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PHASE 2

DOWNSTREAM EFFECTS OF EXCESS MOISTURE IN MANITOBA

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BRANDON UNIVERSITY

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It is important to recognize that the land on which we are gathered is the traditional and ancestral lands of the Dakota, Anishinabe, Inninewak, Oji-Cree, Dene and Metis peoples. We respect the treaties that were made on these lands and acknowledge that Brandon University is located on Treaty 2 Lands. We at Bran-don University acknowledge and respect the history, land and the people of this area.

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Foreword

Manitoba's rapidly changing climate conditions are characterized by increased frequency and intensity of extreme moisture events. For instance, four of the top ten Assiniboine River floods and five of the top ten Red River floods took place during the last 25 years. In addition to these spring floods, other extreme moisture events include prolonged or intense periods of rain. Generally, from an ag-producer's perspective, these events result in soil moisture in extreme of field capacity for a period sufficient to significantly inhibit crop production.

Moreover, the impacts of such events can be local or regional as well as downstream. For producers, the impacts may be short-term, prolonged or persistent depending on the locale, previous moisture mitigation strategies, and the local and regional water infrastructure. These extreme water events harm farm livelihoods as well as the well-being of all downstream rural municipalities and urban centres having to deal with the social, economic and environmental costs due transportation interruptions, property damage, and agricultural run-off impacts on surface and ground water quality.

There are several longer term strategies producers can invest in to manage extreme moisture in their fields. Reducing the risk of crop loss or reductions in yield and quality are generally the main reasons why producers make such investments. Others at the local and regional levels may also benefit from these water management practices as well (e.g., reduced peak flows). This project aims to provide agricultural producers at the early stage of long-term planning with critical factors in estimating socio-economic costs and benefits of different on-farm extreme moisture practices, along with identifying other stakeholder considerations.

To achieve that goal, this project consists of three main activities and took place in two distinct phases. The focus of Activity 1 was to provide producers with an on-farm costs and benefits framework to help evaluate different investment strategies for managing extreme moisture. Activity 2 focused on using farm models to provide information on the impact on yield and farm income due to extreme moisture. Lastly, Activity 3 focused on identifying the downstream impacts and costs of extreme moisture events with a particular focus on the 2011 Assiniboine River flood. For each activity, Phase 1 consisted of gathering and synthesizing academic and other publicly available information and data. Phase 2 of the project sought to get feedback from producers and other stakeholders in an effort to validate the findings of the Phase 1 activities. Overall, the 2 phases of the 3 activities of this project resulted in the completion of 6 reports which are outlined in Figure 1.

Summary of the 6 reports indicating the main objectives for each phase and activity

	ACTIVITY 1	ACTIVITY 2	ACTIVITY 3
	Economic Costs and Benefits Analysis of Excess Moisture Investments	**Impacts of Excess Moisture on Crop Field and Farm Income**	**Downstream Effects of Excess Moisture in Manitoba**
PHASE 1	1. Identify farm investment options for excess moisture management. 2. Identify of on- and off-farm costs and benefits of investment options. 3. Quality costs and benefits of investment options and select suitable proxies for qualitative costs and benefits. 4. Develop a framework to assess costs and benefits of excess moisture investment options.	1. Identify, calibrate and adapt a farm model that could be simulating the impact of excess moisture events in southern Manitoba's field conditions.	1. Identify the physical and socio-economic impacts of excess moisture 2. Identify the direct the indirect costs excess moisture losses. 3. Identify the downstream economic impacts of excess moisture.
PHASE 2	1. Validate the economic cost-benefit framework of proposed investment options of farm-level extreme moisture management. 2. Determine what extreme moisture management strategies are currently being use. 3. Evaluate the willingness of producers to adapt their farm using proposed extreme moisture management strategies. 4. Conduct a Manitoba local market survey to validate cost estimations used in the development of cost-benefit framework.	1. Identify current yield forecasting tools available and being used by stakeholders at different scales of operations. 2. Evaluate the willingness of producers and other stakeholders in crop yield forecasting models.	1. Validate the completeness and accuracy of the physical and socio-economic impacts of excess moisture. 2. Assess the relevance and usefulness of the information for the procedures and stakeholders. 3. Identify other effects, outcomes, and strategies that producers and stakeholders considered in response to the 2011 Assiniboine River Flood

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Executive Summary

Significant rainfall events in the summer and fall and the effects of large amounts of snowmelt runoff in the spring can result in excess moisture in the Canadian Prairies. Specifically, Manitoba has a long history of flooding, and the recent flood in 2011 was unprecedented in magnitude and duration. During the 2011 Manitoba floods, significant flood damage was sustained in communities and facilities throughout the Assiniboine River basin. Even though the damage to crops, livestock, and individual property was substantial, temporary flood mitigation measures were introduced to reduce the effects of the floods in municipalities along the Assiniboine River. Using the Assiniboine River basin in Manitoba as the primary unit of analysis, Phase 1 of this project centered on assessing the impacts of excess moisture at the on-farm and downstream levels. In addition, the direct and indirect impacts associated with the 2011 flood were catalogued and their economic costs were estimated.

Phase 2 of the project concentrated on validating the results of the first phase. This report is focused on verifying the information and getting feedback on the factsheet cataloging the downstream impacts of excess moisture in Manitoba which was created as part of Phase 1. This verification and soliciting of feedback was done by interviewing experts from agricultural/commodity organizations, producers, government officials, academics, and economists with recognized expertise in the social, economic, and environmental impacts of excess moisture event management. This validation through interviews was necessary to highlight the presence and absence as well as the accuracy and details of key information on the factsheet provided through the farmers' and stakeholders' perspectives. In the process of getting feed-back from selected key informants, from stakeholders and producers about the factsheet, this allowed RDI to assess and probe how stakeholders and producers may use the findings of Phase 1. Overall, Phase 2 of this project verified that the information on factsheet was correct and comprehensive; however, the feedback suggested that this information would be more relevant and useful if the information were tailored and targeted to suit the needs of the user.

Introduction

Manitoba's rapidly changing climate conditions are characterized by increased frequency and intensity of extreme moisture events. With four of the top ten Assiniboine River floods and five of the top ten Red River floods all happening in the last twenty-five years, there is clear change afoot. This new reality impacts both our agricultural community on the farm level (e.g., crop losses, delayed farm practices) as well as other residents and regional activities (e.g., loss of lives, damaged infrastructure) as the effects of extreme moisture events usually extend beyond the time and place in which they occur. Excess water conditions occur when soil is unable to convey water, resulting in saturated conditions that are detrimental to topsoil and farm crops. There is runoff from the on-farm to the community downstream as the soil exceeds field capacity, and there is no on-farm excess moisture mitigating investment. Consequently, the effect of excess moisture can broadly be categorized into two: on-farm and community downstream effects. The effects of excess moisture on these two categories are different and this necessitated cataloging the different effects of excess moisture and ascertaining the kind and magnitude of the effects at on-farm and community downstream.

The ultimate purpose of the Phase 1 activity was to determine the impacts and costs of excess moisture on the farm and the community downstream by focusing on the 2011 Assiniboine flood in Manitoba. This led to developing a factsheet (Appendix A) that detailed the effects of excess moisture at the farm, local and regional levels. In Phase 1 of this project activity, RDI conducted research using publicly available resources to identify both the effects of excess moisture and quantify the downstream costs and benefits of excess moisture management. In particular, the research focused on the impacts and costs of 2011 Assiniboine River flood any subsequent investment following the flood. This flooding event caused extensive damage and revenue losses for farms and businesses, resulted in damaged public infrastructure, and had a significant effect on personal property, livelihoods, and general well-being. The first phase of the project assessed the downstream effects of excess moisture, identified direct and indirect losses, and evaluated the economic impact of excess moisture. The aim of the Phase 1 report is to provide a good guide for cataloguing the downstream effects of excess moisture.

Phase 2 aims to validate on the findings and outcomes of this activity executed in Phase 1 by assessing the accuracy of these finding and to solicit feedback on the relevance and usefulness to a range of different groups. To achieve this objective, RDI organized a series of surveys to receive feedback from targeted stakeholders and producers on the information. The overall goal of this report is to reconcile responses from stakeholders and producers on the thematic areas of the physical impacts of excess moisture/flooding, the economic impact of excess moisture, and the mitigation of excess moisture based on a structured factsheet on excess moisture (Appendix A). This assessment and solicitation of feedback through surveys of producers and stakeholders was necessary to highlight the presence and absence of key information on the factsheet provided through the farmers' and stakeholders' perspectives. Validating the accuracy and details of the Phase 1 report was essential to minimize any incorrect information. In the process of getting feedback from selected key informants, from stakeholders and producers about the factsheet, the validation allowed RDI to assess and probe how stakeholders and producers may use the findings of the Phase 1.

The main objectives of this research activity are to:

1. Validate (completeness and accuracy) the physical and socio-economic impacts of excess moisture identified in Phase 1
2. Assess the relevance and usefulness of the factsheet for producers and stakeholders
3. Identify other effects, outcomes, and strategies that producers and stakeholders considered in response to the 2011 Assiniboine River Flood

Research Design and Methods

Design

Phase 2 of this project applied a qualitative research design method using a multistage sampling procedure. It started with a purposeful selection of producers with operations in Southern Manitoba, mainly in the Assiniboine River Basin and secondarily in Manitoba's Red River Basin. The study targeted key participants representing agricultural/commodity groups or government officials (from rural or urban munic-ipalities) who are experts in the social, economic, or environmental effects and management of excess moisture events in Manitoba. In designing phase two of this research, RDI researchers had to consider the framework that best fits the study's objectives. Phase 2 Activity 3 used two research instruments. The first is a Factsheet on Downstream Effects due to the 2011 Flood Event (Appendix A); the second is a set of open-ended interview questions to access the factsheet's accuracy and completeness and identify other effects, factors, and strategies considered by producers or stakeholders in response to the 2011 Assiniboine River Flood. The qualitative research design was adopted over a quantitative design because it al-lowed the RDI research team to examine the producers and stakeholder experiences in managing excess moisture in detail using open-ended questions and in-depth interviews. The RDI team met with individuals across two broad categories, producers (1) agricultural/commodity organizations or agricultural producers, and (2) government leaders, academics, and economists. Each group was given a tailored set of survey questions.

Selection Criteria

The survey's inclusion criteria focused on whether participants represent agricultural/commodity groups or government officials (from rural or urban municipalities) who are experts in the social, economic, or environmental effects and management of excess moisture events in Manitoba. Participants with very similar areas of expertise in the social, economic, or environmental impacts and management of excess moisture events were excluded from the survey by the exclusion criteria. The survey targeted producers with operations in Southern Manitoba, mainly in the Assiniboine River Basin and secondarily in the Red River Basin, who have been involved in moisture mitigation efforts. Following the inclusion and exclusion requirements outlined, these organizations or stakeholders were asked to include names and contact details of those they think may be interested in the research project.

Characteristics of Survey Participants

Six interviews were done, consisting of two producers, two stakeholders, a farm extension specialist, and an academic. The participants are either representatives of agricultural/commodity groups or government officials (from rural or urban municipalities), producers, and experts in the social, economic, or environmental effects and management of excess moisture events in Manitoba.

Recruitment

The RDI research team identified the participants by engaging contacts of agricultural/commodity organizations and other stakeholder groups interested in managing excess moisture. Producers and other stakeholders (including producers, agricultural/commodity organizations, government leaders, academics, and economists) were chosen using a snowball sampling method that targeted experts in the social, economic, or environmental effects and management of excessive moisture events. The RDI team sent an Invitation to Participate in the study to the targeted experts. A summary of the data collection tasks, time commitment, protocol for providing informed consent, and data withdrawal to participate was included in the Invitation to Participate. If the RDI research team received a positive response by phone or email agreeing to participate in the interview, the RDI research team then sets a date and time for the interview. When a stakeholder or producer does not answer after two attempts, the RDI research team assumes they do not consent to participate and stops communicating with them.

Data Collection

Two research instruments were used in this study. The first is a Factsheet on Downstream Effects of the 2011 Flood Event (Appendix A); the second is a series of open-ended interview questions to determine the Factsheet's accuracy and completeness, as well as to identify other effects, causes, and strategies that producers and stakeholders considered in response to the 2011 Assiniboine River Flood. The factsheet of phase 1 cataloged and quantified the impact of the 2011 Manitoba floods at the on-farm and downstream community level. The factsheet summarizes excess moisture in Manitoba, including groundwater, eutrophication of Lake Winnipeg, land erosion, livestock, infrastructure, nutrients and chemicals, soil trafficability on the field, the yield of crops, among several others.

The two instruments were sent to the participants before the interview, and they were asked to provide input on the Factsheet on Downstream Effects of the 2011 Assiniboine River Flood and answers to interview questions and discussion topics. The participant was read the terms and conditions for In-formed Consent before the interview. A positive verbal consent was required before the interview could begin. Due to Covid-19 travel restrictions in Manitoba, the bulk of the interviews were conducted over the phone; however, two stakeholders were interviewed in person.

The key questions addressed during this survey are:

- Did we capture all the possible on-farm and downstream effects of the 2011 Assiniboine River flood?
- Which effects of the Assiniboine River flood were the most and least important to your organization or farm?
- Is the excess moisture factsheet on the 2011 Assiniboine River flood useful to your organization or farm?
- Are the dollar amounts of investment and loss allocated to the effects of the 2011 Assiniboine River flood realistic?
- Did your organization or farm benefit from any of the excess moisture mitigating investments after the 2011 Manitoba flood? What additional support do you need in the event of a flood?

Data Analysis and Reporting

Due to Covid-19 travel restrictions in Manitoba, most of the interviews were conducted over the phone; however, two stakeholders were interviewed in person. Before the interview, the factsheet was sent to the respondents to familiarize themselves with the factsheet information. The in-depth interviews were recorded using a phone recorder after permission was granted. The interviews were transcribed to prevent the RDI research team from losing key answers and information to important interview questions and capturing each detail for review later. The transcribed interview was subjected to a textual analysis, which involved reading the text systematically and repeatedly to establish consistent patterns and interconnections from the data in response to the research questions posed during the interview.

Because this study had a limited number of participants (six), focused on a single event (the 2011 Assiniboine River flood), and did not capture the full diversity of producers and stakeholders, this study serves as a preliminary assessment of user insight and reactions to the information presented on the fact-sheet and their experiences with the 2011 flood. However, this limited information may be valuable as an early indication of what information different participants may find relevant and how their experiences of the 2011 flood differed. Furthermore, this information will also serve as a starting point to better tailor and present information to different groups based on their role (e.g., producer or government), experienc-es with flooding, and the needs of their farm or organization

Results

To report on the responses of the individuals to the interview questions, the research findings focused on six thematic areas: 1) impacts of excess moisture; 2) relative importance of effects; 3) compensation values; 4) mitigating effects and securing/restoring investments; 5) experiences of farmers; and 6) usefulness of the factsheet.

Impacts of Excess Moisture

The 2011 Assiniboine River Flood is described as one of the worst modern floods experienced in Manitoba. Three out of the six respondents interviewed did not comment on the effect of excess moisture on yield. However, the remaining three respondents agreed with the downstream consequences of excess moisture, mainly focusing on how the flooding impacted soil erosion on farms and yield losses. One producer stated as follows:

> … *"As I said, there were also issues of erosion, damage caused to our fields, and so on."* Again, another producer stated, *"I spoke to the conservation district at the time about the issue of erosion along the field, the cost of repairing the damage where the erosion had been was just too astronomical. They would not look at it"*

The damages caused were mainly downstream and attributed to the intersection of the Assiniboine and the Souris rivers in the valleys. Concerning the effect of the floods on the farms downstream, the duration the water spent on land played a significant role in the destruction caused. These scenarios combined erosion and waterlogging in washing away crops and properties (fertilizers and equipment) and rendering farm properties useless for a specific period. One respondent specifically framed his response as follows:

> *"I think the biggest effect that a lot of producers were facing is how long the water stayed on the land, the damage done by the water whether being erosion or just the different cuts it made throughout the fields and economic, there was crop on the land when the floods came so that was an effect as well. A lot of yard site buildings, those types of things that were damaged that producers had to fix and just the overall work when you consider because there was a lot of diking and a lot of sandbagging, all that kind of stuff."*

Thus, necessitating interventions such as diking, sandbagging, relocation, and abandoning properties are the immediate measures adopted by farmers within the waters' reach. The effect of the floods also affect-ed some livestock producers. This was captured in one of the respondents statement:

> *"I have been working with livestock producers who also had lost field and hay lands because mostly hay lands are close to the rivers, so when the flooding comes, have you seen these soccer fields close to the number 1 street, they were much greener one month ago but when the rain came and water came, now they are all done, that's the thing, hay is a very short season, okay and so if you already have water in the spring and standing water for one month then all your hay is gone"*

These experiences from these 3 participants were documented on the factsheet, demonstrating a high degree of alignment of these survey responses to the flooding impacts identified in Phase 1 of this project. Furthermore, during the interview sessions, the five most important impacts of excess moisture on the factsheet were established. These included damage to infrastructure and soil erosion, reduced socio-eco-

nomic activity, loss of yields and income, nutrient losses, reduced soil trafficability, and shortage of live-stock feed were the most significant effects of excess moisture, according to five of the six respondents interviewed.

Relative Importance of Effects

Five out of the six respondents reflected on the most significant impact of excess moisture, but their responses were contradictory. According to one stakeholder, their organization was more concerned about waterlogging on downstream farms and how to minimize those incidents during floods. One stakeholder was also involved in paying compensations to farmers who have experienced excess moisture and so was more concerned about the compensation farmers received after the flooding. The economist provided updated references for some of the estimations in the factsheet, and the two producers were more concerned about the disaster financial assistance they received, and the damage caused to infrastructure and loss of yields. The remaining respondent did not comment of the relative importance of the effect of excess moisture.

The most important effect of excess water identified highlights the drainage of excess water on-farm to the community downstream. This effect is highly relevant as it can relieve the plight of a group of farmers, whereas compounding others' challenges at the downstream level. For example, whenever a farmer upstream manages his excess moisture from his field, and the other farmer downstream does not, the excess water leaves the latter's field and floods the former's field.

One producer captured his response as follows:

> *"Yes, well you know a lot of times, I guess the way the drainage is setup a farmer is not allowed to drain onto somebody else's land off your land"*

Thus, in order to drain water from one field, you would need a drainage permit. An official from the government office will come and approve so drainage can proceed because they realize that the excess water can flow onto another farmer's land, through another's land, and keep going. The same producer, in citing his frustrations stated that:

> *"So, for a farmer to say I am going to drain my land onto your land, legally is not possible. You would need a drainage permit and you wouldn't get a permit like that from the government if it's going to affect somebody else downstream".*

If such instances are not managed carefully, they can create relationship challenges among farmers.

Concerning the least important effects, the leaching of nutrients in the soil was observed to be the most prominent. However, the provision of nutrients to the soil through fertilization was critical to the restoration process. It was observed that a quarter of the yield was lost and it took 4-5 years to restore the yield. For example:

> *"The loss of nutrients, I think, was minimum. We lost a quarter of our yield and it took 4-5 years to get back to where our yield was."*

Another producer also had this to say about fertilizer loss at the farm level:

> *"Well a lot, it is hard to predict how much of flood will cause nutrients to leave the soil surface, percentage wise it is going to be very difficult to quantify. Products like Nitrogen or Sulphur will leach more than runoff,*

> *phosphate is the big one that cause algae blooms in Lake Winnipeg. So, when you get heavy rains phosphate will leave the land with moisture. So that will be the biggest concern with heavy rainfalls, floods and loss of nutrients"*

Therefore, it is important to recognize that on-farm losses are still being realized several years after the event. Further, it was indicated that multiple large events in quick succession may not allow producers to fully recover.

Compensation Values

Two of the respondents did not receive any compensation after the floods because they were not directly affected by excess moisture; however, four respondents did not know how much was paid in compensation to farmers because so many other considerations were taken into account, such as the size of insured land. The exact figures for the compensations offered were not adequately known by the survey respondents. However, it was estimated that an approximately $70-$80 per acre was issued to farmers through excess moisture insurance. Thus, the larger a farmers' farm, the more the compensation if the farmer has excess moisture insurance.

Mitigating Effects and Securing/Restoring Investments

According to all six stakeholders and producers interviewed, the downstream impacts of excess moisture and mitigation measures captured in the Phase 1 factsheet are detailed and reliable. However, one stakeholder recommended that the amount of pesticide and fertilizer losses be modified. A producer and an economist provided updated references and suggested some formatting done to the main report, so transcripts of these suggestions are not provided.

To prevent or lessen the effects of excess moisture due to floods in Manitoba, measures varied considerably based on individual farmers, the elevation of the farm, the proximity of farms to the river, and their previous experience with flooding. The majority of farmers with close proximity to the river had no other choice but to wait until the flood water has receded. However, farmers further from the river and its influence resorted to diking, sandbagging, and relocation of movable property and farm equipment. This observation agrees with information documented on the factsheet highlighting the provision of the diking mechanisms, moving homes, cottages, buildings, and businesses in communities such as Souris, Melta, Wawanesa, Winnipeg and Brandon in the bid to protect and preserve infrastructural property.

Additionally, the Manitoba Agricultural Services Corporation (MASC) was established to facili-tate crop insurance payments to eligible farmers in the case of any floods. The brief description of MASC is captured in the words of a stakeholder as follows:

> *"There was MASC, so that is crop insurance, so if the crops were planted and the flooding came then they will be eligible for the full crop insurance, but if the flood came before they planted it then it, they would get money not being able to seed that land because of excess moisture."*

Concomitantly, a compensation program through a disaster program instituted by the province was rolled out. However, the bureaucracies involved in accessing these interventions allowed victims to access mitigating measures years after the disaster. This finding is corroborated by the allocation of $45 million to the local disaster financial assistance program to aid business owners, homeowners and settle agricultural

claims captured in the factsheet. With respect to the farmers' expected mitigation measures, some of which have been implemented or at various stages of implementation, having experts on the ground to do first-hand feasibility of the situation both during and after the floods can prove crucial in the understanding of the plight of farmers and development of corresponding measures to alleviate the challenges. Furthermore, the practice of draining was identified to be a cost-effective means of dealing with excess moisture. However, the current effect of excess moisture was described as an improvement over previous encounters due to the effectiveness of previous years' interventions.

Further mitigation measures identified are insurance policies to cover farmers' yield. Although the information captured on the fact sheet highlighted the allocation of funds for insuring damaged farm produce and infrastructure, it was observed that insurance premiums disbursed to farmers after the disaster was inadequate. Specifically, the monies did not cover the infrastructural damages recorded. For instance, Souris's main bridge over the Assiniboine River collapsed after the floods and was never restored.

> *"It damaged our bridge, and it has never been replaced, so the bridge is no longer, so we now have to commute about 14km to get around to the other side of the river".*

Thus, farmers needed to commute and additional 14 km to get around to the other side of the river, which is a great inconvenience financially and physically. Despite the multiple allocations of funds for infrastructural rebuilding, several developments remain to be initiated to complete the restoration process.

Experiences of Farmers

Both producers shared their experiences with the 2011 Assiniboine floods in Manitoba. The effects of the excess moisture experienced by farmers in Manitoba highlight erosion, damage to fields and yields, and damage to infrastructure as the main issues. Although financial assistance was provided to farmers, its adequacy in mitigating the damages recorded is still debatable. The adequacy of the support given was in doubt when one of the producers was citing as follows:

> *"The financial support should be able to cover the damage on the field. The NDP government, at the time of the flooding, gave minimal support to us".*

Overwhelming the two producers respondents felt that the support from the provincial government gave to producers after the floods were inadequate. The other four respondents, not being producers, were intentionally not asked to comment on the experience of farmers.

Usefulness of the Factsheet

The information on the factsheet is described as good and informative by all the six respondents interviewed. Although further description by one of the respondents classifies this factsheet as an academic document, the material is highly relevant as reference material in validating and corroborating the discussions indulged. For example, the discussions revealed that livestock farmers lost their fields and hay lands located around the river. This vital information was captured as damage of feed for live-stock barns and store feed on the factsheet. Concomitantly, other effects of excess moisture and flooding in Manitoba have been clearly outlined, comprising on-farm downstream and community downstream, in conjunction with the respective intervention measures implemented to help alleviate the challenges well as the cost of those interventions. The usefulness of the factsheet described as follows:

> *"Ermmm, I think it a good one and a good source of more or less academic information."*

Also,

> *"Well, errrmmm, I think this is very comprehensive and covers pretty much all the effects common to flooding here in Manitoba."*

This suggests that the information collected as part of Phase 1 was of generally thought to be comprehensive, but the overall utility of the document, as a whole, is questionable, especially for producers and other individuals directly impacted by flooding.

Discussion

Soil erosion (on-farm impact) and infrastructure disruption (downstream impact) were the two most important direct impacts, according to the interviews. Infrastructure, such as roads and bridges, was destroyed during the flood, disrupting transportation networks throughout the affected areas. The Province covered most of the costs of restoring the damage caused by the flood through disaster financial aid. However, the assistance was insufficient to cover the full extent of the damage. According to the inter-views, the most significant intervention anticipated from producers following a flood is financial assistance to cover the damage caused by the floods on farms. Even though the Province's disaster financial assistance was available and open to farmers who had lost property due to flooding, it was critical to understand that the assistance was inadequate. The indirect impact of the flooding included loss of yields, nutrients and income; however, farmers who signed up for excess moisture insurance received compensation for their lost yields. By identifying the important direct and indirect impacts of flooding producers, stakeholders, and governments can have information they need to better target flood mitigation strategies and compensations. Lastly, it is important to recognize that the impacts of the 2011 flooding in Manitoba varied at the on-farm and downstream levels. Therefore, policy, investment, and decision making may be ineffective if broadly applied to both on-farm and downstream levels. In the future, more research is needed to see how farmers can minimize the effects of excess moisture on their farms and downstream. Producers should be able to choose from a range of excess moisture on-farm and downstream investment options, each with its own set of costs and benefits. This will ensure that farmers are proactive during ex-cess moisture events rather than waiting to receive compensation for damaged properties and crops that are woefully inadequate.

This survey demonstrated that the impacts of excess moisture and in particular the experiences surrounding the 2011 Assiniboine River flood varied across the different participants. For example, the producer survey respondents are directly and personally effected by excess moisture events and are responsible for mitigating the effects and losses (e.g., crop insurance) and making decisions and investments (e.g., subsurface drainage) to limit and prevent these impacts. Whereas other stakeholders not being directly impacted by excess moisture had a broader geographic scope of the issues surrounding excess moisture. This diversity in perspectives is further highlighted in the discussions surrounding the usefulness of the factsheets. The use of terms and phrases including "academic" and "covers pretty much every-thing" to describe the factsheet indicates that all the respondents found the factsheet factually correct and thorough, the comprehensive and detailed nature of the factsheets was found to be overwhelming and not all the information was deemed to be practical, or directly useful to every survey respondent. In fact, de-pending on the background of the survey respondent, (e.g., producer or stakeholder) different portions of the factsheet were found to be more relevant and useful than others. Overall, this preliminary assessment has identified that that information on the physical and socio-economic costs and mitigating investments of excess moisture identified in Phase 1 is useful but indicated that tailoring the information based on individual or group (e.g., producers vs commodity organizations) experiences and requirements, is needed to have a greater impact.

Conclusion

The purpose of the research was to validate the findings from Phase 1 activities and determine how best to respond to information needs of producers (on-farm) as well as downstream stakeholders to assist in informing their decisions about managing excess moisture, based on the Assiniboine River Ba-sin. The objectives of validating the impact of excess moisture, the direct and indirect costs of excess moisture, and its corresponding economic impacts were achieved. However, due to the COVID-19 pandemic, it was impossible to visit the producers' farms to have a firsthand experience of the effects of ex-cess moisture as described during the phone interviews.

This validation through surveys of producers and stakeholders highlights the presence and absence of key information on the factsheet provided through the farmers' and stakeholders' realities. Assessing the accuracy and details of the Phase 1 report was essential to minimize any misinformation and to identify missing components. The factsheet was validated to minimize the risk of producers and stake-holders making decisions on incomplete knowledge based on the factsheet that does not indicate the situation at hand. It was observed that key effects of excess moisture as a result of flood results in erosion, field damage, crop damage, livestock feed loss, fertilizer loss, loss of infrastructure. It was further observed that the factsheet validated the information provided by farmers and stakeholders whiles providing a more comprehensive list. Additionally, a number of funds provided farmers with insurance claims and restoration of property, although there were some elements of discontent on the part of farmers due to the payouts' perceived inadequacy. Lastly, physical measures such as drainage, diking and sandbagging were adopted by farmers to either prevent or lessen the effect of the flooding waters.

The next step of this research should focus on using these preliminary findings to produce more targeted communication of this information to producers and stakeholders managing excess moisture in Manitoba. Providing targeted, relevant, and concise information on the impacts of excess moisture in Manitoba to those who are directly or indirectly impacted will help them make informed decisions surrounding mitigating, and compensating for, the impacts of excess moisture. Furthermore, there should be further collaboration and continuous engagement between producers, stakeholders, and policy makers to understand further how best to respond to excess moisture issues in Manitoba by scaling up the research to cover more participants in the study area and expand to other river basins (e.g., Red River).

Appendix

Activity 3 Factsheet on Downstream Effects Due to the 2011 Assiniboine River Flood

Table 1: Downstream Effects due to the 2011 Assiniboine River Flood

Effects	On-farm downstream	Community downstream
Degradation of downstream land by surface water	On-farm excess moisture caused 600,000 acres of land to be unseeded. (MASC, 2011) Soil carbon losses in the range of 29–35%. (Jacinthe et al. 2004)	Destruction of community river dikes (Manitoba Flood Report, 2013)
Groundwater pollution	In the absence of subsurface drains, nitrate concentration will increase in the groundwater. Levels of nitrate above 10mg/l nitrifying ammonium, is estimated to cost City of Winnipeg $100 million (Schindler et al., 2012; Schubert et al., 1999)	Nitrate infiltration into groundwater can affect the quality of drinking water and pose a risk of severely low oxygen levels in infants (Spalding & Exner, 1993)
Soil erosion	Runoff water increases the amount of topsoil loss by a factor 10 on a 10% slope (Skaggs & Broadhead, 1982)	Damage to roads and bridges. 2011 floods of Manitoba damaged 650 roads and 600 bridges (Blais et al., 2015)
Damage to infrastructure, buildings, and machines	Damage to irrigation systems, buildings, machinery and equipment, and drainage systems (Thieken et al., 2009)	Damage to community infrastructure and private properties (MASC, 2011) Decrease of 2–5% of property value for all properties in the floodplain. (Braden & Johnston, 2004)

Effects	On-farm downstream	Community downstream
Nutrients and chemical losses and leaching	The farmer loses 51% - 62% of herbicide to surface runoff (Muir & Baker, 1976)	Phosphorus and nitrogen removal and denitrification by the City of Winnipeg has been estimated to cost $400 million (Schindler et. al., 2012)
Reduce soil trafficability	Reduction in optimum stocking rate by 0.6–0.9 cows/ha. Damage to fields by wheels can range in extent from 20 to 35% for each operation. (Tullberg, 2000; Fitzgerald et al., 2008)	Provision of bridges for affected communities (Manitoba Flood Report, 2013)
Loss in Yield	In 2011 excess moisture caused 73 % of the crop losses in Manitoba. (MASC, 2011)	N/A
Soil quality decline	Soil clogging	Waterlogging
Reduced socio-economic activity	Financial assistant to farmers in the flood zone (MASC, 2011)	Financial assistance to landowners and business owners in a flood zone (MASC, 2011)
Shortage of feed for livestock	Shortage in livestock feed due to excess moisture. $9,551, 000 paid to livestock producers (MASC, 2011)	Damage to livestock barns and Store feed (Flood Facts Sheet, 2017)

Table 2: 2011 Manitoba Excess Moisture Events and Mitigating Investments

Location on Assiniboine Basin	Impact of Excess Moisture	Downstream excess moisture mitigation Investment/impact	Level of impact	Amount of investment/ lost
Brandon	Damage to infrastructure	Provision of community diking.	Local	$27 million
Portage la Prairies	Damage to Infrastructure	Portage Diversion: assessment and upgrading	Local	$7.4 million
Winnipeg	Damage to Infrastructure	Winnipeg secondary ring dikes Petersfield Community dikes	Local Local	$10.4 million
Shellmouth	Damage to Infrastructure	Install gates on the spillway Wave Breaking Trial Program	Local	$8 million
Lake St. Martin	Damage to Infrastructure	Emergency channel to drain water to Lake Winnipeg	Regional	$100 million
Fairford	Damage to Infrastructure	A control bypass to draw down on Lake Manitoba	Local	$60 million
Souris, Melita, Wawanesa, Lake Manitoba Narrows, Peltz Drive/ St. Peter's Road	Damage to Infrastructure	Converting emergency dikes into permanent dikes	Regional	$20 million
Individual Flood Protection	Damage to Infrastructure	For raising, diking, terracing or moving homes, and farm and business buildings, cottages	Regional	$75 million
Disaster Financial Assistance	Reduce Socio-Economic Activity	Financial assistance to business owners, homeowners, and agricultural claims	Regional	$45 million
Manitoba Farms	Chemicals and Nutrients losses	Fertilizer (phosphorus) losses	Local	$9 million
Manitoba	Eutrophication of Lake Winnipeg	Nutrient loading to lakes	Regional	Denitrification cost $400 million

Location on Assiniboine Basin	Impact of Excess Moisture	Downstream excess moisture mitigation Investment/impact	Level of impact	Amount of investment/ lost
Manitoba	Groundwater pollution	Nitrate leaching into groundwater	Regional	Nitrate removal cost $100 million
Assiniboine Valley Producers Flood Assistance Program	Loss of yield	Provide Manitoba producers with financial assistance for yield losses	Regional	$1.5 million
Manitoba feed and transportation assistance program	Shortage of Livestock feed	Assist producers who had a shortage of overwinter feed for a breeding herd	Regional	$10 million
Manitoba Farms	Chemical and nutrient losses	Herbicide losses from farms	Local	$25.2 million
Manitoba farms	Reduce soil trafficability on field	Excess moisture Insurance program for 2.92 million acres unseeded agricultural land	Regional	$41.6 million
Building and Recovery Action Plan at Manitoba	Reduce Socio-economic activity	• Hoop and Holler Compensation • Property Tax Relief • Business Principal and Non-Principal Residence • Manitoba Pasture Flooding Assistance • Lake Manitoba Ag Infrastructure Transportation and Crop/ Forage Loss • Shoal Lakes Agriculture Flooding Assistance • Excess Moisture Economic Stimulus • Dauphin River Flood Assistance	Region-al	$175 million

Source: (Manitoba Flood Report, 2013; MASC, 2011; Schindler et. al., 2012; Water Quality Re-port, 2010; Muir and Baker, 1976; Government of Manitoba, 2014)

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