practice of entrepreneurship necessary for pursuing innovation opportunities go hand in hand with the creation of an enabling environment for enhancing innovation capacity (FAO, 2014a). Incorporation of value addition activities carried out by farmers in equitable value chains or inclusive business models can help realize the sustainable development of rural livelihoods (UNDP, 2010). This developmental approach can work by integrating rural actors within the global markets (FAO, 2014a). The creation of an environment that promotes innovation capacity depends on several institutional factors necessary for realizing farmers' entrepreneurial efforts. Farmers in both places reported several barriers such as lack of institutional support, regulatory environment and lack of recognition and incentive among others that posed barriers for operationalizing value addition. In both case study areas, regulatory mechanisms deterred farmers from pursuing their choice of value addition. For instance, regulations associated with quota production are ofttimes viewed as being necessary for price regulation, however, restricted access to quota leads to inequalities that disallowed farmers to undertake diversification activities on their respective farms (Akimowicz et al., 2016). For instance, in Port Hood, the economic justification for operating a farm-based biogas plant would necessitate a large amount of manure and feedstock as inputs for the digestor operation. Under the tightly supply-managed Canadian dairy industry, the number of cows one can own is controlled by quotas which are high in demand and very expensive to purchase (Sooksom, 2013). This affects the amount of raw material that can be used to generate optimum levels of biogas. As a farmer in Port Hood put it, “the limitation is that you only have so much quota so you don't need to be growing more corn because you can only have so many cows” (PH-1).

Alternatively, farmers stressed the role of institutions in enabling agricultural innovation. From a value chain perspective, factors such as access to markets and information are institutional in nature; if not properly addressed can result in loss of opportunities related to growth, infrastructure and innovation negatively impacting small farmers (Albu & Griffith, 2006). Accordingly, it is important to reinforce stronger means of governance and organization along the value chain that reduces institutional barriers that farmers face (UNIDO, 2011). Coordination between different institutions such as the government, local bodies and voluntary organisations can result in creating strong value chains with extensive benefits (Rodríguez-Pose & Hardy, 2015; UNIDO, 2011). Governments play a crucial role in providing agricultural extension and advisory services, training and financial support to farmers which they are unlikely to receive from the private sector (FAO, 2014a). Towards this end, a farmer in Puthar responded by saying,

> “we have found good use for waste (paddy) straw but there is risk associated with this work as there is no trained manpower, one might be landless, and costs are more. So, the government should encourage this activity and increase subsidies. The raw material is all available, dung is available, market is available, young people who are unemployed are also available. First there is need to give training and then the money; both things should be given. If you have giving training but no money, then it doesn’t work so well” (PU-2).

Additionally, community-based organizations such as farmers' groups and cooperatives can ensure transparent and accountable provision of such services that caters to farmers' needs (FAO, 2014a). A farmer in Puthar agreed, "right now there is no fixed price for selling these (mushrooms). That depends on the market. If we have a cooperative, then the prices become fixed and it is better for the farmers" (PU-3). Another source of institutional support to tackle reported barriers of lack of information and knowledge of opportunities are universities and research institutes which can contribute to technology transfer and strengthening of extension services to farmers for rural development (Theodorakopoulos et al., 2012). Apart from barriers of credit and extension, new value chains introduced on account of diversification activities performed by farmers, face hurdles related to price fluctuations and product marketing which can be resolved by establishing institutional arrangements as discussed above (Dev, 2014). Thus, reducing institutional barriers by creating conditions for organizational integration within value chains can lead to a degree of risk absorption and give small farmers the confidence to pursue diversification by creating partnerships to bolster rural development.

3.4.2.3 Sphere of influence of actors involved in the resolution of barriers

There are a number of actors that can influence the decision-making of farmers involved in value addition activities as presented in Table 2. All these actors were derived from the conversations with the farmers who find a supportive environment provided by relevant actors as essential. Additionally, an enabling environment provided by these actors can enhance and strengthen and decision-making abilities of farmers. The presence of external actors in the decision-making of farmers implies that farmers have little influence over the resolution of barriers that have been identified in the process of interviewing the farmers. The onus for providing support mechanisms for family farmers largely lies on the government, public and private enterprises (FAO, 2014). In particular, “governments must recognize the importance of advisory services in which different actors play different roles and provide different services to different groups of farmers” (FAO, 2014, p. 71). In this regard, it is important that governments take steps to forge private-public partnerships that respond adequately to national and local circumstances (FAO, 2014).

Table 2: Primary actors’ sphere of influence for the resolution of barriers

Barriers	Primary Actors Involved
Risk Aversion	Farmer groups, cooperative societies, non-governmental organizations working for farmer welfare
Lack of Recognition and Incentive	Government/semi-government organizations, autonomous bodies, non-governmental organizations
Lack of Awareness	Private/public research institutes, agricultural universities, government extension services
Regulatory Environment	Federal and provincial governments
Lack of institutional Support	Federal and provincial governments, non-governmental organizations

3.4.3 Understanding farmers’ motivations for decision-making

So far, we have focussed on the relationship between farm and farmer features with the feasibility of value addition, however, there is a growing need to understand motivations that drive farmers’ decision-making for pursuing diversification activities (Hansson et al., 2013). The interpersonal and institutional barriers, discussed in §3.4.2, reflect personal (e.g., networking skills, enthusiasm, amount of land owned, etc.) and external opportunities (e.g., market information, infrastructure, finance, etc.) that the farmers capitalize on to make their decisions (Farmar-Bowers & Lane, 2009). Both these components coupled with motivation influence the decision-making of farmers; an idea reflected in the mental model of decision-making devised by Farmer-Bowers & Lane (2009). Additionally, Hansson et al. (2013, p. 242) discusses agricultural diversification as being “opportunity driven (pull factor) or necessity driven (push factor)”. This implies that diversification is influenced by the presence of opportunities such as employing a new business idea or reallocating resources for growth, or by necessities such as sustenance which can be fulfilled by self-employment or securing family income (Hansson et al., 2013). Whichever the case, the decision-making process of farmers is underpinned with complexity arising from unique beliefs and attitudes which translate to behaviours driven by motivations that are varied in nature (Willock et al., 1999). The adequate understanding of farmer decision-making processes can help us generate new opportunities and deal with challenges that farmers face when looking to pursue on-farm diversification activities such as value addition (Barbieri & Mahoney, 2009). Towards this end, the factors identified in §3.4.1 were mapped based on their level of influence (Figure 6) with the farmers in Puthar to gain better insight into their decision-making process for pursuing mushroom cultivation as a means of value addition.

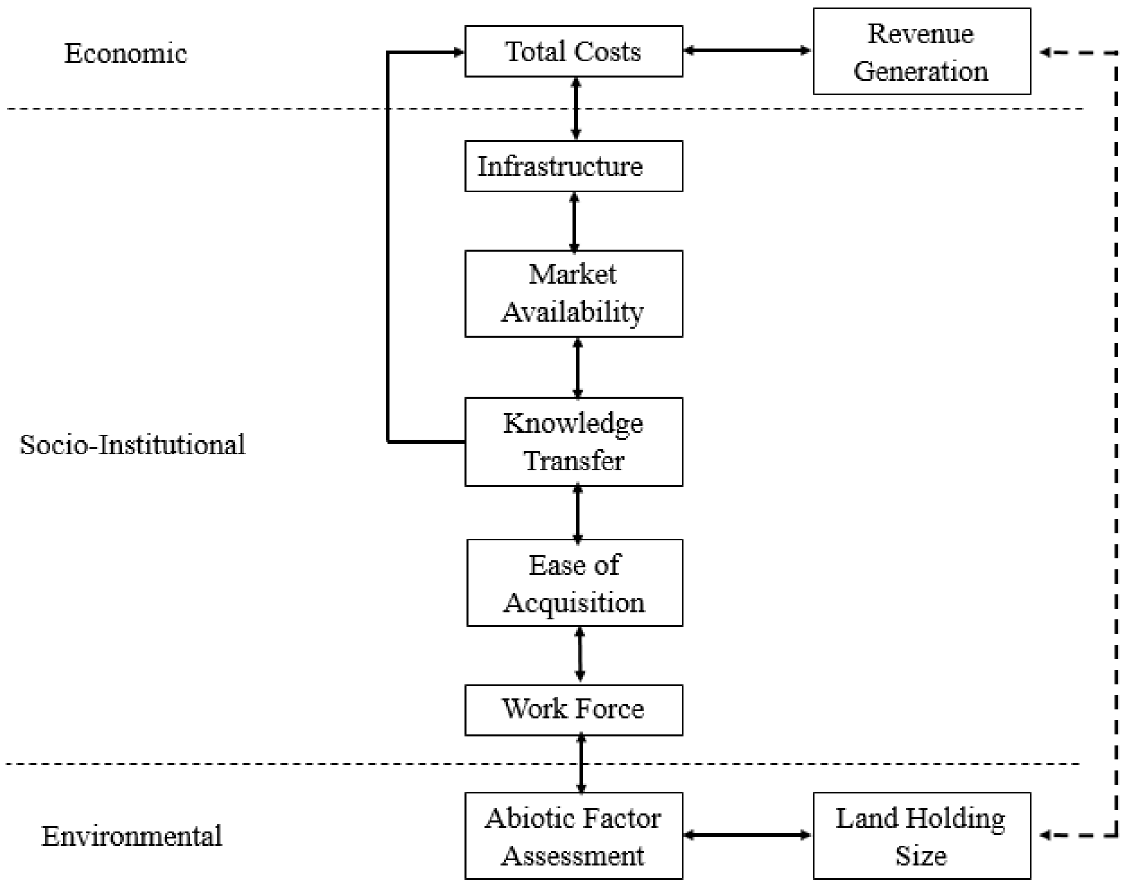

Figure 6: Mapping of the variables under consideration for decision-making for the pursuit of value addition activities

As is evident in Figure 6, the previously identified variables were found to be interlinked and iterative reflecting the complex and multi-faceted nature of agriculture-based decision-making (Hansson et al., 2013). Although, the primary driver behind utilizing waste agricultural biomass was the generation of profitable economic returns, this was dependent on financial feasibility and availability of information around diversification opportunities signified by the factors of total costs and knowledge transfer respectively. For example, when asked about constraints that hold farmers back from pursuing diversification, a farmer replied, “money, it’s always money” (PU-4). In addition, environmental factors too determined the possibility of value addition given the state of on-farm natural resource availability. As a farmer in Puthar remarked, “we are at the whims of mother nature and a lot of things are out of your control that can tip the balance between a profitable year and not so profitable year" (PU-1).

From a value chain perspective, the socio-institutional factors formed the operational backbone for decision-making as the factors associate with market conditions and infrastructural arrangements determined access to new value-driven markets (FAO, 2014a). Another farmer said, "…to do this (mushroom cultivation as a value-added activity) first you need your own land but this is not enough. You have to be very enterprising; you have to do your research, pool the money, then find the market and then implement the plan of action" (PU-1). Another farmer remarked, "one of my farmer friend has the land, the money, he also hired people, still because of lack of expertise, he incurred losses. There needs to be a bridging in our knowledge gap" (PU-2). To interpret the farmer's motives as purely economic would run the risk of over-simplifying the decision-making process which is an outcome of the socio-economic, environmental, psychological and business circumstances that surround the farmer (Farmar-Bowers, 2009, Wilson, 2008; Willock, Edward-Jones, et al., 1999). Accordingly, motivations driving decision-making are "embedded in, and dependent on, the context in which the farm business is situated" (Hansson et al., 2013).

The multi-dimensional motives influencing farmers' decision-making processes have implications on the understanding of sustainable development from a rural agricultural economy perspective. Key rural actors such as farmers strive for generating profitable livelihoods by working within socio-ecological constraints presented by the growing population and resource scarcity (Biggs et al., 2015). They do so by undertaking diversification activities like value addition that aim to maximally utilise existing resources (Hansson et al., 2013). In the process of seeking sustainable livelihoods, farmers take complex decisions that depend on varied considerations discussed in this section. As Snapp and Pound (2011, p. 28) have rightly said, "farmers are system thinkers" who "think of today's priorities and tomorrow's sustainability".

3.5 Conclusion

The role of the rural economy is crucial in the collective pursuit for sustainable development. The agriculture-driven rural economy fulfils majority of the world's biomass demands. Subsequently, the effective management of biomass resources relies on sustainable agricultural practices adopted by small farms. The pursuit of multifunctionality through on-farm diversification and value addition as an approach lends itself to this end as it not only relies on the principles of resource efficiency but also incorporates innovative thinking to create higher value products from agricultural biomass. The ability to market these products for the benefit of the rural economy requires a value chain perspective that prioritizes strong and stable relationships between the different actors of the agricultural value chain. This thinking not only creates circumstances for effective governance of global and local biomass production but also has implications for increasing the resilience of local agricultural economies and societies, solidifying their immense contribution to fulfil global biomass needs and demands.

In this context, this chapter sought to better understand the decision-making processes of farmers regarding diversification activities for the effective use and governance of agricultural biomass from a value chain perspective. Specifically, farmers in two case sites- one in Puthar, India and the other in Port Hood, Canada were interviewed separately and in a focus group to study their decision-making processes. In both places, the farmers were engaged in biomass value addition activities. Data analysis revealed several factors that determine the feasibility of carrying out on-farm diversification activities. These factors were categorised into environmental, social, institutional and economic spheres to further explore the influence of changing circumstances on farmers' ability to make decisions. Additionally, interpersonal and institutional barriers were identified that hinder the farmers' ability to undertake value addition activities. Lastly, there was an attempt to explore farmer motivations for undertaking value addition in Puthar. This revealed that the farmers' decision-making processes are complex and cannot be simplified as arising from a singular belief but are rather an amalgamation of the socio-economic and environmental conditions that surround the farmer.

These findings give an insight into the decision-making mechanisms employed by small farmers when looking to diversify their on-farm activities and income. This study has explored barriers and opportunities that farmers face when looking to perform on-farm value addition activities. This understanding is facilitated from a value chain perspective which constitutes a significant step in the direction for implementing innovative and sustainable agricultural practices such as multifunctional agriculture to inform sustainable management of limited resources and contribute positively towards the development of rural agricultural communities. In particular, this research paves way for identifying and understanding the influence of other relevant local stakeholders in the collective decision-making process for local resource management. A close examination of different influential voices is critical to operationalizing similar site-specific resource diversification activities as are presented in this chapter.

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CHAPTER 4: CONCLUSION

At this point, it is appropriate to recap the primary aim of this thesis which was to understand and support decision-making in local agricultural communities for effective agricultural biomass resource utilization in a sustainable manner, i.e., not only economically profitable but socially equitable and environmentally progressive. The objectives that this thesis sought to fulfil are recapitulated below:

1. To propose strategies for the sustainable utilization of agricultural biomass resources in local agricultural communities.

    ii. To understand sustainable resource management as a complex social-ecological system.

2. To explore the implementation of identified strategies (objective 1) in local agricultural contexts for sustainable development.

    iii. To establish the relationship between biomass utilization and the rural economy.

    iv. To study and understand the decision-making process of small farmers undertaking on-farm diversification activities.

The first research objective and sub-objectives were discussed in Chapter 2. Specifically, we addressed the complexities and impacts associated with global trends of biomass production and consumption. In the background of negative externalities caused by these trends, an urgent need to address the sustainable utilization of biomass resources was expressed. It is well known that the management of resources is a complex endeavor and requires an integrated approach afforded from various disciplines to enable sustainable decision-making (Charnley et al., 2017; Virapongse et al., 2016). An effort was made in Chapter 2 to explore the multi-faceted nature of sustainable resource management that interacts at developmental, spatial and temporal scales and involves multiple actor regimes. Given this complex understanding of natural resource systems, the three approaches of multifunctional agriculture, value chain thinking and stakeholder engagement were put forward as management strategies that could be employed in alignment with the complexity of agricultural biomass systems.

Chapter 3 dealt with the implementation of these three strategies discussed in Chapter 2. Given that 56 percent of agricultural production takes place on more than 500 million small farms across the world, an inextricable link can be drawn between biomass resource use and the rural economy (FAO, 2014b). Concurrently, it is imperative that small farmers, who are the key actors in rural agricultural systems, are engaged in decision-making for sustainable resource use. Chapter 3 delved into sustainable resource practices such as on-farm value addition as a means of extending multifunctionality from a value chain perspective for the sustainable development of the rural economy. Furthermore, the decision-making processes of farmers in two case sites of Puthar, India and Port Hood, Canada were studied to understand the feasibility of such innovative management strategies. A total of nine factors were identified that require consideration when deciding to pursue on-farm value addition. Additionally, several interpersonal and institutional factors were identified that pose barriers in the uptake of the desired value addition activity. Finally, it was ascertained that the decision-making processes of small farmers are complex and require further study to understand the implications of adopting diversification activities from a value chain development perspective.

The research presented in this thesis is highly relevant and informs the broader issues of sustainable resource management. The utilization of globally available biomass requires approaches that focus on resource efficiency whilst promoting sustainable growth. Biomass is linked with agricultural activity and as a natural asset is spread unevenly in different places and communities (Cleary & Hogan, 2016; Prosperi & Lopolito, 2016). Due to its association with agriculture, biomass is concentrated within rural regions which play a significant role in the provision and processing of site-specific biomass value streams. As is discussed throughout the thesis, rural development and biomass utilization are closely linked and innovative approaches that focus on local value generation of under-utilized biomass resources present opportunities for revitalizing the rural economy. However, the operationalization of such approaches is often hindered by many barriers and uncertainties that are explored in this thesis. In this regard, the participation of local stakeholders is crucial for generating site-specific innovative solutions to counter increasingly complex resource problems. This thesis has taken a concrete step in this direction by presenting an example for gathering and mobilizing farmers' knowledge and motivations when seeking to utilize biomass locally in an effective manner.

Subsequently, this thesis identified that decision-making of small farmers is contingent upon the presence of an enabling environment driven by varied actors that affect the implementation of diversification activities especially from a value chain context. A significant next step in operationalizing value addition is by understanding 'who' are the varied voices, apart from individual farmers themselves, that impact and influence decision-making. These actors most often act independently and beyond the community and aid in the generation of knowledge and resources that are not generated in the community itself (Chaudhury et al., 2017). Towards this end, there is a need for additional research efforts in the direction of identifying and involving other local stakeholders to understand and enable the adoption of multifunctionality at all nodes of the value chain of the value-added product in question. Additionally, there is a need for more comparative research among different global rural community settings to fully grasp and examine the role of local actors in local decision-making. Such research efforts are central to developing an understanding of sustainable resource management specifically in local communities leading to sustainable development.

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APPENDIX A: INTERVIEW DISCUSSION GUIDE

To guide the discussion, the following questions will be asked, and the written feedback requested will reflect these points:

1. **What is the primary activity being undertaken in this agricultural community?** The primary activities could be farming, rearing of livestock or any other activity that drives the agricultural production in this community.

2. **Apart from the primary production activities, what kind of secondary activities are being undertaken, especially, for waste treatment/management and by-product (from production processes) utilization?** This question implies to understand if and how do you use agricultural by-products or waste biomass in your community to create more value-added products apart from the products produced from the primary agricultural activities. The secondary activities could be the generation of biogas from waste biomass or growth of other secondary crops from the biomass waste of the primary crop.

3. **Give a brief overview/description of the primary and secondary activities as stated above.** Specifically, what and how do you produce.

4. **What is the motivation behind pursuing these primary and secondary agricultural activities?** Is it economic growth, social opportunity or any other reason.

5. **Which resources are needed to enable the functioning of the primary activity?** For your primary activity, what kind of biotic or abiotic inputs do you require?

6. **Which additional resources are required to enable the functioning of the secondary activities?** Apart from the resources that are used for the primary agricultural activity, what kind of biotic or abiotic resources does the functioning of the secondary activities require?

7. **Do you face any constraints regarding resource acquisition and utilization for undertaking the primary agricultural activity?** Do you face any difficulty in procuring the relevant resources mentioned in the question 5 and 6? Additionally, are all the stated resources readily available at your disposal to perform your agricultural activities?

8. **Do such resource constraints affect the value proposition of the activities you undertake?** How do you deal with such resource constraints in order to create benefit/value for your undertaking? Is the outcome of your primary and secondary activities affected by resource constraints discussed in question 8? If the relevant resources are not available, are you still able to generate the same outcome as with the availability of all resources?

9. **Are the required resources internally available? If not, how are they sourced, and which upstream channels are used for their acquisition?** Are the relevant resources

available readily or within the reach of your agricultural operations? If not, how do you arrange for their procurement? Additionally, what kind of channels (involving transportation, etc.) do you employ for their procurement?

10. **Who are the key stakeholders involved upstream of the primary agricultural activity? Describe their role.** How and who is involved in the upstream procurement of the resources.

11. **What is the outcome/product derived from the primary agricultural activity production chain?**

12. **If any, what other products and by-products are generated from the secondary and the primary agricultural chains, respectively?**

13. **How are the products distributed for consumption downstream of the primary and secondary agricultural chains?** How are the products generated from the primary and secondary activities distributed upon production?

14. **Who are the key stakeholders involved downstream of the primary agricultural activity? Describe their role.** How and who transports or buys the products?

15. **Are there any other stakeholders that indirectly (socio-cultural, policy context) impact the primary and the secondary agricultural chains? Describe their role.** Are there other actors whose presence positively or negatively affects the optimum functioning of the agricultural chains? If yes, then how?

16. **What is the cost for acquiring and maintaining internally and externally sourced resources?** This could include transportation costs, costs of procuring not readily available resources.

17. **What are the operational and maintenance costs regarding the primary and secondary agricultural undertaking?** This could include costs of production of the final products.

18. **What are the costs in relation to the upstream and downstream activities essential to the smooth working of the agricultural chain?** This could include costs of transportation and other transactions related to engaging different stakeholders/actors involved directly or indirectly in the production process.

19. **Which activities and products account for the main streams of revenue generation in the agricultural chain?**

20. **What is the approximate percentage of your total revenue generated by these activities and products?**

APPENDIX B: OPERATIONAL COMPONENTS THAT LINK AN AGRCILUTURAL VALUE CHAIN

Operational Components	Classification
Key activities	• Agriculture (for the production of food, feed, fiber, fuel) • Livestock farming • Waste treatment, etc.

Key resources	• Extent/composition of land
	• Biotic resources
	    ○ Soil
	    ○ Water
	    ○ Livestock
	    ○ Bio-materials
	• Abiotic resources
	    ○ Fertilizers
	    ○ Energy use
	• Infrastructure/technology

Key partners	• Stakeholders • Role that they play in enabling different components (includes socio-cultural context)
Value proposition	• Main products • Value-added products
Input sourcing channels	• For resources • Infrastructure • Labour
Output distribution channels	• Distribution of Products • Customer segment/relationship
Cost structure	• All of the above
Revenue streams	• All of the above (defines scope for value chain development)

APPENDIX C: ELECTRONIC RECRUITMENT OF THE PARTICIPANTS (VIA EMAIL)

Dear Potential Participant,

I am emailing to officially introduce myself and to invite you to participate in an academic study for which I am the principal investigator. My name is Ms. Navya Pandit, and I am a graduate Student at Dalhousie University in Canada. As a requirement for my master's program, I am expected to write a thesis in fulfilment of my degree.

For my thesis, my research is focused on understanding ways in which agricultural land-based resources can be used in a way to provide maximum benefit in local agricultural communities, with case studies in Canada and India. Specifically, my research is focused on understanding the barriers and opportunities faced by the local communities while pursuing agricultural activities. This research will include a discussion in the format of a stakeholder consultation meeting with farmers in the identified communities which will last up to approximately an hour and fifteen minutes.

In all, it is expected that the discussion will be conducted with the relevant stakeholders, i.e. farmers like yourself, followed by a session where you will be given an opportunity to provide written feedback in addition to the discussion conducted as a part of this study. Participants will not receive any compensation for participating in this study because participation is entirely voluntary. Furthermore, any information that is provided by you will be confidential. Your personal information will not be used or mentioned in any part of the study.

If you have additional question or concerns, please feel free to contact me for further clarification. I will be reachable through email or by phone at +1 902-412-3322.

Thank you,
Navya Pandit,
Master of Environmental Studies,
Halifax, Nova Scotia,
Canada

APPENDIX D: VERBAL RECRUITMENT OF THE PARTICIPANTS (VIA PHONE)

Dear Potential Participant,

I am emailing to officially introduce myself and to invite you to participate in an academic study for which I am the principal Investigator. My name is Ms. Navya Pandit, and I am a graduate Student at Dalhousie University in Canada. As a requirement for my master's program, I am expected to write a thesis in fulfilment of my degree.

For my thesis, my research is focused on understanding ways in which agricultural land-based resources can be used in a way to provide maximum benefit in local agricultural communities, with case studies in Canada and India. Specifically, my research is focused on understanding the barriers and opportunities faced by the local communities while pursuing agricultural activities. This research will include a discussion in the format of a stakeholder consultation meeting with farmers in the identified communities which will last up to approximately an hour and fifteen minutes.

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If you have additional question or concerns, please feel free to contact me for further clarification. I will be reachable phone at +1 902-412-3322.

Thank you,
Navya Pandit,
Master of Environmental Studies,
Halifax, Nova Scotia,
Canada

APPENDIX E: INFORMED CONSENT INFORMATION SHEET FOR THE PARTICIPANTS IN CANADA

Project title: Optimization of the Value-Chain in Localized Agricultural Context for Sustainable Development

Lead researcher: Ms. Navya Pandit,

School of Resource and Environmental Studies

Email: navya.pandit@dal.ca

Phone Number: +1 902-412-3322

Other researchers: Dr. Michelle Adams,

School of Resource and Environmental Studies

Email: michelle.adams@dal.ca

Phone Number: +1 902-494-4588

Introduction

We invite you to take part in a research study being conducted by me, Navya Pandit, a student at Dalhousie University as a part of my Master of Environmental Studies program. The choice to participate in this study is entirely up to you. The information below tells you about what is involved in the research, what you will be asked to do, and about any benefit, risk, inconvenience or discomfort that you might experience.

Purpose and Outline of the Research Study

The purpose of this study is to understand the barriers and opportunities that local agricultural communities face. In this study, we are looking to understand how local communities can use resources at their disposal to maximize economic, social and environmental benefit to the respective communities. In order to do so, we require the participation of fifteen to twenty local farmers for discussing issues relevant to the study objective.

Who Can Take Part in the Research Study

The main aim of this study is to research ways of using agricultural biomass in communities that generate agricultural waste. Specifically, the study aims to study the different ways in which this biomass waste is transformed into value added products, which may include the generation of renewable energy or new agricultural products. You may participate in this study, if you are a farmer of the local community undertaking agricultural activities that are similar to this description.

What You Will Be Asked to Do

You will be asked to participate in one discussion which will revolve around the barriers and opportunities that you face while undertaking your agricultural activities. You will then be given an opportunity to provide written feedback based on what was discussed, in case you wish to do so. The time for these activities to take place is estimated to be one hour and fifteen minutes. This study will take place in Sydney, Cape Breton during the day.

Possible Benefits, Risks and Discomforts

You may not necessarily experience any direct benefits if you decide to participate in this study. However, I hope that this study will give you an opportunity to voice your opinions, experiences and observations regarding the barriers and opportunities you face while undertaking your agricultural activities. This could be useful in addressing issues you may have about this research, and the information from this study may help address these issues.

The risks associated with this study are minimal, and there are no known risks for participating in this research beyond being bored or fatigued. However, you will be offered breaks between the activities to reduce these risks.

Compensation / Reimbursement

There will be no specific compensation for your participation. However, please accept our deepest gratitude for your willingness to participate in this research.

How your information will be protected:

Information that you provide to us will be kept private. Only the research team at Dalhousie University will have access to this information. We will describe and share our findings in the form of a thesis and journal articles. We will be very careful to only talk about group results so that no one will be identified. This means that you will not be identified in any way in our reports. All your identifying information will be securely stored. All electronic records will be kept secure in an encrypted file on the researcher's password-protected computer. Only the researcher and the research supervisor will have access to the data records. The written feedback provided by you will be scanned, and the paper copies will be shredded/destroyed. After the span of two years, all the electronic records will also be destroyed.

When the study results are being shared, pseudonyms or false names will be used to prevent the identification of participants in order to maintain anonymity. As a part of this consent process, you will be given an opportunity to consent to the use of quotations in the results of this study. If you choose to give verbal consent, it will be recorded.

If You Decide to Stop Participating

You are free to leave the study at any given time.

How to Obtain Results

We will provide you with a summary of the study results via email when the study is finished in approximately six months. No individual results will be provided. You can obtain these results by including your contact information at the end of the signature page. Also, as and when the research thesis or other publications are made public, you will be sent a link to access these electronically.

Questions

We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Navya Pandit (at +1 902-412-3322, navya.pandit@dal.ca) or Dr. Michelle Adams (at +1 902-494-4588, adamsm@dal.ca) at any time with questions, comments, or concerns about the research study. We will also tell you if any new information comes up that could affect your decision to participate.

APPENDIX F: INFORMED CONSENT INFORMATION SHEET FOR THE PARTICIPANTS IN INDIA

Project title: Optimization of the Value-Chain in Localized Agricultural Context for Sustainable Development

Lead researcher: Ms. Navya Pandit,

School of Resource and Environmental Studies

Email: navya.pandit@dal.ca

Phone Number: +1 902-412-3322

Other researchers: Dr. Michelle Adams,

School of Resource and Environmental Studies

Email: michelle.adams@dal.ca

Phone Number: +1 902-494-4588

Introduction

We invite you to take part in a research study being conducted by me, Navya Pandit, a student at Dalhousie University as a part of my Master of Environmental Studies program. The choice to participate in this study is entirely up to you. The information below tells you about what is involved in the research, what you will be asked to do, and about any benefit, risk, inconvenience or discomfort that you might experience.

Purpose and Outline of the Research Study

The purpose of this study is to understand the barriers and opportunities that local agricultural communities face. In this study, we are looking to understand how local communities can use resources at their disposal to maximize economic, social and environmental benefit to the respective communities. In order to do so, we require the participation of fifteen to twenty local farmers for discussing issues relevant to the study objective.

Who Can Take Part in the Research Study

The main aim of this study is to research ways of using agricultural biomass in communities that generate agricultural waste. Specifically, the study aims to study the different ways in which this biomass waste is transformed into value added products, which may include the generation of renewable energy or new agricultural products. You may participate in this study, if you are a farmer of the local community undertaking agricultural activities that are similar to this description.

What You Will Be Asked to Do

You will be asked to participate in one discussion which will revolve around the barriers and opportunities that you face while undertaking your agricultural activities. You will then be given an opportunity to provide written feedback based on what was discussed, in case you wish to do so. The time for these activities to take place is estimated to be one hour and fifteen minutes. This study will take place in Puthar, Haryana during the day.

Possible Benefits, Risks and Discomforts

You may not necessarily experience any direct benefits if you decide to participate in this study. However, I hope that this study will give you an opportunity to voice your opinions, experiences and observations regarding the barriers and opportunities you face while undertaking your agricultural activities. This could be useful in addressing issues you may have about this research, and the information from this study may help address these issues.

The risks associated with this study are minimal, and there are no known risks for participating in this research beyond being bored or fatigued. However, you will be offered breaks between the activities to reduce these risks.

Compensation / Reimbursement

There will be no specific compensation for your participation. However, please accept our deepest gratitude for your willingness to participate in this research.

How your information will be protected:

Information that you provide to us will be kept private. Only the research team at Dalhousie University will have access to this information. We will describe and share our findings in the form of a thesis and journal articles. We will be very careful to only talk about group results so that no one will be identified. This means that you will not be identified in any way in our reports. All your identifying information will be securely stored. All electronic records will be kept secure in an encrypted file on the researcher's password-protected computer. Only the researcher and the research supervisor will have access to the data records. The written feedback provided by you will be scanned, and the paper copies will be shredded/destroyed. After the span of two years, all the electronic records will also be destroyed.

When the study results are being shared, pseudonyms or false names will be used to prevent the identification of participants in order to maintain anonymity. As a part of this consent process, you will be given an opportunity to consent to the use of quotations in the results of this study. If you choose to give verbal consent, it will be recorded.

If You Decide to Stop Participating

You are free to leave the study at any given time.

How to Obtain Results

We will provide you with a summary of the study results via email when the study is finished in approximately six months. No individual results will be provided. You can obtain these results by including your contact information at the end of the signature page. Also, as and when the research thesis or other publications are made public, you will be sent a link to access these electronically.

Questions

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APPENDIX G: INFORMED CONSENT SIGNATURE SHEET FOR THE PARTICIPANTS

Project Title: Optimization of the Value-Chain in Localized Agricultural Context for Sustainable Development

Lead Researcher: Ms. Navya Pandit,

School of Resource and Environmental Studies

Email: navya.pandit@dal.ca

Phone Number: +1 902-412-3322

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand that I have been asked to take part in a discussion and give written feedback as a part of the study that will occur at a location acceptable to me, and that that discussion and feedback will be recorded. I understand direct quotes of things I say may be used without identifying me. I agree to take part in this study. My participation is voluntary and I understand that I am free to withdraw from the study at any time, until after two months from the completion of this study.

I agree that the discussion may be audio-recorded ☐Yes ☐No

I agree that direct quotes from my interview may be used without identifying me

☐Yes ☐No

____________________	____________________	____________________
Name	Signature	Date

I confirm that I have participated in the discussion and agree that direct quotes without my name may be used.

____________________	____________________
Signature	Date