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# Irrigators' Vulnerability to Drought in the Flathead River Basin, Montana

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IRRIGATORS' VULNERABLITY TO DROUGHT IN THE FLATHEAD RIVER

BASIN, MONTANA

By

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Irrigators’ Vulnerability and Perceptions of Drought in the Flathead River Basin, Montana

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Irrigation has traditionally been used to buffer the effects of drought in agricultural communities. However, drought events can still lead to drought damage for irrigators by reducing irrigation water supplies, increasing crop water demand, and creating habitats for invasive pests and weeds. Further, drought will be increasingly problematic in irrigated areas as climate change continues to affect global climates and water resources. The Flathead River basin contains substantial areas of irrigated agriculture including the 128,000 acre Flathead Irrigation Project (FIP). The FIP is the largest irrigation project in Montana as well as the largest of the 16 Bureau of Indian Affairs (BIA) federal irrigation projects.

This thesis explores the drought experiences of irrigators in the Flathead River basin using a case study approach. Eighteen semi-structured interviews were conducted with irrigators in the basin and then analyzed using content analysis. Themes from this analysis were then explored in order to understand how irrigators are vulnerable to drought.

Findings show that drought for irrigators in the Flathead River basin is a complex phenomenon. It is physically constructed of processes affecting both long-term water availability and short-term growing season dryness. Additionally, institutional arrangements affecting water management and the economic marginalization of the agriculturalist lifestyle have led to drought vulnerabilities for some irrigators in the basin. These findings illustrate how the political economy of irrigation and agriculture are contributing to drought impacts and drought hazard in the Flathead River basin.

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# CHAPTER 1 - INTRODUCTION

This chapter provides an introduction to the problem of drought and irrigation in both the United States and the Flathead River basin, Montana. It also specifically outlines the four research questions that are the focus of this thesis. Lastly, it provides an outline of the thesis and an overview of each chapter.

## Problem Statement/Purpose of the Study

Despite advancements in drought monitoring, prediction, and planning, drought damage in the United States continues to rise. In fact, one estimate puts the total financial cost of drought impacts in the United States from 2000-2007 at more than $4 trillion, which is more than any decadal total for the time period 1970-2000 (Kallis 2008).

While drought can affect all sectors of society, its effect on farm and ranch operators is particularly significant as the livelihoods of agriculturalists are tied directly to drought conditions. In regards to drought and agriculture, irrigation has primarily been perceived as a tool that reduces drought impacts (Wilhelmi and Wilhite 2002). This conceptualization of drought and irrigation has led to an incomplete understanding of how drought affects irrigators, and there has been limited research on irrigation related drought impacts and drought vulnerability in the United States.

Experience from the developing world has shown that irrigators are not immune to drought. For example, irrigators in the African Sahel, who were using water from irrigation projects created during the relative wet period of the early 1900s, suffered from tremendous famine when conditions became much more dry in the 1980s (Olsson 1993). While the relatively high standard of living in the United States makes drought impacts of this magnitude unlikely, this example indicates that an assumption that irrigators in the United States cannot be affected by drought may be spurious.

The lack of research on drought and irrigation is of particular concern as the International Panel on Climate Change's (IPCC) fourth assessment report notes that increasing competition for water resources coupled with future climate change is likely to increase the occurrence of irrigation related drought impacts, especially in snow and glacier fed river basins. Specifically, the report notes that, "Of all sectoral water demands, the irrigation sector will be affected most strongly by climate change…" (Kundzewicz et al. 2007, 192).

Reducing drought impacts for irrigators is an important part of minimizing future drought damage in United States, especially in light of a changing climate. Further, reducing impacts will rely on an understanding of irrigators' vulnerabilities to drought. Vulnerability is a function of physical exposure; the social, economic, and political processes that affect how households access resources; and the decisions that households make in order to reduce impacts (Burton et al. 1978; Cutter 1996; Wisner et al. 2004).

In this thesis, a case study approach is used to examine the drought experiences of irrigators in the Flathead River basin of northwestern Montana, in the United States, in order to explore if and how they are vulnerable to drought and how that vulnerability is changing over time. The Flathead River basin is a glacier and snow fed watershed that is prone to periodic episodes of physical drought conditions. Since irrigation began at the turn of the 20$^{th}$ century, irrigators have experienced both a changing environment and a changing society. Understanding drought vulnerability and how it is changing through time will not only provide valuable information that can be used to reduce future drought impacts in the Flathead River basin, but also add to the body of literature regarding drought and irrigation in the United States.

## **Research Questions**

To explore irrigators' vulnerability to drought in the Flathead River basin and how that vulnerability has changed through time, I employ four primary research questions. These include:

- How have irrigators in the Flathead River basin experienced drought?
- How do these experiences relate to drought vulnerability?
- How have irrigators adapted to drought through time?
- How have those adaptations affected drought vulnerability?

## **Thesis Outline**

The next chapter in this thesis is a review of the relevant literature regarding vulnerability, hazard perception and behavior, and drought. This thesis draws largely from the social sciences in order to conceptualize what it means for a population or group to be vulnerable. Further, adaptation and adjustment are explored in order to explain how people can purposely reduce their vulnerability to hazards. Lastly, hazard perception and behavior are examined in order to understand how individuals make decisions in the face of environmental hazards.

Chapter 3 provides an overview of the Flathead River basin study area. The physical, social, and hydro-political context of drought and irrigation in the basin are examined in order to outline the context for the research.

Chapter 4 describes the methodology employed in this study. This study makes use of a qualitative methodology to examine drought vulnerability in the Flathead River basin. The primary data source is 18 semi-structured interviews that were conducted with irrigators in four different areas of the basin. These interviews were coded for both manifest and latent content in order to identify important themes relating to the research questions.

Chapter 5 presents the results that emerged from the content analysis of the irrigator interviews. Themes relating to the characteristics of the interviewees, their experiences with drought, and the contextual economic and policy/management issues affecting their livelihoods are reported.

Chapter 6 discusses the results presented in Chapter 5 in relation to the four research questions proposed in this study. This discussion also draws from the literature review presented in Chapter 2 in order to examine the themes reported in Chapter 5 and build on existing theory.

Chapter 7 concludes the thesis by examining the implications of the findings presented in Chapter 6. Additionally, the limitations of the study are acknowledged and future areas of research are highlighted.

# CHAPTER 2 – LITERATURE REVIEW

In this literature review I explore the theoretical foundations of both hazard vulnerability and hazard perception research. Vulnerability theory has developed largely from the work in the geographic risk-hazard tradition. However, the fields of human dimensions of global change and political ecology have made more recent contributions. This thesis also seeks to explain how vulnerability is changing through time by exploring the role of irrigator adaptation strategies. The adoption of strategies in order to avoid damages is to a large extent influenced by hazard perception. Hazard perception theory has been greatly influenced by research in both geography and environmental psychology. These contributions are explored in this literature review. Lastly, this literature review explores both the concept of drought and empirical research used in its study.

## Hazard Vulnerability

At a broad level, vulnerability represents a potential for loss or damage (Eakin and Leurs 2006). However, a more precise definition is rarely agreed upon due to the converging theoretical frameworks that have been used in its study (see Cutter 1996; Eakin and Luers 2006; Fussel 2007). This section of the literature review explores several aspects of vulnerability theory in order to come to a more complete conceptualization of what it means to be vulnerable. It also examines the role of purposeful adaptation and adjustment to hazards and how this affects vulnerability over time.

**The Geographic Risk Hazard Tradition**

In the traditional hazard paradigm, natural disasters were viewed as physical events, thus requiring modification of the physical environment to ensure protection (Smith 1996). Geographers, working from what has become known as the risk-hazard perspective, challenged this viewpoint by arguing that disasters were actually the product of human and environment interactions and that disasters could be prevented not only by suppression of the physical environment but through the modification of human behavior (White 1974; Burton et al. 1978).

This argument was based on the observation that although the frequency of natural disasters had remained relatively constant, the amount of damage had increased. Further, the cause of increased damage was seen to lie in two factors: 1) human occupancy in places that were prone to environmental extremes had increased, and 2) these populations were becoming more susceptible to extreme variations in environmental conditions. Burton et al (1978, 215) noted: “A more nearly satisfactory explanation for the increasing disaster vulnerability of both developed and developing nations is yielded by the view that nature is neutral, and that the environment event becomes hazardous only when it intersects with man.”

These observations led to a new conceptualization of natural hazards where the actual hazard itself “represents the potential interaction between humans and extreme natural events” (Tobin and Montz 1997, 5). Embedded within this perspective is the idea that the vulnerability of a given system (i.e., household, group, place), or the potential for loss, can be realized as a function of both exposure and sensitivity. Here, exposure refers to a range of hazard specific environmental parameters that include magnitude, frequency, duration, areal extent, speed of onset, spatial dispersion, and temporal spacing (i.e., random vs. non-random). In this perspective, sensitivity refers to the socioeconomic attributes of the exposed human system, and an individual's ability to make decisions that limit loss (Burton et al. 1978).

**Adaptation and Adjustment**

Geographers working with the risk-hazard perspective have historically used the terms adaptation and adjustment in order to explain how people respond to hazards (White 1974; Burton et al. 1978). These responses are important because they have the potential to alter a society's vulnerability to extreme environmental conditions and increase their absorptive capacity. Here, absorptive capacity refers to the extent to which a society remains unaffected by deviations in mean environmental conditions (Burton et al. 1978, 206). In other words, a society that is less vulnerable has a higher absorptive capacity. Following White and Haas (1975, 5) and a geographic risk-hazard interpretation, an adaptation refers to "a long-term arrangement of activity to take account of the threat of natural extremes" and an adjustment refers to "all those intentional actions which are taken to cope with the risk and uncertainty of natural events."

A key distinction here is the temporal dimension of the response. For example, Smucker and Wisner (2008) identified over 70 adjustments that farmers in Thakara, Kenya had adopted over a thirty-year period in order to cope with drought (i.e. collect wild food, sell cattle). While the farmers had developed many short-term adjustments, they had done little to adapt any long-term strategies. In contrast, Whebe et al. (2006) found that farmers in Mexico and Argentina had developed several adaptation strategies in response to drought that varied from crop timing and the diversification of income, to the adoption of crop insurance (Table 2.1). As a general guideline, "livelihoods that have a broader range of short-term responses [adjustments] and a greater long-range recovery capability [adaptations] are less vulnerable" (Vasquez-Leon 2003 et al., 160).

**The Range of Response**

Hazard responses (adjustments and adaptations) can take on many different forms. Smith (1996, 78) groups these responses into three general categories: modify the loss burden, modify the hazard event, or modify human vulnerability. To this classification, the response of "do nothing" or "bear the loss" should also be added, as taking no preemptive or reactionary measure is always an option (Burton et al. 1978; Tobin and Montz 1997). Modifying the loss burden is essentially loss sharing through the use of insurance or disaster aid. Modifying the event includes activities that adjust the event to people. This group of adjustments is predominantly made up of modifications to the environment (i.e., reservoirs, levees). Modifying human vulnerability refers to purposeful decision making that is aimed at altering human behavior, or reducing the sensitivity of a system to a given hazard. This is the widest range of hazard response and can include modification of land use (e.g., land use planning, land use change), hazard preparedness plans, and even an outright change of location.

**Table 2.1 Examples of Adaptations and Adjustments**

| Adaptations (Whebe et al. 2006) | Adjustments (Smucker and Wisner 2007) |
| --- | --- |
| Adjustment of planting dates and crop variety | Move livestock |
| Accumulation of commodity stocks as economic reserve | Ask for family help |
| Spatially separated plots for cropping and grazing to diversify exposure | Ask for help from government |
| Diversification of income by adding livestock operations | Hunt or fish |
| Set-up/provision of crop insurance | Collect bush food |
| Creation of local financial pools | Sell livestock |
| | Sell firewood |
| | Sell handicrafts |
| | Engage in local wage labor |
| | Out migration in search of wage labor |
| | Work for food locally |

As noted above, hazard response in the dominant hazard paradigm is focused on adjusting the environment to humans. While these responses reduced vulnerability for many, White (1945) and other early risk-hazard geographers pointed out that society should not rely solely on these modifications to protect humans from natural hazards. This argument, in part, rests on the fact that modifications to the environment are based on probabilistic calculations of risk. Further, these calculations are based on a less than full understanding of physical processes and cannot take into account future changes in social systems (Sarewitz et al. 2003). One only needs to examine the aftermath of hurricane Katrina to see the hubris in thinking that levees alone would be adequate to withstand a hurricane hazard in the $21^{st}$ century in Louisiana (Elliot and Pais 2006).

Modifications of the environment also can also give a “false” sense of security. White et al. (1945) famously illustrated this point by showing how structural modifications (e.g., levees, dams) in the United States had actually increased flood damages as they had encouraged people to move into floodplains. When these protective measures were overwhelmed, the damages were more catastrophic, thus leading to an overall increase in flood damage in the United States.

There is no special recipe for identifying what response is “best,” as the effect of a response on vulnerability and absorptive capacity is highly contextual to the hazard event and society in which it occurs. For example, Burton et al. (1978) noted: “the absorptive capacity may be smaller for a modern industrial state than for a traditional society because the technology used is more subject to disruption. Conversely, the wealth of an industrial society may serve to increase its absorptive capacity.” However, it is commonly agreed that a middle of the road approach, where decisions are made in a sustainable manner, can be considered a good starting point (Turner II et al. 2003; Smith 1996). While an in-depth discussion of sustainability is not within the scope of this thesis, I refer to the process here broadly as “Meeting fundamental human needs while preserving the life-support systems of planet Earth” (Kates et al. 2001).

**Dynamic Vulnerability**

Traditionally, the study of hazards and vulnerability within the risk hazard framework consisted of case studies involving disaster events and the assessment of the adaptation and adjustments taken (White 1974). While, these studies provided valuable insight into hazard response and vulnerability, they rarely gave more than a snapshot view.

More recently, a dynamic conceptualization of vulnerability has been emphasized, especially within the human dimensions of global change literature (Eakin and Luers 2006). This field, which focuses predominately on the implications of climate change, emphasizes the study of environmental change over space and time in order to understand the trajectory of vulnerability in coupled human and environment systems (Adger 2006; Smit and Wandel 2006). The importance of this perspective is that it is forward looking and attempts not only to understand how vulnerability is manifested in current situations, but how its presence can be attenuated in the future.

One aspect of this research has been the focus on how adjustments and adaptations evolve over time. It has been found that people do not only adjust or adapt once, but make a series of decisions that incrementally work to increase absorptive capacity and reduce vulnerability. For example, Liu et al. (2008) identified three interconnected temporal strategies that farmers used from 1991 to 2000 in response to low flows on the Huang He (Yellow River) in China. Farmers in the river basin first adjusted to low flows by selectively irrigating farmland. Next, farmers sought to increase water supply through structural adaptations including groundwater exploration and the development of reservoirs and canals. Finally, moving away from structural adaptations, the farmers developed adaptation strategies that included the introduction of drought resistant crops and crop diversification. These results showed how, over time, decision making moved from short-term adjustments to more sustainable long-term adaptation strategies.

Another important aspect of this dynamic perspective is a focus on the changing context of vulnerability. As both the environment and society change through time, a society's vulnerability and absorptive capacity change as well. For example, Mortimore (2010) identified 12 key transformations in the African Sahel that took place from 1960-1990 that worked simultaneously to both create and reduce vulnerability to drought. These included changes in rural land use, growth in the agriculture service markets, and the destabilization of the pastoral system. While unsustainable rural land use and the destabilization of the pastoral system worked to increase the vulnerability of the traditionally pastoralist community, growth in the agricultural service sector simultaneously provided an opportunity for farmers to earn off-farm wages and become less susceptible to fluctuations in environmental conditions. This illustrates the dynamic nature of human and environment systems as they are constantly changing thus constantly altering a society's vulnerability to hazards. Commonly, and somewhat confusingly, this process is also termed "adaptation" in the human dimensions of global change literature as the entire human and environment system is thought to adapt over time. However, for the purpose of this thesis this process will be referred to as the "changing context" of vulnerability and the term adaptation, as noted above, will be used to define purposeful long-term change at the household level made by individuals (see Adger 2006 and Smit and Wandel 2006 for further discussion).

**The Political Economy Perspective**

The political economy perspective has added to vulnerability research by emphasizing the role of institutional forces in creating differential vulnerability. This approach was essentially a Marxist interpretation of disaster that sought to reduce damage through the redistribution of power and wealth in society in order to provide better access to resources. Fundamentally, it rejected traditional hazard reduction frameworks that relied on the application of science and technology to control nature (Smith 1996, 49).

The political economy perspective views the vulnerability of an individual or group as a process that limits access to resources and constrains livelihoods (Adger and Kelly 2001; Wisner et al. 2004). In this way, vulnerability is not viewed merely in relation to a hazard, but as an *a priori* process working within a system (Fussel and Klein 2006). This approach is highly influenced by the field of sustainable livelihoods and development. The application of this perspective in hazard research is based on the idea that people who have a more sustainable livelihood also have a better baseline capacity to withstand extreme environmental conditions (Cannon et al. 2002).

To define vulnerability within this context Wisner et al. (2004) described an access model that examined both social relations and structures of dominance. Here, social relations refer to the flow of goods from one actor to another. If this flow of resources is diminished, livelihoods are impaired and the ability of an individual or household to cope with hazardous conditions is reduced. Additionally, Wisner et al. (2004, 87) note that "goods" can entail the following types of resources:

- Human capital (skills, knowledge, health, and energy)
- Social capital (networks, groups, institutions)
- Physical capital (infrastructure, technology and equipment)
- Financial capital (savings, credit)
- Natural capital (natural resources, land, water, fauna and flora)

In this model, the flow of goods among individuals is not entirely within an individual actors' control. Structures of dominance, which refer to the politics of relations between individuals at different levels, can often determine who has access to these goods. For instance, globalization has increased wealth and the standard of living for many people around the world while simultaneously increasing inequality and diminishing access to resources for others. This, in turn, has marginalized many individuals and groups and subsequently increased vulnerability in areas where people have no control over globalization policies (O'Brien and Leichenko 2000; Pelling and Uitto 2001).

Adger and Kelly (2001, 20) similarly argue that an architecture of entitlements can control how resources are distributed. The use of entitlements in this context refers to society's determination of an individual's access to resources. This theory argues that entitlements are affected by social, political, and economic structures that are largely beyond an individual's control. For example, Adger (1999) found that market liberalization policies had increased income inequality and the incidence of poverty in Vietnam's coastal Xuan Thuy. In turn, this increased vulnerability to climate change by "concentrating the resources of a population in fewer hands, thereby constraining entitlements for use and disposal of assets under coping strategies in times of stress" (Adger 1999, 266).

This perspective often sees the ability of an individual to adapt in order to reduce vulnerability as minimal. Brooks (2003) notes that an individual cannot often change the social, political, and economic processes that work to create vulnerability. Further, the individuals who are the most vulnerable are often the most removed from positions of power that have influence over these processes.

## Hazard Perception

Hazard perceptions are important for understanding how individuals place themselves in their environment, understand threats, and make protective decisions. Slovic (1987) notes: "The ability to sense and avoid harmful environmental conditions is necessary for the survival of all living organisms… Humans have an additional capability that allows them to alter their environment as well as respond to it. This capacity both creates and reduces risk." This section of the literature review explores the geographic, psychological, and political economy aspects of hazard perception theory.

### Expected Utility and Bounded Rationality

Expected utility theory, first introduced by Nicholas Bernoulli in 1713, is a useful normative framework for understanding decision-making. Under this theory an individual makes a rational decision by assessing all possible outcomes and maximizing the benefits. In the real world, empirical research has shown that decision-making process rarely follows this model. Burton et al. (1978) summarized years of observational studies in hazard research and proposed that peoples' decision making in the face of hazards has often been done using a "bounded rationality."

In this theory, it is thought that individual decision-making is based on a subjective perception of the world and not the expected utility of a given decision. For instance, a scientist examining crop yields may see a farm decision, which was perceived to be perfectly rational from the perspective of the farmer, as inefficient or irrational. There may be many reasons that help to explain this farmer's decision: perhaps the farmer did not have information that the scientist had, or perhaps the farmer had speculated that farming will no longer be viable and invested capital in a non-farm venture. In either one of these possible scenarios the farmer would be making decisions using a bounded rationality that is based on his or her perception of the world. Burton et al. (1978, 52) notes: "It is rare indeed that individuals have access to full information in appraising either natural events or alternative courses of action. Even if they were to have such information, they would have goals quite different than maximizing the expected utility."

**Situational Factors**

Working from the idea of bounded rationality, geographers in the risk-hazard tradition have examined situational factors and their influence on perceptions in order to explain subsequent decision-making. Situational factors can include both the physical environment and socioeconomic status. Experience with hazards and the physical attributes of that hazard (i.e. frequency, magnitude, and onset) have been observed to be significant factors in hazard perception (Burton et al. 1978; Tobin and Montz 1997). For example, Tobin and Montz (1997, 151) note that unless floods are experienced relatively often and damages are high, people may not take actions to adequately protect themselves.

Socioeconomic factors can also play a role in hazard perception. Tobin and Montz (1997, 155) use the example of age in explaining this area of perception: "the elderly and infirm are generally less able to undertake any major moving of possessions in the event of a flood or hurricane. Race, ethnicity, and gender affect different patterns of behavior, which while not necessarily causal, nevertheless point to other concerns." The last portion of this statement must be emphasized. While situational factors help to explain the experiences of individuals, they should not be viewed as causes. For this reason, situational factors should only be examined as a portion of the perception process. Further, portraying them as causal would border on environmental determinism and even racism.

**Cognitive Heuristics**

Cognitive heuristics can be thought of as mental "tools" that help people make decisions. Heuristics can be helpful in bridging the gap between situational factors and perception. This field was pioneered by the psychologists Tversky and Kahneman (1974) who introduced the representativeness, availability, and adjustment and anchoring heuristics. Since then, several other heuristics have been proposed. In the hazard literature, this has included both the optimism and finite pool of worry heuristics.

*Representativeness*

Representativeness alludes to the phenomenon of attributing a probability to an event based on how much it represents another event. Tversky and Kahneman (1974, 1124) explain this heuristic by using a description of “Steve”. “Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality.” In the representativeness heuristic, the probability of Steve’s profession being a librarian (given the choices of several other professions) is thought to be highest because his characteristics most represent that of a stereotypical librarian. In reference to hazards, the representativeness heuristic has been shown to influence the perception of patterns in hazardous events. People may be more likely to observe drought or flood patterns as cycles when their actual probability of occurring is random (Burton et al. 1978).

*Availability*

The availability heuristic represents a bias in judgments of probability where perceptions are effected by how easily retrievable information and experiences are. Easily retrievable events are perceived to occur at higher probabilities. This can be affected by both the frequency and recency of an experience. Additionally, perception was found to vary with the type of experiences available. Experiences that were learned were perceived to be more probable than experiences that were merely described (Hertwig et al 2004). For example, Brody et al. (2008) found that perceptions of climate change were well correlated with locations where the effects of climate change were more salient (i.e. low lying coastal areas). This result supports the availability heuristic, as perceived risks were higher in places where climate change experiences were more readily available.

*Anchoring and Adjustment*

The anchoring and adjustment heuristic can be described as “anchoring” judgments on one piece of information and failing to fully adjust the judgment when new information is provided. This heuristic is often evident when somebody makes an initial judgment using incomplete information and additional information fails to adjust the original judgment enough to where it is compatible with new information. In regards to hazards, this heuristic has been empirically observed in hazard forecasting scenarios. For example, Nicholls (1999) observed the anchoring and adjustment heuristic at work during drought forecasting in Australia: “In Australia, the prevalence of media stories relating El Niño to serious drought (e.g., the 1982/83 situation) now produces a public expectation that any predicted El Niño will lead to severe drought everywhere in eastern Australia. The public are likely to be surprised if an El Niño does not lead to a severe drought, or if a drought occurs without an El Niño. Yet both of these have happened in the past.” Nicholls goes on to note that incomplete public knowledge regarding the relationship between El Niño cycles and drought have partially attributed to the anchoring of drought risk perceptions on 1982/83 drought experiences.

*Optimism*

The optimism heuristic proposes that, while people may perceive hazard risks at different levels, they almost always perceive themselves to be at less risk than their peers. This has real implication for hazard preparedness as Weinstein (1989, 246) notes: "Optimistic biases in personal risk perceptions are important because they may seriously hinder efforts to promote risk reducing behaviors." Further, this heuristic has been observed empirically in a natural hazard context as Costa-Font et al. (2009) found that individuals consistently perceived their personal climate change risk to be much lower than society's collective risk.

*Finite Pool of Worry*

Another proposed heuristic is the finite pool of worry heuristic (Hansen et al. 2004; Marx et al. 2007). This heuristic refers to the concept of only having a limited "pool" of risks to worry about. This heuristic posits that, as perceived risk from one set of potential sources increases, the perception of other risk decreases. Hansen et al. (2004) illustrated the finite pool of worry heuristic using a scenario building experiment with Argentinean farmers. When the farmers were introduced to a hypothetical increase in climate change risk, their perception of political risk declined even though a change in political risk had not been suggested.

**Culture and Society**

Another concept in hazard perception has been the idea that society and culture influence how an individual makes decisions. This view attributes perception to cultural biases which in turn effect which risks are acceptable, which risks to avoid, and the fairness of the distribution of risk across a society (Pidgeon 2008, 352). Geographers have long been interested in this concept as a tool for explaining perception. Burton and Kates (1962, 412) noted: “To the Englishman on his island, earthquakes are disasters that happen to others. It is recognized that ‘while the ground is liable to open up at any moment beneath the feet of foreigners, the English are safe because it can’t happen here.’ Thus is described a not uncommon attitude to natural hazards in England; its parallels are universal.”

More recent work regarding the effect of society on perception has been centered on the Social Amplification of Risk (SAR) framework. The SAR framework refers to the process of risk being compounded through social processes (Kasperson et al. 1988). The significance of this theory lies in its integration of sociocultural and cognitive factors in understanding how risk is perceived and communicated. The main argument presented by Kasperson et al. (1988, 182) is that “Risk events interact with psychological, social, and cultural processes in ways that can heighten or attenuate public perceptions of risk and related risk behavior.”

Borrowing from communication theory, the SAR model uses “signals” to explain how risk is affected by socio-cultural factors. Signals can be thought of as a radio signal that people in society are able to “tune in” to. For example, an event such as a train wreck, which happens in a familiar and understood fashion, is not likely to cause social impacts beyond those incurred by the victims and their families. In comparison, an event such as a nuclear reactor malfunction is more likely to cause widespread social impacts such as industry and governmental reform. The signal, or the spread of information regarding risk, sent out by the nuclear reactor malfunction is thought to be much larger than the train wreck even though the immediate and direct impacts (loss of life) are much less (Slovic 1987).

The SAR model presents a holistic view of understanding risk perception. In this model risk perceptions are not only a viewed as a function of an individual's ability to cognitively process the probability of events, but also society's ability to communicate risk. According to Kasperson et al. (1988) the key steps in risk amplification are:

- Filtering and decoding signals
- Processing risk information (heuristics)
- Attaching social value to the information
- Interacting with ones culture and peer groups to validate signals
- Formulating behavioral intentions to tolerate or take actions in response to risk
- Engaging in group or individual actions to accept tolerate or ignore the risk.

**Political Economy**

The political economy perspective on perception and behavior is philosophically different than perspectives reviewed above. In this perspective people may perceive hazards as dangerous, but access to resources can restrict their ability to engage in impact reducing behavior (Wisner et al. 2004). For example, Gaillard (2008) found that although individuals located at the base of Mt. Pinatubo in the Philippines perceived themselves to be at significant risk of volcanic eruption, there was little action taken to protect themselves during a 1991 eruption. This was due, in part, to the residents' abilities to access the necessary resources needed in order to relocate or take preventative measures during the eruption. Government policy during previous eruptions had reduced farmland in the area in order to build re-settlement communities. This lack of access to traditional farm livelihoods had created a community that was characterized by high poverty levels and widespread unemployment. In turn, this had diminished the ability of residents to properly respond to volcanic threats as their daily life was focused primarily on reducing their economic and social hardship and away from hazard reduction activities.

## Drought Research

A drought can be defined conceptually as "any unusually dry period which results in a shortage of water" (Smith 1996, 287). However, this definition is inherently broad as the concept of drought varies greatly depending on both the unit of analysis and the definition of "usual." More specifically, Kallis (2006, 87) argues that a drought largely depends on the following factors:

- Precipitation intensity and frequency
- Precipitation timing
- Spatial distribution of precipitation in relation to water resource demands
- Hydro-environmental factors such as soil, reservoir, snowpack, and aquifer storage
- Water uses (i.e. farming and municipal needs differ in the timing and quantity of water necessary to avoid drought.)

Moving from a broad conceptual definition of drought to a more operational definition is not easy due to the difficulty that arises in making generalized assumptions about drought characteristics. However, Wilhite and Glanz (1985) attempted to facilitate this process by introducing a typology of drought that included four major drought types. These included meteorological, agricultural, hydrologic, and socioeconomic drought. Further, the National Drought Mitigation Center (NDMC) (2006) links these drought types together in a progression of drought framework that explains aspects of drought are related over time (Figure 2.1).

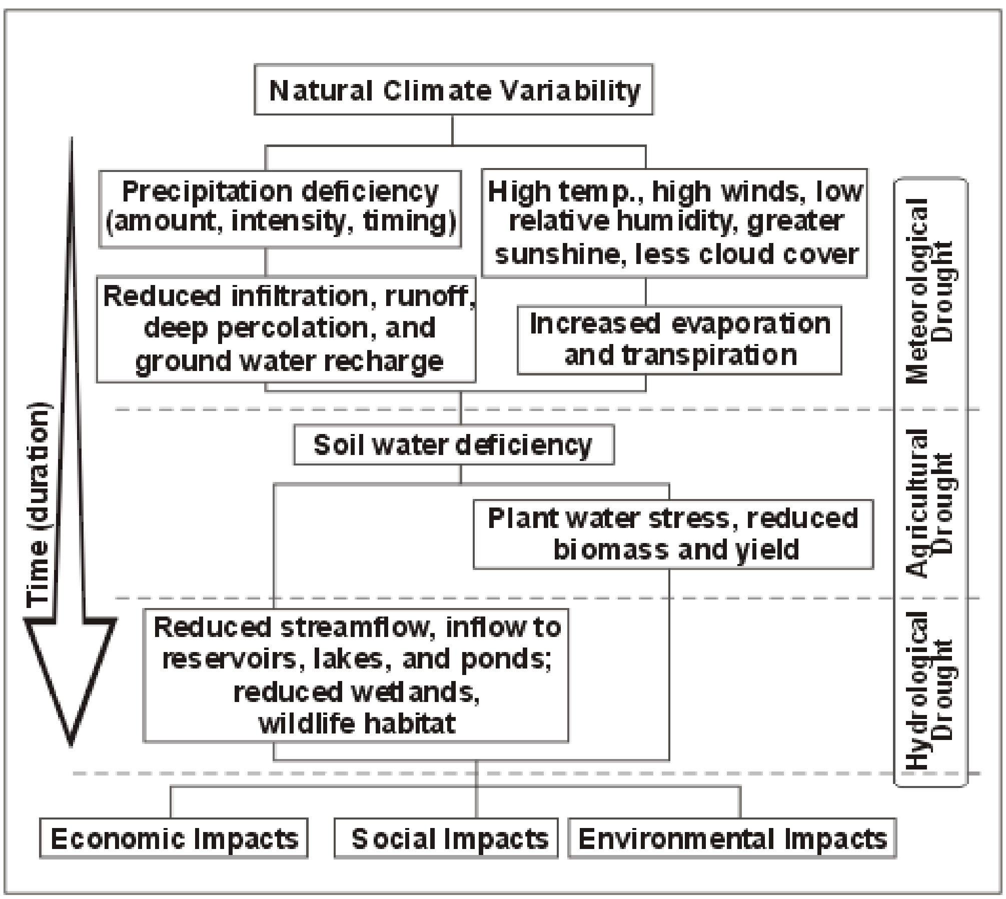


**Figure 2.1 NDMC Progression of Drought Framework (Source: National Drought Mitigation Center 2006)**

In the progression of drought framework, the root causes of drought are extremes in natural climate variability. At the most basic level, these extremes can be seen as meteorological drought. Meteorological drought can be thought of as the level of physical dryness and is a function of climatic variables such as temperature, precipitation, and wind.

Moving through the progression, agricultural drought refers to the effect of meteorological drought on agriculture. More specifically, agricultural drought can be thought of as a measure of crop water supply and demand. Crop water demand, in simple terms, is the amount of soil moisture a crop needs to maximize growth. This demand varies depending on evapotranspiration rates. Evapotranspiration is the combined effect of evaporation and plant transpiration and is a function of heat, humidity, and wind. In this sense, agricultural drought occurs when crop water demand is high (high evapotranspiration rates) and crop water supply is low (low precipitation).

Hydrological drought refers to the effect of meteorological drought on hydrologic functions such as stream flow, lake, and reservoir levels. Hydrological drought is usually out of phase with meteorological or agricultural drought, as it takes much longer for abnormally dry conditions to affect hydrologic processes like lake levels as compared to crop water demand.

In the end, drought can cause social, economic, and environmental impacts. The affect of these impacts on human systems can be referred to as socioeconomic drought. This type of drought occurs when the demand for water as an economic good outweighs water supply.

**Measuring drought**

A large portion of drought research has focused on measuring drought. This process, in general, attempts to normalize long-term atmospheric data (i.e., precipitation and temperature) and describe drought severity as a function of deviation from the mean. The rationale behind this research is that if the physical properties of drought are known then drought occurrences can be detected and predicted. Additionally, the benefit of a standard drought metric is that it allows for a universal comparison of drought events. Comparing droughts allows for the allocation of resources to the high priority drought areas. One of the first and most widely used drought indices developed was the Palmer Drought Severity Index or PDSI (Palmer 1965). This index uses meteorological variables that effect both precipitation and soil moisture.

In recent years, many additional drought indices have been developed including variations to the original PDSI. There is still much debate over the merits of particular drought indices and in which context they are the most appropriate (Alley 1984; Heim 2002). However, a multi-index approach, which is utilized by the U.S. Drought Monitor at the University of Nebraska-Lincoln, has more recently been noted as an innovative and useful approach (Steinemann and Cavalcanti 2006). The U.S. Drought Monitor, often considered at the forefront of drought assessment, uses an Objective Blend of Drought Indicators (OBDI) index to monitor drought (Svboda et al. 2002). The OBDI uses a weighted average of the PDSI, a crop soil moisture index, and a 30-day precipitation anomaly index.

## Drought and Climate Change

Drought, as a function of climatic abnormalities, is ultimately tied to climate change. Given this, much attention has been given to future droughts and the effects of climate change on these. Research from the Intergovernmental Panel on Climate Change (IPCC) notes that drought will increasingly become a problem especially in semi-arid snow and glacier fed regions (Wang 2005; Barnett et al. 2005; Kundzewicz et al 2007). Estimates of future drought conditions from global circulation models (GCMs) show that there will be an overall increase in drought affected areas as temperature, precipitation variability, and water consumption patterns increase (Easterling et al. 2000; Burke et al. 2006).

## Drought Vulnerability and Perception

As noted above, the thrust of drought research has focused on measuring drought. However, these measurements only take into consideration droughts physical dimensions. In this regard, the human dimension of drought, or socioeconomic drought as it is termed above, has been relatively neglected. This is a fundamental problem as most relevant drought impacts have a human component. Kallis (2006, 87) notes: "Natural scientists frame the social dimensions of drought into a black box called 'socioeconomic drought,' i.e., droughts that impact some social good/function. But in a sense all droughts that we humans care about are socioeconomic." However, as the study of hazards has become increasingly influenced by vulnerability studies, research on the human dimensions of drought has become more prevalent.

The literature on drought vulnerability is dominated by case studies involving drought in the developing world (Eriksen et al. 2005; Smucker and Wisner 2007; Brondizo and Moran 2008). Specifically, widespread drought in the African Sahel, which began in the 1960's, spurred particular interest due to the extreme famine and disaster that it caused (Glanz 1976; Wisner 1977). For example, Smith (1996, 300-304) attributes impacts from the Sahel drought to damaging social, economic, and political processes. The need for governments to export earnings put pressure on agriculturalists to grow cash crops instead of more traditional drought resistant crops (i.e., millet, sorghum). In addition, national governments increasingly legislated against nomadism and attempted to settle pastoralists. This strained agricultural resources and eroded traditional emergency aid systems that were based on inter-household gifts and loans.

In contrast, examinations of drought vulnerability in the developed world have been sparse. This is undoubtedly due to the disparity in potential drought impacts between developed and developing nations. While drought can cause enormous financial damage in the developed world (i.e., $38 million in the 1988 western U.S. Drought see National Climatic Data Center 2003), it rarely ever causes famine or death.

Additionally, drought in irrigated areas is even less well documented. As irrigation is often used as a tool to reduce the impacts of drought, there has been little motivation to understand how drought impacts this sector of agriculture. However, Liverman (1990) suggests that irrigation can potentially increase the chances of catastrophic drought impacts when supplemental water resources, such as stored surface water, become scarce or non-existent. For instance irrigation projects created in the

African Sahel during the relative wet period of the early 1900s collapsed during periods of long term drought in the 1980s (Olsson 1993).

In contrast to drought vulnerability research in the United States, drought and climate change perception research has been given slightly more attention. For example, Diggs (1991) conducted a comprehensive study of drought perceptions on the Great Plains. He found that while over 60% of farmers reported incurring financial loss due to a severe 1988 drought, less than 45% reported being "damaged" by the drought event. Additionally, less than a third of the farmers reported making adjustments to farm management and no more than 15% reported that they intend to respond any differently during future droughts. In terms of climate change, drought experience did not prove to initiate concern, but it did tend to solidify perceptions of its certainty.

More recently, both Finan et al. (2002) and Vasquez-Leon et al. (2003) found that farmers' perceptions of climate change vulnerability in Arizona were relatively non-existent. Further, Vasquez-Leon et al. compared the perceptions of Arizona farmers to Mexican farmers located directly across the border who were exposed to a similar climate profile. The Mexican farmers, partially due to their lower socioeconomic status, perceived themselves to be more vulnerable to climate change than their United States counterparts. Both Finan et al. and Vasquez-Leon et al. noted that the Arizona farmers seemed to have successfully "buffered" themselves. Here, buffering refers to the "dynamic interaction of technology adjustment and social restructuring that links public policy, social institutions, and private decision-making in such a way that rural residents perceive that climate risk has been reduced to the point where they may no longer see themselves as vulnerable to climate variability" (Vasquez-Leon et al. 2003, 161). In other words, their interactions with nature, resource use, wealth, and technology has led to the perception of nature being conquered. This perception does not always denote a less vulnerable population and can actually become detrimental. Bryant et al. (2000, 194) notes that, while Canadian farmers perceive their vulnerability to climatic variation to be low, “the frequent and widespread crop losses and economic hardship associated with other-than-normal climatic conditions, and the ongoing need for public relief and compensation suggest the agricultural sector is not as well adapted to temporal variations and uncertainties in climate as often claimed.”

## Conclusion

The literature review presented here provides a theoretical background for understanding vulnerability and hazard perception. Additionally, it reviewed the concept of drought and highlighted empirical research associated with its study. The research presented in this thesis will not only draw from this literature but also extend the existing knowledge base in these fields of study.

# CHAPTER 3 – STUDY AREA

This chapter first provides a description of land and water use in the Flathead River basin study area. This includes a general overview of the basin, its settlement and irrigation history, the characteristics of the irrigation community, and the extent of surface water resources in the basin. Next, the basin's climate and drought history are examined by exploring the basin's climate patterns, history of drought conditions, and the effect of climate change on drought. Lastly, the hydro-politics of the basin are discussed in order to provide information on irrigation water management in the basin.

## Land and Water Use in the Flathead River Basin

The Flathead River basin is located in the northwest of Montana and contains 5.4 million acres, 195,247 of which are covered with water. While a small portion of the basin is located in British Columbia, Canada, it contains little irrigated agriculture. The context and themes of this thesis relate only to the United States' portion of the Flathead River basin. Furthermore, this thesis will herein refer to the United States portion of the basin as the Flathead River basin (Figure 3.1).

The Flathead River basin contains Lake County, the majority of Flathead county, and small portions of Sanders, Missoula, Powell, Lincoln, and Lewis and Clark counties. In total, Lake and Flathead counties make up 79% of the basin. The basin also contains the Flathead Indian Reservation. This reservation was created by the 1855 Hellgate treaty and is governed by the Confederated Salish and Kootenai Tribes (CSKT). The Reservation covers 1,244,940 acres, most of which are located in Lake County.

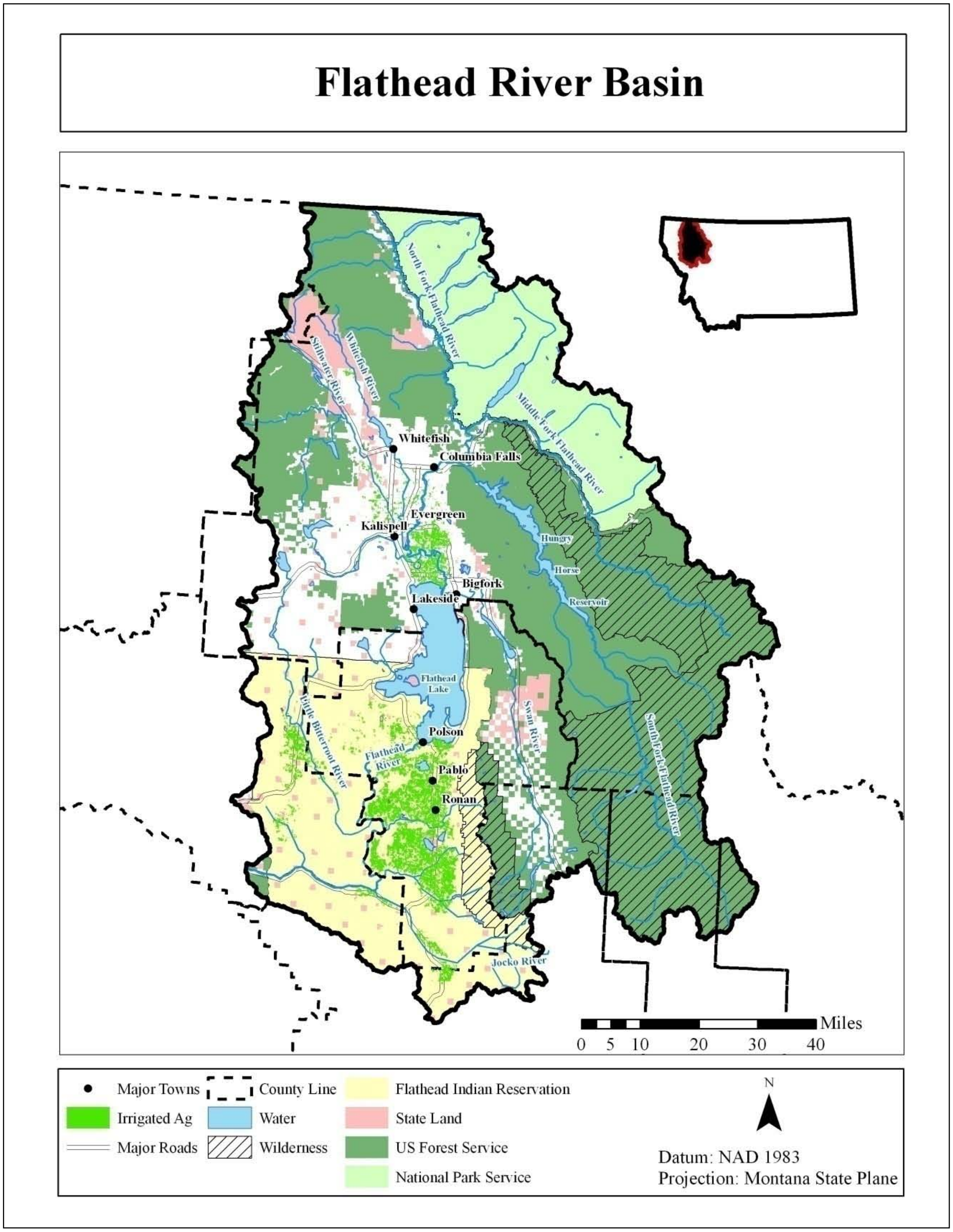


**Figure 3.1 The Flathead River Basin**

The majority of the land in the basin is publicly owned. Glacier National Park, located in the basin's northeast corner, was established in 1910 and is managed by the National Park Service. The basin also contains the Mission Mountain Wilderness Area and portions of the Bob Marshall and Great Bear Wilderness Areas. Additional federal lands in the basin are comprised of the Flathead National Forest and Lewis and Clark National Forest. On the state level, the Department of Natural Resources (DNRC) and Montana Fish Wildlife and Parks (FWP) also manage significant areas of basin (Montana Department of Natural Resources and Conservation 1976, 5-6).

**Settlement and Irrigation**

The Flathead River basin is the traditional home of the Kootenai, and Salish (Flathead and Pend Oreille) Indians. White influence began in the basin with the signing of the Treaty of Hellgate (1855) and the subsequent creation of the Flathead Indian Reservation. However, significant white settlement of the basin did not occur until the early 20$^{th}$ century when homesteaders began moving to the Flathead Indian Reservation due to the *Flathead Indian Allotment Act* (1904). The *Flathead Indian Allotment Act* was the application of the *Dawes General Allotment Act* (1887) on the Flathead Indian Reservation. The *Dawes General Allotment Act* allowed for the survey of reservation lands and subsequent allotment of trust land as private property to tribal members. This left surplus, or non-trust, land to be settled by the general public.

After the Department of the Interior had surveyed the reservation and distributed 80 and 160 acre parcels to the tribal population, white settlement began. White homesteaders flocked to the reservation to purchase unalloted land. Cheap land and the potential for irrigation were extremely desirable at the time. The *Flathead Indian Allotment Act* provided for the construction of irrigation ditches. While these ditches were originally proposed to benefit the tribal population, it soon became apparent that irrigation would greatly benefit new homesteaders as well. Initial plans for the Flathead Indian Irrigation Project (or FIP - this project is more commonly referred to as the Flathead Irrigation Project) soon developed out of this need and in 1938 construction of the 127,000 acre FIP was eventually finished (Cahoon 2005, 82-89). This period of FIP development constitutes the majority of irrigation development in the southern portion of the Flathead River basin.

As compared to white settlement on the FIP, settlement north of Flathead Lake in Flathead County occurred at a slower rate. Early agricultural development consisted mostly of dry land farming although limited irrigation did occur. By the 1950s the traditional natural resource based economy of Flathead County began to shift towards a service based economy (U.S. Bureau of Reclamation 1951, 10-13). From 1950-2000 both population and non-agricultural development have increased rapidly in Flathead County (Table 3.1). During this same time period irrigation development has also increased, as it has become a way for agriculturalists in Flathead County to increase profitability amid increasing economic and development pressure.

**Table 3.1 Population in Lake and Flathead Counties 1930-2000**

| | 1930 | 1940 | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|---|---|
| Flathead County | 19200 | 24271 | 31495 | 32965 | 39460 | 51966 | 59218 | 74471 |
| Lake County | 9541 | 13490 | 14285 | 13104 | 14445 | 19056 | 21041 | 26507 |

*Source:* Montana Population of Counties by Decennial Census: 1900 to 1990 (U.S. Census Bureau 1995); 2000 Census of Population (U.S. Census Bureau 2000).

### Irrigation Characteristics

Irrigation in the basin is located in two primary areas. In Lake County, the FIP located on the Flathead Indian Reservation is one major irrigation area. The other major irrigation area in the basin is located above Flathead Lake in Flathead County. The table below (Table 3.2) shows the characteristics of these two agricultural areas. These characteristics are largely a product of the basin's settlement history. In Lake County, where there has historically been more irrigation development due to the FIP, irrigated farms make up 66% of total farms as compared to only 26% in Flathead County. Additionally, irrigated farms in Lake County are smaller and the proportion of irrigated land is higher relative to total farm size. This reflects relatively higher dependence on irrigation that irrigators on the FIP have historically had in comparison to Flathead County irrigators.

**Table 3.2 Irrigation and Agriculture in Lake and Flathead Counties**

| | Lake County | Flathead County |
|---|---|---|
| No. of Farms | 1,280 | 1,094 |
| No. of Irrigated Farms | 846 | 289 |
| Avg. Size Irrigated Farms (ac) | 367.78 | 441.70 |
| Avg. Land Irrigated Per Farm (ac) | 101.09 | 80.55 |

*Source:* U.S. Census of Agriculture (U.S. Department of Agriculture 2007).

### Surface Water Resources

The Flathead River basin is the most northeastern basin located within the United States' portion of the Columbia River watershed. The basin is a mountain watershed, meaning most surface flows originate from winter snowpack. The basin's tributaries start collecting snowpack runoff in the late spring and summer and deliver it to the major branches of the river systems at lower elevations. Peak runoffs typically occur in late May and early June. Surface water is the primary source of irrigation water in the basin. It makes up 87% of the irrigation water used in Flathead County and 99% of the irrigation water used in Lake County. By sector, irrigation in Flathead and Lake County accounts for 79% and 99% of all water use (U.S. Geological Survey 2005).

The Flathead River basin discharges 8.5 million acre-feet (ac-ft) of water per year into the Clark Fork River. The North, Middle, and South Forks of the Flathead River system all contribute major surface flows. However, the Whitefish, Stillwater, Swan, Little Bitterroot, and Jocko drainage areas all produce additional significant flows. The basin also contains over 450 lakes including the 126,000 acre Flathead Lake.

Several dams exist in the basin including the Hungry Horse dam, Kerr dam, and 16 smaller dams used to store water for the FIP. Hungry Horse dam impounds the South Fork of the Flathead River creating Hungry Horse reservoir; Hungry Horse reservoir is the largest body of water, by volume, in the basin at 3,468,000 ac-ft, 2,982,000 ac-ft of which are considered active storage. Hungry Horse dam was constructed in 1953 by the U.S. Bureau of Reclamation and is utilized for flood control and hydroelectric production. Kerr dam is located on the Flathead River just south of Polson. The dam produces hydroelectric power and regulates the level of Flathead lake to a minimum level of 2893 feet, putting the storage capacity of the lake at approximately 1,826,000 ac-ft (Montana Department of Natural Resources and Conservation 1976, 5).

The FIP maintains a system of 15 dams with reservoir storage capacity totaling 157,500 ac-ft (Figure 3.2). The FIP also operates several pumping stations, the most significant of which is located below the Kerr dam on the Flathead River. This pumping plant consists of three 3,000 hp pumps that can lift water at 339 cfs. With 1300 miles of canals and laterals, the FIP has the capacity to serve water to more than 127,000 acres of land to the Flathead, Mission, and Jocko Irrigation Districts (Bureau of Indian Affairs 1991, 1-23). It is worth noting that these districts are not hydrologically homogenous. The Flathead Irrigation District is actually made up of two distinct hydrologic sub basins. The main portion of the district, located in the Mission valley below Flathead Lake, is served by project reservoirs that collect water from the Mission mountains to the east. In contrast, the Camas area, which is also part of the Flathead Irrigation District, receives its water from reservoirs that collect from a catchment area located west of Flathead Lake.

## **Climate and Drought**

Precipitation in the valleys of the Flathead River basin, where irrigated agriculture is located, varies from about 15 to 20 inches annually. Ample precipitation in excess of 80 inches annually can occur in the mountainous areas of the basin. These mountainous catchment areas provide runoff that is utilized heavily for irrigation within the Flathead River basin (Montana Department of Natural Resources and Conservation 1976, 10). Temperatures typically peak in August where the mean monthly high temperature is around 80 °F. The coldest month is January where the mean monthly high temperature is around 30 °F (National Weather Service 2010).

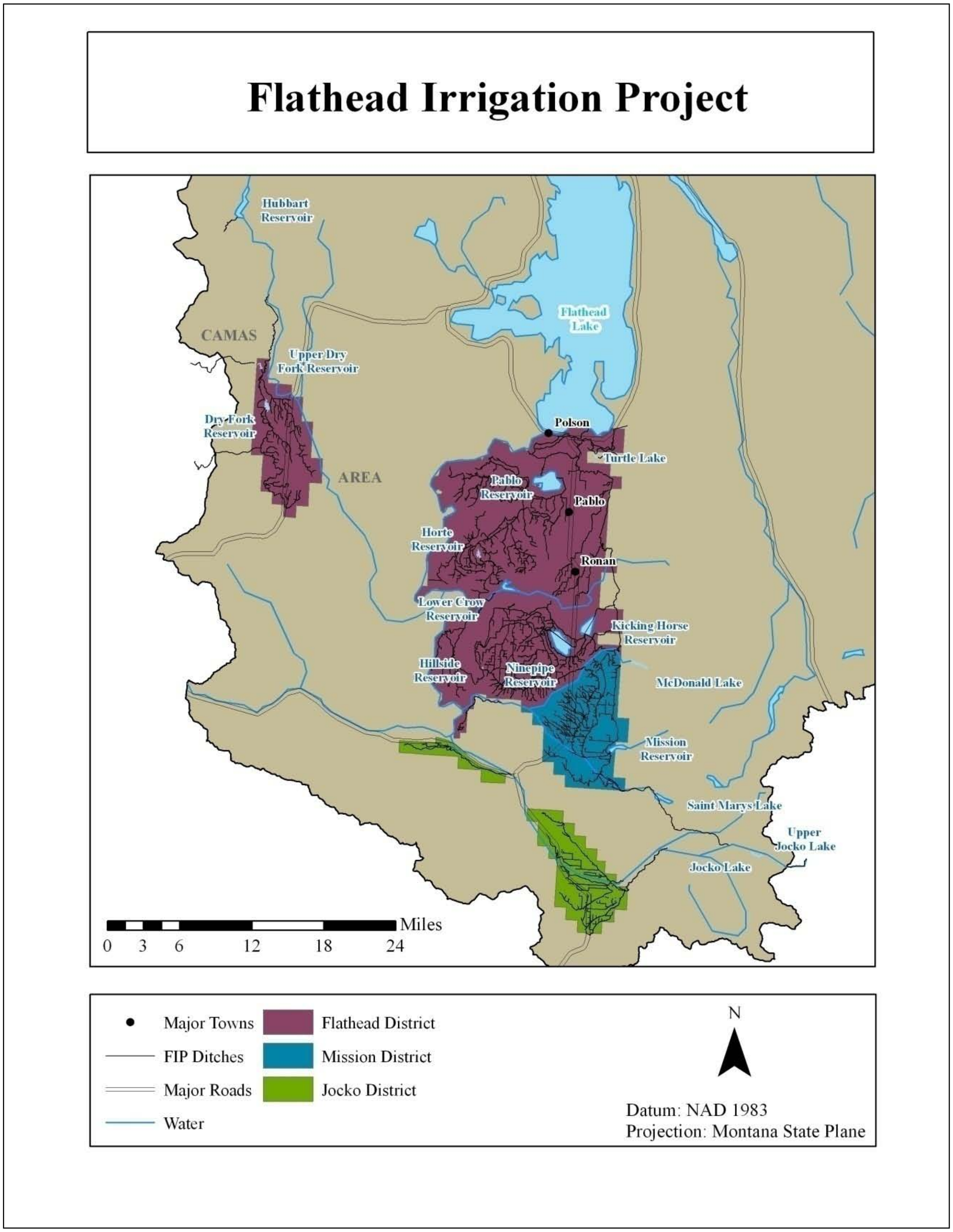


**Figure 3.2 The Flathead Irrigation Project**

**Drought**

Drought conditions are a reoccurring phenomenon in the Flathead River basin. Figure 3.3, which shows monthly Palmer Drought Severity Index (PSDI) values for the western Montana climate region, indicates that western Montana has experienced several periods of significant drought conditions from 1980 to 2010 (National Climatic Data Center 2010). Specific periods of note include 1985, 1988, 1992, 1994, and 2000-2004. It should be noted that these drought conditions are not synonymous with irrigator drought impacts as there are limited data available linking physical drought characteristics, which indices like the PSDI measure, to drought damage incurred by irrigators in the Flathead River basin. However, this drought index data are nonetheless important as they portray the variations in climate that irrigators in the Flathead River basin have experienced over time.

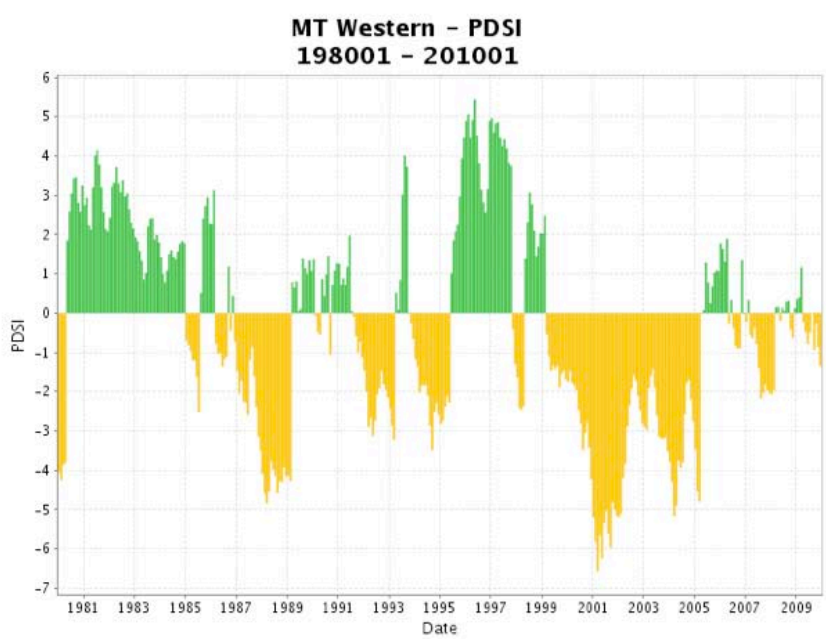


**Figure 3.3 Western Montana Palmer Drought Severity Index (PDSI) 1980-2010 (Source: National Climatic Data Center 2010)**

**Climate Change**

Climate data in the Flathead River basin dates back, at the earliest, to the turn of the $20^{th}$ century. To understand how climate change has affected drought conditions in the basin it is important to put drought in an even greater historical context. A paleoclimatic reconstruction of drought conditions on the northern plains indicates that, for several periods before AD 1200, drought conditions were both more intense and more frequent (Laird et al. 1994). This shows that, given a climatic history of several thousand years, drought conditions in the Flathead River basin may not be near their extreme.

Additional research on climate change in the Flathead River basin has focused on an examination of surface water resources. This type of research is particularly pertinent to irrigation and drought in the basin as surface water is the basin's major source of irrigation water. Recent research shows that winter snowpack in the western United States is decreasing due to increasing temperatures (Hamlet et al. 2005; Mote et al. 2005). Further, streams in the Columbia River basin, which the Flathead River basin is part of, have seen increasingly early runoff patterns as well as increased variability in runoff volume (Jain et al. 2005; Moore et al. 2007; Luce and Holden 2009). Specifically in reference to the Flathead River basin, Moore et al. (2007) found that the median flow from 1951-2005 for the Flathead River at West Glacier has shifted 9 days earlier.

## Hydro-Politics

The hydro-political landscape of the Flathead River basin is complex due to the multiple institutional arrangements affecting the management of water resources and the current uncertainty of water rights. In Montana, water resources are under the jurisdiction of the state. Currently, all state water rights are going through an adjudication process where rights are being quantified and accounted for in order to provide for a more accurate and enforceable water right system. Additionally, the CSKT are currently negotiating a still unquantified, and potentially large, reserved water right to which they are legally entitled. Adding to this complexity, water on the FIP has been historically managed under a unique institutional arrangement where the Bureau of Indian Affairs (BIA), a federal agency, manages water that serves primarily non-tribal water users.

**State Water Rights, Prior Appropriation, and Adjudication**

The state water right system in Montana is based on the doctrine of prior appropriation. Prior appropriation is a common water law framework in the western United States that is built upon a hierarchical water use system. In this system, water rights are given priority based on the adage, "first in time, first in right." This means that whoever develops a water right first along a stream course gets the highest priority water right. In times of scarcity, water is appropriated to the most senior user first and then sequentially distributed in order of priority (Getches 1990, 75).

Water rights in Montana are defined as "the right to use water as documented by a claim to an existing right, a permit, a certificate of water right, a state water reservation, or a compact," and are administered by the DNRC (MCA § 85-2-422). Historically, Montana water rights were established in one of two ways. Montanans could either post notice of a water right with a county clerk or simply divert water and put it to a beneficial use. However, no centralized system was ever developed to maintain water right records until the *Montana Water Use Act* (1973). This act required all pre July 1, 1973 water rights to be "finalized" and any new water rights to go through a water right permitting process with the DNRC.

The motivation for this largely centered around the uncertainty, both legally and physically, of water resources in Montana and the state's desire to quantify its resources. Ultimately, in 1979, the Montana State Legislature mandated that all water rights established prior to July 1, 1973, must be filed with the state as claims by April, 1982, in order to be later evaluated and considered legal and enforceable. This deadline was later extended to July 1, 1996, by the 1993 Montana state legislature. The process of evaluating state water claims, known as adjudication, and resolving conflicts falls under the jurisdiction of the state water court. The water court is also responsible for issuing preliminary, temporary, and then final water right decrees on a basin-by-basin basis where adjudication is complete (Upper Clark Fork River Basin Steering Committee 2004; Montana University System Water Center 2006, 1-14).

The Flathead River basin is made up of five "basin" units that the state is using in the water right adjudication process. As of November 20, 2009, the examination of water right claims in the basin units that contain the Flathead River basin's agricultural centers is still underway (Montana Department of Natural Resources and Conservation 2009). While the examination of these claims will help move the adjudication process along, a final decree will not be issued until the CSKT federal reserved tribal water right is quantified. This process is pursuant to current compact negotiations between the State of Montana and the CSKT of the Flathead Indian Reservation.

**Federal Reserved Tribal Water Rights**

Federal reserved tribal water rights stem from the Supreme Court case *Winters v. United States* (1908). The case involved a dispute between irrigators, who had diverted a portion of the Milk River from above the Fort Belknap reservation in Montana, and the tribes of the Fort Belknap reservation who wanted to put to use the same water. The decision read "the power of the government to reserve the waters and exempt them from appropriation under state law is not denied and could not be" (Winters v. Untied States 1908). This decision affirmed the existence of a federal reserved tribal water right for reservations. Further, these "reserved" rights were implicit in the creation of reservations and not subject to existing state water right law.

Federal reserved tribal water rights differ fundamentally from prior appropriation rights in that, initially, they did not require beneficial use or necessarily represent a quantifiable amount. This difference in prior appropriation water rights and federal reserved tribal rights has caused a serious resource management problem. Disputes over water resources could often not be resolved when federal reserved water rights were involved due to their unquantified nature. Beginning with *Arizona v. California* (1963) litigation became the main avenue for physically quantifying and resolving conflicts surrounding federal reserved tribal water rights. Due to time, money, and constraints on tribal sovereignty, litigation has been noted for its inability to efficiently resolve conflict over federal reserved tribal water rights (Folk-Williams 1988).

Partially due to the constraints of litigation, the Montana legislature created the Reserved Water Rights Compact Commission in 1979 (RWRCC) to negotiate the quantification of federal reserved tribal water rights with the tribes whose reservations are within the states borders. The legislative intent of the RWRCC is to "conclude compacts for the equitable division and apportionment of waters between the state and its people and the several Indian tribes claiming reserved water rights within the state" (MCA § 85-2-701).

Official compact negotiations began between the RWRCC and the CSKT of the Flathead Indian Reservation in 2001. An original proposal by the CSKT was rejected by the state later that year and negotiations on an interim water agreement ensued. In 2003, negotiations on the interim water agreement were called off. Compact negotiations resumed again in 2007 and a draft ordinance was released on September 23, 2008 (Reserved Water Rights Compact Commission 2008).

The current negotiations revolve around both management and water supply issues. On the supply end, releasing water from Hungry Horse reservoir to specifically supply tribal water needs is currently being proposed. In regard to the management of water on the Flathead Reservation, the State and the CSKT are currently trying to develop a management agreement that would entail both CSKT and State oversight of water rights.

**Flathead Irrigation Project Management**

While the management of the FIP has been the responsibility of the BIA since its construction, considerable conflict over the nature of this institutional arrangement did not climax until the 1980s. Since then, considerable concern by both irrigators on the FIP, and the CSKT, arose over how the project should be managed. It should be noted that this conflict has significant implications on livelihoods, Tribal sovereignty, and natural resources. In no way does this thesis attempt to judge the legitimacy of any stakeholder motivations. However, the nature of this conflict plays an important role in understanding the context in which irrigators in the basin are experiencing drought.

The conflict over BIA management is rooted deeply within the history of the FIP. In 1926, Congress realized that irrigators on non-trust lands were not making payments on project construction debts. In turn, it mandated the creation of Flathead, Mission, and Jocko Irrigation Districts to facilitate the re-payment of construction debts from irrigators farming on non-trust land. These districts were further organized under the Flathead Joint Board of Control (FJBC), which is now the entity responsible for organizing payments to the BIA.

In the Department of the Interior's 1985 report detailing a comprehensive review of the FIP, it is noted that the BIA had improperly allowed the FJBC to intervene in project management. At this time the FJBC and BIA were working closely together to the point where a distinction between the two entities was almost non-existent. This relationship was fostered by the fact that the FJBC represented irrigators whose non-trust land had come to make up 90% of the total land served by the FIP (U.S. Government Accountability Office 2006, 9). This relationship constituted a serious conflict of interest for the BIA that is mandated to protect Indian trust resources.

In reaction to this finding, the BIA reorganized the management structure of the FIP, in order to remove FJBC influence over FIP management decisions. On the coattails of this decision the BIA also began to implement new instream flow requirements. These flow requirements mandated that FIP streams and canals be kept at minimum levels for bull trout (*Salvelinus confluentus*) habitat. For irrigators, this new management structure and regulations posed a serious threat to irrigation water availability.

These events were a complete reversal of the FIP management status quo. Further, the looming adjudication of state and tribal water rights introduced uncertainty in the future of water resources in the basin for irrigation. Initially, the FJBC attempted to challenge the new management framework through litigation, most of which proved to be unsuccessful. While many of these attempts at litigation were later abandoned, one avenue of legal recourse that FJBC continued to pursue was the idea of project turnover. This concept dates back to a stipulation in a 1908 amendment to the Flathead Allotment Act. The “turnover” stipulation read:

> When the payments required by this act have been made for the major part of the unalloted lands irrigable under any system and subject to charge for construction therof, the management and operation of such irrigation works shall pass to the owners of the land irrigated thereby, to be maintained at their expense under such form of organization and under such rules and regulations as many be acceptable to the secretary of the interior (U.S Senate 2000, 8).

Originally, project turnover from the BIA to the FJBC was proposed. However, this FJBC proposal faced several obstacles. The CSKT fundamentally rejected project turnover to the FJBC because it would allocate tribal resources to a non-tribal entity. Further, there was considerable uncertainty in the status of the project’s construction debts and when and how turnover would occur. Ultimately such a turnover would have had to gain the approval of the federal government and the BIA. This was also unlikely to occur without the support of both the CSKT and the FJBC (Barrett 1984, 11-20; U.S. Senate 2000, 1-23).

In 2008, project turnover became more of a reality as the CSKT and the FJBC began to work collaboratively in order to form a Cooperative Management Entity (CME) that would serve as the entity that FIP management would be transferred too. This CME arrangement consists of both CSKT and FJBC members sitting together on a management board. While this would allow for increased control over project management for the FJBC, it would also allow for CSKT oversight, thus ensuring that tribal needs are met. In April, 2010 this plan received backing from the Department of Interior and transfer of project management to the CME was approved. It should be noted that irrigator interviews for this thesis were conducted before the CME was approved.

# CHAPTER 4 - METHODOLOGY

This chapter first provides an overview of the qualitative methodology used to examine irrigators' vulnerability to drought in the Flathead River basin. Next, the irrigator interview method is described. This includes an overview of the sampling procedure utilized in this study and the analytical methods that were employed. Lastly, sources of supplemental data, including water manager interviews and observational data are described.

## Methodology

A qualitative approach is fundamentally different than a quantitative methodology in that the latter is rooted in a traditional positivist epistemology: "Positivism holds that there is a knowable reality that exists independent of the research process" (Hesse-Biber and Leavy 2006, 13). Silverman goes on to argue that while a "quantitative approach can tell us a lot about inputs and outputs into some phenomenon, it has to be satisfied with a purely 'operational' definition of the phenomenon and does not have the resources to describe how that phenomenon is locally constituted" (Silverman 2006, 43). Drought is a highly contextual concept whose structure, as noted in Chapter 2, is not easy to define operationally. Hence, a qualitative methodology is used in this study because of its capacity to examine the experiences and perspectives of irrigators in the Flathead River basin and to provide a window into the structure of vulnerability. Winchester (2005, 9) notes that while "People's own words do tell us a great deal about their experiences and attitudes, they may also reveal key underlying social structures."

## **Irrigator Interviews**

Irrigators were interviewed using a semi-structured interview approach. While this approach allows the interviewer to ask questions from a prepared list, it also allows the conversation to deviate from pre-determined topics. The benefit of the semi-structured interview is that it allows for common themes to be addressed by all interviewees while still allowing for unexpected conversation that may be pertinent to the research questions. Open-ended questions were used to allow the interviewee to speak freely about the question topics. This kind of interview strategy provides for rich data as "open-ended and flexible questions are likely to get a more considered response than closed questions and therefore provide better access to interviewees' views, interpretation of events, understandings, experiences, and opinions" (Byrne 2004, 182).

The interview guide (Appendix 1) used for the irrigator interviews consists of five sections. The first section includes opening questions and icebreakers. Additionally, the opening questions served to collect descriptive data on the interviewees' farm operations and land tenure. The second section of the interview guide focused on water shortages, changes in water shortages, and causes of those water shortages. The third part of the interview guide focused on drought and drought experiences. Interviewees were asked to define drought and then recall any droughts that they could remember. Additionally, this part of the interview contained a question regarding perceptions of future drought and climate variability. The fourth section of the interview guide addressed policy benefits and constraints in regards to water and farm management. The last section of the interview guide addressed future drought, mitigation, and preparedness.

The interview guide was submitted to the University of Montana Institutional Review Board (IRB) before any field interviews were conducted. The IRB process is required for any University of Montana student who intends to do research involving human subjects. The purpose of this is to ensure ethical considerations are made before research on human subjects begins. All irrigators who participated in this study signed an informed consent document. Additionally, irrigators were asked to consent to an audio recording of the interview. All but one irrigator agreed to be audio recorded. Personal identifiers were removed during the transcription process and individual irrigators will herein be referred to by an identification code.

**Irrigator Interview Sample**

Irrigators were selected using a purposive sampling method. This sampling method is used in order "to look at a 'process' or the 'meanings' individuals attribute to their given social situations, not necessarily to make generalizations" (Hesse-Biber and Leavy 2006, 70). Given this, a sample of irrigators was chosen by selecting participants based on their irrigation experience and not simply by using a random sample of all irrigators in the basin.

Irrigators from across the basin with in-depth knowledge of local drought history, water policy, and farm experience were sought for the purposive sample. To achieve this, interviewees were required to have operated an agricultural operation for at least 10 years and have at least half their income come from their operation, or operate an agricultural operation that irrigates more than 40 acres. Additionally, four sample areas were created to ensure that all irrigated areas in the basin were sampled from. These sample areas include an area north of Flathead Lake in Flathead County and the Flathead, Mission, and Jocko Irrigation Districts (Figure 4.1). In total, 18 interviews were conducted with three located in the Jocko Irrigation District, four located in the Mission Irrigation District, six located in the Flathead Irrigation District, and five located in Flathead County (Figure 4.1).

Irrigators were selected using several recruitment techniques. Potential interviewees in the Flathead, Mission, and Jocko Irrigation Districts were first selected from FJBC meeting minutes. Names of individuals who were either on the board of the FJBC or in attendance at a meeting from January to April 2009 were contacted. Additional irrigators were also found using a tax assessment list provided by the FJBC. Operation and maintenance fees are bundled with annual tax assessments for all properties receiving water from the FIP. This list included a mailing address for all individuals that were billed for water deliveries in 2008. Properties on the list where the mailing address was not located on the FIP were immediately excluded from the sample. The remaining properties were then randomly chosen, their phone numbers identified in a phone book, and solicited for interviews. Potential interviewees were also found using a snowball method. The snowball method entails asking interviewees to recommend other potential interviewees. For interviews north of Flathead Lake, water managers were asked to identify knowledgeable irrigators in the area in order to generate a sample. After the first irrigators were identified a snowball method was again used to find additional interviewees.

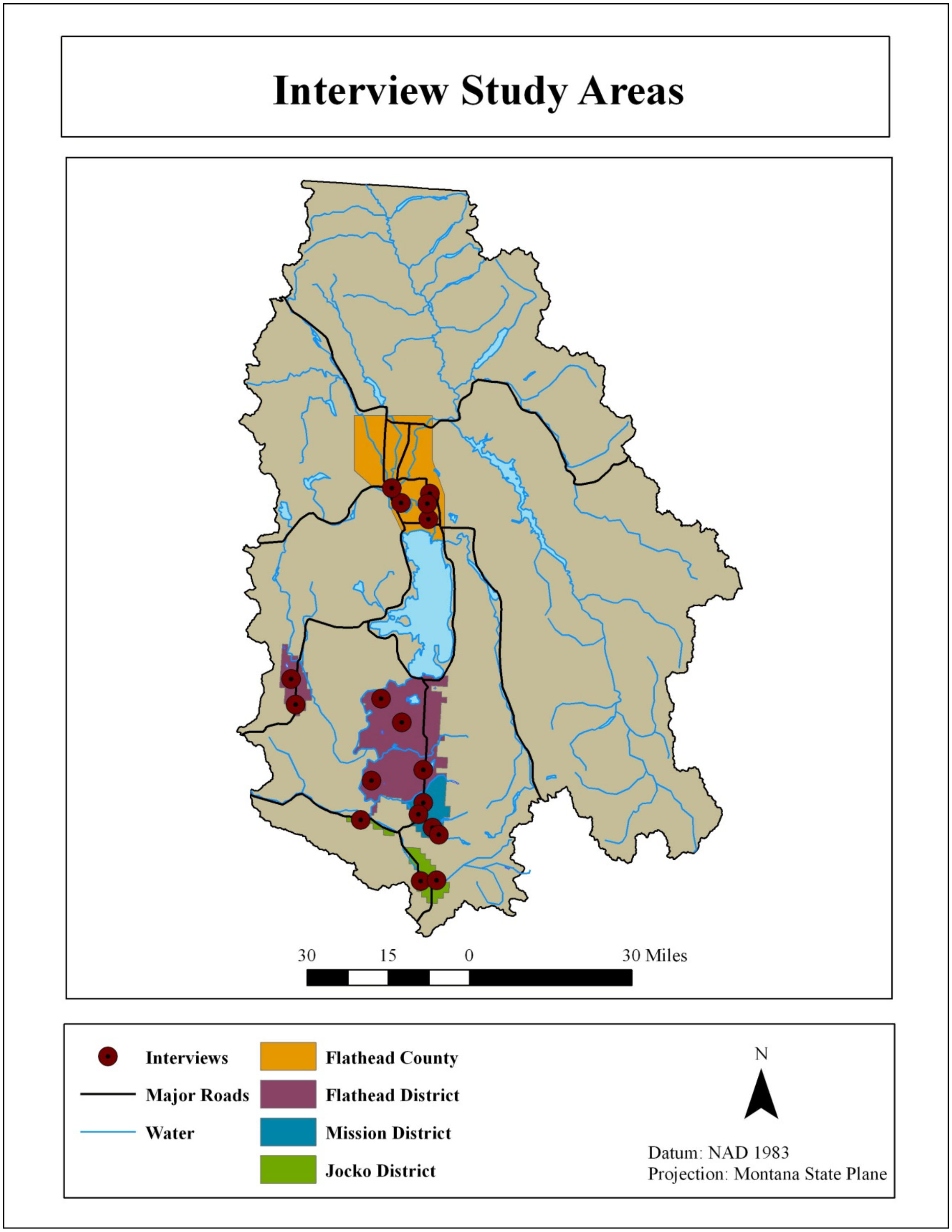


**Figure 4.1 Interview Study Areas and Approximate Interviewee Locations**

References from water managers and the snowball method proved to be the most successful way to recruit interviewees. Irrigators often felt more comfortable if they had been referred by an acquaintance. Additionally, these referrals usually came with quality contact information so it was much easier to make first contact. In total, 18 of out 66 irrigators who were contacted agreed to interviews.

**Data Analysis**

Irrigator interview data were collected through audio recordings or field notes when no audio recording was available. As previously noted, one irrigator chose not to be audio recorded. Additionally, the audio recording device failed to operate on three other occasions. In total, 14 of the 18 irrigator interviews were recorded. These recorded interviews were later transcribed using a word processor.

To analyze the interview data a coding system was developed and used within the qualitative research software QSR NVIVO (Version 8). The purpose of coding is to reduce large amounts of data through the identification and organization of important sections of text that are pertinent to the research questions. Cope (2005, 225) notes, "some form of reduction, or abstraction, is desirable to facilitate familiarity, understanding, and analysis." A key portion of Cope's description is that the process in itself is an important step in the analysis of the data. Coding is a recursive process where the organization of data continuously informs the analysis.

A coding system that identified both latent and manifest content in the data was used to analyze irrigator interviews. Berg (2004, 203) defines these two sources of content: "Manifest content is comparable to the surface structure present in the message, and latent content is the deep structural meaning conveyed by the message." The coding strategy used in this thesis treated direct answers to interview questions as manifest content and emerging content, or content that was not directly addressed by interview questions, as latent content.

Using the qualitative research software QSR NVIVO (Version 8), both types of content were selected and stored within a database structure. Initially, one node was developed for each question in the interview guide. As each interview was analyzed, direct responses to each question were organized into sub-nodes of the corresponding question node. Simultaneously, latent content was stored in new nodes developed on an ad hoc basis. From this initial coding structure nodes and sub-nodes were combined when appropriate to form both the latent and manifest themes presented in Chapter 5.

## Supplementary Data Sources

Supplementary data used in this research include both water manager interviews and field observations. Water manager interviews provided information on irrigation issues and, as noted above, valuable references to potential interviewees in the community. Observational data were collected in the form of observations made regarding irrigation culture in the basin. This provided valuable context into the experiences of irrigators and how they interact as a community.

### Water Manager Interviews

These interviews provided background information on irrigation issues and, in some cases, references to potential irrigator interviewees. Here, water managers are defined as individuals who facilitate the management of water resources. These interviews were generally informal and unstructured. In some cases, questions were borrowed from the irrigator interview guide. Six of these interviews were conducted with water managers representing the following agencies or groups:

- CSKT
- Natural Resource Conservation Service (NRCS)
- Flathead Conservation District
- Northwest Agricultural Research Station
- FJBC
- CHS Agricultural Services Center

**Field Observations**

Ethnographic methods are used to gain an understanding of how "different cultures and subcultures make sense of their lived reality" (Hesse-Biber and Leavy 2006, 230). This type of research is conducted through unobtrusive methods where the researcher observes the social structures from within a particular research setting. During fieldwork in the Flathead River basin, observations were made while driving to and from interviews, observing surroundings in irrigators' homes, and interacting with the local irrigation community. While ethnographic methods were not specifically used to collect data for this thesis, these observations contributed to an understanding of farm and irrigation culture in the Flathead River basin.

The majority of irrigator interviews were conducted within the homes of irrigators. This provided interesting information about how the irrigators lived. Family structure, farm structure, and relationships within those structures could sometimes be inferred just from observations made in the interviewee's home. While these observations provided insight into the household-level structure of irrigation society, larger-scale community-level observations were made while commuting throughout the basin and interacting with irrigation groups.

Commuting to and from interviews within the basin provided valuable information about land use and the community. From the road it was obvious which fields were being irrigated, what crops were being grown, and where new development was occurring. While these observations are not a substitute for quantitative measurement, they do provide valuable information about how the irrigation community is structured.

Another source of information regarding irrigation community came from observations made at the August 2009 FJBC monthly board meeting. These meetings are conducted to address issues concerning the management of the three FIP Irrigation Districts. However, these meetings take on an interesting dynamic as the both the BIA's Superintendent of the FIP and the public are invited to attend this meeting. The interactions between the FJBC board, the Superintendent of the FIP, and the public revealed information regarding the structure of the relationships between these three entities.

# CHAPTER 5 - RESULTS

This chapter is divided into three sections. The first section describes the characteristics of the irrigators interviewed for this thesis, and the latter two sections report the actual interview results. More specifically, the second section describes the major themes concerning drought that emerged from the interviews. The third section describes drought context; here, drought context refers to issues that irrigators perceived as important but were not directly tied to drought. This section includes important themes on both the economic context and the policy/management context of irrigation in the basin.

## Interviewee Characteristics

This section reports the pertinent characteristics of irrigators interviewed in this research. It also introduces a coding convention for the interviewees, some of whose statements are quoted and referenced later in this chapter. These data were collected from both interview data and field observations.

As noted in the previous section, a total of 18 interviews were conducted. Each interviewee was given a unique identification code in order to protect their identity. This code consists of study area identifier (FC for Flathead County, FD for Flathead District, MD for Mission District, and JD for Jocko district) and a number representing a specific interview in the study area (Table 5.1). Of the18 interviews, five were conducted with more than one interviewee. Interview FD1a/FD1b, FD3/FD3b, and JD3a/JD3a were conducted with a husband and wife pair, interview FD4a/FD4b was conducted with neighbors, and interview JD2a/JD2b was conducted with a daughter and her father.

**Table 5.1 Interviewee Reference Codes and Selected Characteristics**

| Interviewee Reference Code | Sex | Land Tenure | Irrigated Acreage | Agricultural Activity |
|---|---|---|---|---|
| FC1 | M | Na* | Na* | Cattle, Alfalfa |
| FC2 | M | 40+ | 250 | Alfalfa, Wheat, Barley |
| FC3 | M | 46 | 102 | Grain, Peppermint, Dill |
| FC4 | M | 32 | 130 | Cattle, Alfalfa, Wheat, Barley |
| FC5 | M | 23 | 410 | Potatoes |
| FD1a | M | 30+ | 500-600 | Potatoes, Grain, Alfalfa, Chickpeas |
| FD1b | F | 30+ | 500-600 | Potatoes, Grain, Alfalfa, Chick Peas |
| FD2 | M | 40+ | 400 | Cattle, Alfalfa |
| FD3 | M | 10 | 225 | Alfalfa, Orchard grass |
| FD4a | M | 27 | 350 | Alfalfa |
| FD4b | M | Na** | Na** | Na** |
| FD5a | M | 90+ | 350 | Cattle, Alfalfa |
| FD5b | F | 90+ | 350 | Cattle, Alfalfa |
| FD6 | M | 40+ | 308 | Cattle, Alfalfa, Wheat |
| MD1 | M | 33 | 500 | Alfalfa, Grain |
| MD2 | M | 50+ | 133 | Pasture |
| MD3 | M | 10 | 40 | Alfalfa |
| MD4 | M | 100 | 400 | Alfalfa, Pasture |
| JD1 | M | 55+ | 120 | Cattle, Pasture, Alfalfa |
| JD2a | F | 30+ | 380 | Cattle, Pasture, Alfalfa |
| JD2b | M | 30+ | 380 | Cattle, Pasture, Alfalfa |
| JD3a | M | 70 | 100 | Cattle, Pasture, Alfalfa |
| JD3b | F | 70 | 100 | Cattle, Pasture, Alfalfa |

**Data not available due to recording device failure*
***Interviewee arrived mid-interview and data was not collected*

In the interview guide, questions regarding land tenure, amount of land irrigated, and type of agricultural activity were specifically asked. Here, land tenure includes the amount of time each interviewee, or their family, has operated the same land that they are currently operating. The subsequent data collected from these questions for each interviewee and the interviewee's gender can be found in Table 5.1. The only females interviewed in this study were the above mentioned wives in the husband and wife interviews and the daughter in the father and daughter interview. The land tenure of the interviewees ranged from 10 to 100 years with median land tenure of 40 years. The amount of land irrigated by interviewees ranged from as little as 40 acres to over 500 and the median was 308 acres. The agricultural operations of the interviewed irrigators consisted of operations revolving around both ranching and farming. The cattle ranches produce irrigated hay crops primarily for their own cattle, but some also produced hay for sale. Farms produced a wide range of crops with hay crops such as alfalfa being the most common. Other crops included wheat, potatoes, barley, chickpeas, peppermint, and dill.

While off-farm work status was not specifically addressed in the interview guide, it emerged as an important socioeconomic characteristic of the interviewees. Many irrigators noted that in addition to their agricultural activities they also held a second job that was, in many cases, their main source of income. One irrigator noted:

> If you want to farm you [get a second job] so that you can continue to farm. That is generally the way this valley is, most small valley farms are… (MD4)

Still, several irrigators reported that farming or ranching was their only source of income. Many of the irrigators interviewed were also very well educated. While, specific education data was not collected the sample contained many irrigators with college degrees including one who now works as a successful civil engineer and another who holds a professorship at a state university.

## Drought

This section focuses on the major drought related interview themes. More specifically, these themes consist of defining drought, irrigation water supply drought impacts, non-irrigation related drought impacts, response to drought, perceptions of climate change and future drought risk, and drought mitigation.

## Defining Drought

Irrigators in the Flathead River basin defined drought in several ways. The most common definitions consist of descriptions of drought's physical attributes. Additionally, these attributes describe drought both in terms of its acute effect on growing season conditions and its longer-term effect on snowpack and surface water supply. Attributes used to describe drought as an acute short-term condition include below normal growing season precipitation, heat, and wind. The attributes used to describe drought by its longer-term effects consist of snowpack level, melt rate, and runoff timing.

For irrigators on the FIP, slow snowmelt rates were specifically emphasized as being important. The FIP consists of 16 relatively small reservoirs that in and of themselves are not able to hold the volume of water needed for an entire irrigation season. Instead, the FIP relies on the continual storage of runoff during the growing season to refill project reservoirs as water is being released. If runoff occurs too quickly, the FIP does not have the capacity to store the water it could under slower runoff conditions. One FIP irrigator elaborated on the importance of melt rate:

> If you have snowpack to start with, how it comes out is a lot. If you can manage for that you can probably collect a little bit more I feel. If it all gets hot and comes out at once it's just like a lot of it can't come down the canals or whatever because it's just too much, it can't handle it. It's just a short window to try to capture it versus a long window to try and capture it. (FD5)

In addition to these physical definitions, two irrigators defined drought by referencing current long-term drought conditions. These definitions were less abstract and consisted of personal accounts of long-term environmental change. In their view, the basin has seen an overall increase in dryness over the last 30+ years. One of these irrigators noted:

> How do I see drought? My experience here in the Jocko Valley is that this has been a long-term drought. It maybe didn't have a large effect on things all at once but you see here I've been here for 55 years going on 60 years of being an irrigator. Hay used to get wet in July a lot of times and you didn't put up hay until after the fourth of July because it was probably going to rain all of June but now the last couple years sometimes all the hay is up by the fourth of July. It doesn't get wet as often…. It started drying up probably in the 60s, definitely by the 70s it was noticeable. Probably the late 60s it was drying up and maybe before that I just kind of remember. (JD1)

Lastly, one irrigator provided a drought definition that contrasted sharply with the above definitions. He believed that he could not define drought because as an irrigator, he has never experienced a real drought. Of particular interest is the fact that he also irrigates in the Jocko Irrigation District and is located no more than a few miles away from the irrigator referenced in the previous quotation (JD1). He noted:

> You got to look at the whole picture. We have never really had a drought because we have the two dams up here and they are the reason that they were put there in the first place. As far as our explanation of drought, we have never really had one. (JD2a)

**Irrigation Water Supply Drought Impacts**

The reporting of irrigation water supply drought impacts differed significantly between irrigators interviewed in Flathead County and the FIP. In Flathead County, only two out of the five irrigators noted that their irrigation water supply had been affected by drought. One of these irrigators noted that recent drought had reduced the water available in his “groundwater pit.” Groundwater pits as, they are referred to here, are pits dug near streams that irrigators use to pump surface water for irrigation use. Reduced surface flows directly affect the height of water in these pits and thus the available irrigation water. He notes:

> Yeah well we are in one [a drought] right now. And what has happened, when the water table has dropped out here, we have loss. If you were to look at our groundwater pit there is an upper seam of gravel where most of the water used to come in. We were able to run 6 wheel lines out of that pit: somewhere around, oh, 1300 to 14000 gpm. We can get around 600 gpm now sustainable. That upper seam of gravel is dry. It’s a couple feet of water year-round now. Yeah, drought has definitely impacted us. It’s reduced the amount of lines we can run at one time. (FC2)

The other irrigator in Flathead County that reported an irrigation water supply related drought impact noted that the groundwater supply in his area (the Stillwater drainage area) seemed to be declining. This is of note, as his report contrasts with those of two other irrigators interviewed in Flathead County who reported that their groundwater supply has not been affected by drought. However, one of these irrigators did admit that while drought did not seem to affect his groundwater supply, he had not actually measured his well’s static level (here, static level refers to the water level inside a well when water is not being pumped).

In contrast to Flathead County, there was mention of at least one drought related irrigation water supply shortage in 11 of the 13 interviews conducted on the FIP. These shortages were most commonly referred to as end of irrigation season water cut-offs. In normal years, irrigation water is available from the FIP until the first few weeks of September. In years where drought has significantly affected water availability, irrigators report that water is usually cut off by the middle of August. For crops that require significant moisture late in their growth cycle like potatoes, this kind of sudden loss of water supply can cause significant impacts. One irrigator noted:

> There was one year that we ran out of water on the 12th or 15th of August. It was hot and dry year. It was one of those things where we didn't have much snowpack, didn't get much rain… Some of the neighbors who grow potatoes over here they figured they lost quite a bit because they didn't have that late August irrigation for the potatoes, you know what I mean. (MD2)

For irrigators growing a hay crop or using water to irrigate fall pasture, late season water shortages can prove to be just as damaging. Hay crops like alfalfa can be harvested several times a year and profits are not usually realized on the crop until the last cutting. If irrigation water is cut off early, it reduces the overall return on the crop and subsequent profits. Additionally, many ranchers irrigate a hay crop, or fall pasture for their own cattle. A last cutting of hay or a productive fall pasture provides the feed ranchers need in order to bring cattle up to size. If that hay crop or pasture is not produced due to a late season water cut-off, ranchers are often forced to purchase hay or sell underweight cattle, which can also greatly reduce profits. One irrigator elaborates:

> What happens in a short year is you end up getting cut off in August. If you get cut off in August, you can't do a third cutting. I lost a third cutting a couple years ago. You can't irrigate your pastures for say another feeding of your cattle or pasturing your cows. It could really get bad if you get cut off here. (FD3)

While late season water cut-offs were the most common drought related irrigation water supply impact that irrigators on the FIP experienced, the irrigator interviews conducted in the Camas area revealed a slightly different experience. Irrigators in this area of the project receive water from a distinct system of reservoirs and canals that are not connected to other areas of the project. One irrigator noted that this makes the Camas water supply less reliable than other areas of the project:

> Our watershed is a lot less prolific. We don't have nearly the irrigation water and we wish we did… we are ten percent of the project so of course we are scaled way down, but it comes back to our watershed. [Water] is just not as abundant over here… it's a totally different basin than the mission. It's drier. That sums it up. It's certainly drier. (FD4a)

Given this difference, the irrigators interviewed in this section of the project were not just impacted by late season water cut-offs but season long reductions in irrigation water availability. While the exact year could not be recalled, both interviews conducted in the Camas area referenced an irrigation season in the mid 2000s where only .17 ac-ft of water was allocated compared to their usual .8 ac-ft allocation.

In general, irrigators on the FIP rarely indicated that non-environmental factors exacerbated the impacts of drought. The few exceptions to this were comments made about FIP management and its role in managing water. For example, an irrigator in the Moiese area attributed an increase in recent drought risk to the poor management of a project dam. He noted that the dam's spillway had been damaged due to mismanagement of flows, and that subsequently the reservoir was not allowed to reach full pool anymore. This, in turn, was perceived to have caused an increase in the Moiese area's susceptibility to drought:

> We have a much higher [drought] risk now because of the Crow Reservoir. The BIA did not properly manage or maintain the reservoir. There was rainfall that resulted in damage to the spillway and the spillway is where the reservoir fills up and is kind of an escape hatch for some of the water. That was damaged and the Bureau of Reclamation, and the safety of dams kind of came along and they said, 'well because of the state of the spillway you have to keep the reservoir way low to provide more room in case there is a big rain storm.' We are subject to cutoffs and less water because of that. Now we need to get money to make that repair. (FD3)

However, and somewhat confusingly, not all water shortages were actually attributed to drought. For example, many irrigators noted that ditch failures, which were unrelated to drought, commonly caused short-term losses in irrigation water availability. For example, one irrigator in the Jocko Irrigation District noted that a ditch washout had caused a water shortage in his area of the FIP. Another irrigator commented on her somewhat comedic experience with a water shortage that was caused by children playing in her irrigation ditch:

> We have had one time where we were waiting for water and waiting for water and we called the ditch rider and we said, ‘can we have water,’ and he says, ‘I’ve sent water,’ and we call the ditch rider again and he says, ‘I sent water,’ and on the fourth of July his dad [FD1's Father] had the ditch rider riding the ditch and he found out that some kids had damned it up for a swimming hole. Those are just silly things that happen. (FD1b)

Overall, irrigation water supply drought impacts were noted in 13 of the 18 interviews. However, the perceived significance of those impacts varied considerably. On one end of the spectrum, the majority of irrigators noted that while their water supply had been affected by drought on a few occasions, it was not a problem that had a large impact on their livelihoods. For example one FIP irrigator noted:

> Most of the time we usually get enough water. I’m on the end of a couple of ditches generally we get enough water to irrigate at least 3 times… There were a couple of years when they ran out of water by the middle of August. As a general rule the project does a pretty good job. I’ve never run out of water to often or really early or anything. (MD4)

On the other end of the spectrum, several irrigators perceived drought related irrigation water supply shortages as much more important. For example, one irrigator commented briefly on the severe drought impacts that he incurred from a past drought event:

> I don’t know how we ever made it. Actually we put a first cutting up and then we had pasture we didn’t get no second that year. We just didn’t have water. (FD5a)

**Non-irrigation Water Supply Drought Impacts**

Irrigators in the Flathead River basin did not exclusively define drought impacts in terms of its effect on irrigation water. Several interviewees noted that even if a drought doesn't affect their irrigation water supply, it could still have an impact on their agriculture operation. For example, one irrigator located in Flathead County noted that his irrigation water supply was never affected by drought because he irrigated out of a slough off the Flathead River in between Hungry Horse dam and Flathead Lake (which is regulated by Kerr dam). This stretch of river is highly regulated as water levels between Hungry Horse and Kerr dams are set at specified levels for flood control and hydroelectric power production. However, he still felt that drought was a problem on his farm as significant areas of his agricultural operation were non-irrigated and susceptible to acute drought conditions:

> We have some fields that are hurt quite a bit. Some of them that we don't have water available on and one that we didn't have the system on particularly should have been an 80 bushel winter wheat crop and it's a 20. (FC4)

It was also noted that sometimes, when acute drought conditions are severe enough, there is nothing you can due to prevent drought impacts, even on irrigated land. One irrigator commented:

> Those are drought situations. What can you do on those things, that's just part of the environment. It's nothing that the project is doing. It's nothing that you're doing, it's just when it's 90 degrees, 100 degrees, out and you have the sprinklers going around out there and the wind is blowing you're just evaporating it away. (MD2)

Lastly, several irrigators commented that drought conditions could also lead to weed and grasshopper infestations. These types of drought impacts can occur in irrigated agriculture regardless of whether irrigation water supply is impacted or not.

Further, these types of impacts were not regarded as trivial. One irrigator in the Jocko Irrigation District noted:

> Eighty grasshoppers will eat as much as one cow you know. They have a big effect. You know you kill the grasshoppers that are there and pretty soon there are bunch of other grasshoppers that have moved in. They have come for the funeral or something. The grass here in the yard, I've killed the grasshoppers three times and there are still quite a lot of grasshoppers there. Not like there was in June but there is a lot of grasshoppers… (JD3)

**Responding to Drought**

Irrigators interviewed in the Flathead River basin reported a wide range of responses when asked if they had taken any steps to prepare for drought (Table 5.2). Further, these responses can be categorized as either changes made in irrigation practices, changes made in cropping practices, changes made in the management of the agricultural operation, or no change at all.

**Table 5.2 Drought Responses**

| Type of Response | Specific Response Mechanism |
|---|---|
| Change in irrigation practices | Improve sprinkler nozzle efficiency |
| | Purchase center pivots |
| | Selective irrigation |
| | Deep wells |
| Change in cropping practices | Change crop patterns |
| | Change crop timing |
| Change in operation management | Sell cattle |
| | Keep hay reserve |
| Do nothing | Do nothing |

While no one category emerged as the dominant drought response, changes in irrigation practices were cited most frequently. Within this type of response, upgrading sprinkler technology through the purchase of new sprinkler nozzles or the purchase of a center pivot system was most commonly noted. The goal of upgrading sprinkler technology is to maximize water use efficiency. This, in turn, improves the ability of irrigators to sustain productivity in the face of drought conditions. Upgrading to "low flow" sprinkler nozzle heads can improve sprinkler efficiency by regulating application rate and droplet size. In general, sprinkler heads that allow for a slower application rate and a larger droplet size are more efficient because they reduce evaporation and let more water reach the actual crop. However, finding the most appropriate nozzle size is not easy, as low flow sprinklers do not have as large of a spray pattern as more traditional higher-pressure heads. Thus maximizing sprinkler nozzles is a function of both nozzle size and spray pattern.

Upgrading to center pivots systems can similarly improve the efficiency of sprinkler irrigation. However, they have the added benefit of allowing for a more frequent irrigation application rate. Center pivots consist of a motor driven irrigation pipe that rotates around a central irrigation pump. This is different than more traditional hand line or wheel line sprinkler systems that must be moved across a field manually or, in the case of some wheel line systems, with a motor driven system. An irrigation hose must be removed and reconnected in each move, or "set." A typical set consists of an approximately 30 ft. move and a 12 hour irrigation period. In contrast to these methods, center pivots can return to the same spot in a field in a much timelier manner, thus keeping a crop more consistently watered and less susceptible to acute drought conditions (i.e., extreme heat, lack of precipitation). One irrigator noted:

> You can put on the same amount of water with a center pivot in half the time. So timing is really critical you know, and not only that but time that you can get your

> pasture or your crop to come back [from drought]. It's so much better because you can put on a circle of water and its staring to come and you can hit it with another pass it its getting more… With an irrigation system you are stuck going here and here. It takes so much time to come back across where you can do it in half the time with a center [pivot] so it's really a beneficial management tool. (FD5a)

While upgrading technology was the most commonly reported way in which irrigators changed their irrigation practices, other strategies were noted. One irrigator in the Camas area reported that he routinely participated in selective irrigation during times of drought. This practice involves drying up one field in order to apply more water to another. He described this practice as necessary when there is limited irrigation water available:

> As you were coming down the road you probably saw that there is a large brown dry field. You dry one up, you rob Peter and pay Paul. You dry one up to green one up. That's typical. The less water I have the more brown acres I will have. In other words, bring all the water we get on a smaller parcel of land. It's an absolute necessity. In other words you'd have the whole place brown instead of a little bit brown. (FD4a)

Another way in which one irrigator in Flathead County changed irrigation practices in response to drought was by developing deep aquifer wells. He hypothesized that the shallow aquifer on the west side of the upper Flathead Valley, in which most groundwater irrigation is drawn from, would eventually become depleted. In response to this, he developed deep aquifer wells for his irrigation operation that do not utilize the shallower aquifer in that area.

Irrigators in the basin also reported changes to cropping practices. The most commonly noted response in this category was to change cropping patterns. One way in which irrigators changed cropping patterns was by diversifying their cropping patterns to include both high dollar/high input intensive crops and other less input intensive crops.

For example, one irrigator in the Flathead Irrigation District reported that he now grows two kinds of orchard grass for hay. The first variety he fertilizes intensively and the second he does not as it is not worth the risk to fertilize that crop if he cannot get enough water for it:

> Like I said earlier, I keep two kinds of orchard grass because I decided that I just can't risk another fertilizing if I can't get water for the whole thing. And you can do that. Some farmers do that. (FD3)

Another way in which an irrigator reported changing their cropping practices in response to drought was by changing their crop timing. One Flathead County irrigator noted:

> We planted earlier and we are going to have better crops because of timely planning. My son's been working with me and he is really on the ball about the cropping. Its going to make a lot of difference over what someone did that weren't growing like that. (FC4)

By planting earlier, this irrigator plans on both taking advantage of early season moisture availability and avoiding late season drought conditions.

The third category of drought responses that irrigators in the Flathead River basin reported consisted of changes made in the management of their agricultural operations. The most cited type of response in this category was the selling of cattle. On several occasions it was noted that during a drought, one of the only things you can do is be the first to the sale barn. One Jocko Irrigation district irrigator noted:

> I guess the only preparation you can make for being in a drought is going to the sale barn first. You can beat your neighbors there to get the higher price because everybody is going to be in the same boat. They are pretty much doing that right now there is an awful lot of ranchers that are liquidating their herds or reducing because of, I guess because of the drought. (JD3a)

This category of responses also includes the storing of hay. This response was reported by husband and wife irrigators in the Camas area who grow hay for their cattle operation. They noted that the primary drought impact that they incur is the reduction in hay crop or pasture. Their subsequent response has been to store surplus hay instead of selling it because the cost of not selling it ends up being less than the cost of having to purchase it during a drought:

> Well there is one thing we do. We try to keep a little reserve of hay around for drought, you know as far as trying to keep a little supply ahead instead of cutting it right down to the last… (FD5a)
>
> You don't sell any hay. (FD5b)
>
> By having a reserve crop of hay around, having reserve in your stacks you can probably omit your second [cutting]. So you wouldn't have to go out and buy hay or whatever. (FD5a)

Lastly, the response of "do nothing" was reported several times across the basin. For some, this response was reported simply because the irrigator had perceived that their agricultural operation is not affected by drought. However, this answer was also reported from others who perceived that they could not do anything to prevent the effects of drought. For example, one irrigator noted that there was nothing he could do to prevent late season drought impacts except hope for rain:

> And we just have to hope that the rains will start which is usually around the first of September but if they don't then we just have to live with it until they do or until next spring. (MD1)

**Future Climate Change and Drought**

No irrigator interviewed in the Flathead River basin reported that they had taken any specific precautionary actions in order to reduce the future impacts of climate change. The most prominent explanation for this lack of response can be attributed to the perception that climate change is more a political issue and less an actual physical phenomenon. Further, climate change was often associated with a liberal political ideology and viewed skeptically by irrigators with conservative political ideologies. For example, multiple irrigators believed that climate change was a political tool used by former presidential candidate Al Gore (a Democrat) and not a valid scientific concept. In this context, irrigators often referred to climate change as "global warming" even though it was addressed in the interviews as climate change or future climate variability. For example one irrigator in the Flathead Irrigation District noted:

> Global warming is not an issue that we worry about a bunch. Quite frankly I think it's pretty natural and I think that we are going to have to adjust and I don't think we are going to burn up tomorrow. I mean we talked about global cooling in the eighties. Al Gore has made global warming a big issue but he's not necessarily scientific and factually based in some of his allegations. (FD1a)

Although some irrigators did not politicize climate change in the same way that FD1a did, they still remained similarly skeptical. This skepticism arose from the perception that there did not seem to be enough evidence that the localized impacts of climate change would be so severe that specific actions were necessary. One Flathead County irrigator noted:

> We have always chased the water. It's always been cyclical. In 1997 it [the Stillwater River] was as high as anybody had ever seen it because we had that tremendous snow year. But you talk to my parents, my mom was raised out here. There was an old rock pile, they said in the spring they used to swim off those rocks. There hasn't been water around them since I was a kid. I think part of the problem was that when this area was settled I think it was a very wet time in the West. I think if you go all the way across the West it was very wet time. That is what we are basing most of our records off of… As an engineer I am trained to look at data. You are supposed to have a lot of data before you present an answer. We've got maybe 100 years of decent data and yet water, rain, has been falling for millions of years. You don't have enough accurate data to project out what is going on and so all we have is what we know in our life time and in reality that is not enough to plan off of if you look at the grand scheme of things. (FC2)

**Future Drought Mitigation**

The majority of the irrigators interviewed reported that they did not plan to make any future changes in response to drought or that they did not plan to make any additional changes beyond those that they had already made. For some irrigators, this response was due to the perception that drought impacts were unavoidable and there is nothing you can do to prevent them when a drought occurs:

> We are strictly at the mercy of Mother Nature. Mother Nature gives us a lot of snowfall in the mountains. So we get a lot of runoff in the spring and it continues until later on into the summer. We thrive quite well. If we don't have enough runoff, enough snowfall in the mountains then there is no way to change it. (MD1)

Other irrigators noted that while they did not personally plan to make any future changes in response to drought, they felt that some community or basin level changes could be made in order to become better prepared. For example two irrigators commented that having more water storage in the form of small ponds and reservoirs would help to prevent drought related irrigation water supply shortages. Another irrigator in Flathead County noted that he would like to see someone from the local conservation district address water conservation issues with irrigators:

> I would like to see somebody from maybe the conservation district standpoint taking a more proactive stance on water conservation strictly with irrigators. (FC2)

In contrast to the majority of irrigators, two irrigators noted that they did plan to make future changes in response to drought. For one irrigator this included his continued involvement in adjusting the timing of his crop planting. For the other, it included a more conscious effort to keep his crops consistently watered.

Lastly, one irrigator noted that one possible way he might mitigate drought in the future is to develop springs located on his property for additional water sources during times of drought. However, he noted that this would be expensive and that the springs are hydrologically connected to surface water sources meaning they too might be diminished by drought:

> If I had any water shortages I have some springs down here that I would develop. It would be a lot more expensive to put a pump in there and pump water out of there you know. If there is a shortage in the irrigation there is probably going to be a shortage in those springs too. It's all related, all the water. (JD3a)

## The Drought Context

This section describes the context in which irrigators perceive drought to be occurring. This includes themes on both economic and policy/management issues in the Flathead River basin. A large portion of the irrigator interviews revolved around these issues, as they were often perceived to be of major concern.

### The Economic Context

Economic concerns were a major topic of discussion for irrigators interviewed in the Flathead River basin. Of note, is that this topic does not coincide with a specific question or set of question included on the interview guide. Instead, a number of latent themes emerged from the interview data. A discussion of economic concerns often began with references to the way in which economic processes have shaped the development of agriculture in the basin. Specifically, the transformation of agricultural operations from small homesteads into larger modern farms was noted:

> It was lots of small farms, a lot of dairies. They were self sufficient, they could provide for their needs, but the way the world has gone you get bigger and everyone is trying to get bigger and more efficient. You used to see little

> lights… You could see there were a lot more little farmsteads or farmhouses. Everyone had their little farms or dairies or whatever. Now they can't compete in the real world. (FD1a)

The above quote speaks broadly to the economic reality of being an irrigator in the Flathead River basin in the 21st century. Many irrigators in the basin noted that it is becoming increasingly difficult to compete in the world agricultural market. For example, one irrigator commented on how commodity pricing has not been able to offset the increasing costs of ranching:

> You know I would have to say that the price of cattle has not come up to meet the price of what it costs to grow them and that's where it's hurting us. Last year the fuel prices were huge. You know you think that fuel prices, you think about trucking, you think about running your cattle here there and everywhere and trucking was huge. For every pound of beef you sold X amount would come off for trucking so you know it's really tough. (FD5b)

Irrigators also noted that local economic processes have acted to constrain agricultural activity. In Flathead County, many irrigators commented that amenity driven development has caused land value to increase. One Flathead County irrigator noted that this development pressure has affected the future sustainability of his agricultural operation:

> I mean how much longer are we going to be able to afford to farm this ground? They are trying to divide it… I mean the slowdown in the economy has helped as far as people pushing wanting to buy places. It's a beautiful area and it has got a value. (NL4)

Additionally, irrigators in Flathead County noted that development speculation has caused a steep rise in electricity pricing. According to one irrigator, The Flathead Electric Co-op invested significantly in the development of power infrastructure for proposed development projects. However, many of these areas were never actually developed as the market has slowed since 2000. In response to this, the Flathead Electric

Co-op purportedly raised power rates in order to regain some of their speculation costs. For irrigators who operate pumps this can become a significant economic constraint:

> Electricity has gotten very expensive now. It used to be very cheap for the farmers… We saw a lot of speculation in this area and you saw a lot of development and a lot of lots created but no homes were built. The power company was putting all this infrastructure in but it was not used. And typically they get a pay back with the power costs when it's used. (FC2)

In contrast to Flathead County, irrigators on the FIP have been relatively unaffected by development pressure and electricity costs. This is because the speculation boom of the 1990s occurred primarily in Flathead County and power costs on the project have been kept low due to a low cost block of power that irrigators receive from the Kerr Dam hydroelectric facility. However, they still voiced concern over other local economic constraints. Several irrigators in this area commented that the FIP operation and maintenance fees that they incur for delivery of FIP water were significantly higher than then they could afford.

> What is it, $24 something now for an acre of water. We don't make enough for them to raise the rates. (MD2)

Another perceived constraint that irrigators throughout the basin noted is a lack of labor. Many activities associated with operating an irrigated agricultural operation are labor intensive. For example, changing and moving irrigation pipe for both hand lines and wheel lines requires high intensity labor. Additionally, this kind of labor is needed only during the summer growing season. Historically, these kinds of jobs have been filled locally by a high school and college aged demographic. Some irrigators in the Flathead River basin have noted that, as of recently, this demographic has not been willing to work farm and ranch related jobs:

> Kids today don't want to work. All of the sudden I had one young guy working when I first moved here helping me a lot during the summer, helping me with bailing and stuff, and all of the sudden July 15th he's gone because he's got football practice and of course kids today don't have the same work ethic. I had a kid down here constantly pestering me to work for me. So one day I said I need some help picking up rocks and he said "you mean off the ground?" Another time I had some hand lines to move and this was when I was doing a lot of acres with hand lines or wheel lines and it was a Sunday and it was mid day and it was hot and these are heavy hand lines. He worked for about 15 minutes and all of the sudden said, "I just remembered my father was going out to the lake." I just hired a kid recently to take some hand lines off the field. First time I hired someone to do that in half a dozen years, and he complained, "I don't like moving hand lines. (FD3)

While the attitudes of young workers was commonly perceived as being an important reason for the reduction in available farm labor, another irrigator hypothesized that the trend was due to increased outmigration of a knowledgeable farm workforce:

> One of the big challenges with the farm is trying to find help. It tends to be seasonal and it tends to not pay very well and it's difficult now to get help that's been around farms. You're not seeing any established work force that has a history working around farms, heavy equipment, big equipment, farm type equipment. So it's very difficult to find good help. They talk about brain drains well it's the same thing with farming. The farms get bigger and more mechanized there are less and less people that do it. The next generation, and we are going to see a lot of farmers leave and I don't know who is going to replace them. Maybe it is corporate farming; maybe we are going to start importing immigrants for laborers. (FC2)

While irrigators perceived several aspects of both the local and global economy to be constraining their agricultural livelihoods, they also reported developing strategies aimed at offsetting these constraints. One of these reported strategies was to seek off-farm employment. For one irrigator in the Jocko Irrigation District, this was a necessity in order to sustain her family's agricultural operation. However, the financial capital obtained from her husband's off-farm work was not without its costs. Her husband's off-farm work had increased her farm labor activities and added stress to her family life:

> We have got this place plus my husband works in Frenchtown at the paper mill. It's very hard especially for us being young, just starting into it. You got to buy your land, you don't inherit everything. It does make it hard and you have to have that second job to help pay for it… that is what a lot of people don't understand, everything that it takes to put that hay up. All they see is, 'well prices went down, fuel went down, this went down, that went down.' Well it still costs to put it [hay] up. People just don't see everything that goes into it. They just think you walk out there and snap your fingers and you're done. This time of year a lot of nights we don't get to the house until 10:30. People don't see that. (JD2a)

Another common strategy that was employed to deal with economic constraints was to purchase a new piece of farm equipment in order to improve yields and operational efficiency. Interviewees noted that in many instances this included improving irrigation methods. More specifically, center pivots were seen as attractive investment because they can not only increase irrigation efficiency but save on labor costs as well. One irrigator noted:

> Whenever we can afford a new piece of equipment a lot of times we will try to get a pivot because it frees us up. Changing [hand line or wheel line] pipe is hard work... its like milking cows. (FD1a)

However, purchasing a center pivot could not always be justified from a cost-benefit standpoint. One irrigator noted that the high costs of installing a center pivot on his land would not be offset due to the size of his land parcels:

> I had one [center pivot] priced. $75,000 dollars to irrigate 45 acres on a center pivot. If you had the land you could almost spend $75,000 and put in a center pivot that would irrigate 160. But that's the thing, it costs as much to put a pivot on a 40 or 50 or 80 or 90 than it does on 160. Unless you got 160 to where a pivot can do a full circle its pretty tough to justify, you know what I mean. It's a lot of labor savings but still that a lot of money considering you only make 100 bucks an acre on a crop. (MD2)

## The Policy/Management Context

Just as irrigators in the Flathead River basin often discussed economic concerns, policy and management issues were also brought up frequently during interviews. In Flathead County, irrigators noted that the state water right permitting process has been difficult to navigate. More specifically, one irrigator had difficulty getting both a streamside protection permit (310 permit) and a water right change of use permit (404 permit) processed in a timely manner. He had intended to move his irrigation water right point of diversion in order to improve water management:

> We are trying to move a pump location for my father further up on the Stillwater River and getting through the permitting process, the 310 permit, the 404 permit, has been challenging. It's taken two years to get everybody together and you know by the time you get the Conservation District to get the permits and place they have to come out and inspect, Fish and Game has to come out and inspect, it has to go back, it has to go through permission, it has to get approval and just it takes time. It's very frustrating in that respect. (FC2)

In addition to the time it takes to get through the water right permitting process, the financial burden of the permitting process was also noted. One irrigator commented that specialized help, which is often costly, is needed to successfully proceed through the permitting process:

> The Water Rights Bureau is nearly impossible to navigate without hiring someone. It used to be they just helped you and got your job done. They have made it so complicated now that unless you hire someone you just virtually cannot go through that… You used to go down there with your request and they would help you fill out the appropriate forms and now they just look at you and say, "oh that is going to be too complicated you need to go hire a specialist." Most of those guys who have worked there in the past have left and become specialists that specialize in helping you. (FC5)

Another issue brought up by one Flathead County irrigator is the enforceability of Noxon Dam's water rights located downstream of the Flathead River basin. Currently Avista Corporation, the owner of Noxon Dam in Noxon, Montana, holds three water rights totaling 50,000 cfs with priority dates of 1951, 1959, and 1974. It has been found that these rights are only satisfied 6-8% of the year (Clark Force Task Force 2004). One irrigator speculated that, as these water rights are located downstream, irrigators with water rights junior to Avista's could theoretically be subject to "call." In the prior appropriation system a call refers to the action of a senior water right holder requesting that a junior water right holder limit their water use:

> The big [issue] is the legality of the water rights with the Avista… You know those senior and junior water rights… The real reason we are doing it [developing the water right] is we are trying to protect the water right. We haven't used it in a number of years and there is a chance with the adjudication of the basin that's going on right now we can lose those water rights. You got to use them or lose them. (FC2)

Irrigators on the FIP, as compared to those in Flathead County, were largely concerned with a different assortment of policy and management issues. Many of these centered on the BIA's management of the FIP. More specifically, many irrigators noted that, as a federal agency, BIA management of the FIP is affected by bureaucratic federal policy that has inhibited efficient management. For example, irrigators consistently cited a situation where the FIP was unable to obtain the herbicide "Magnicide" to kill moss that has collected in ditches due to a BIA ordering policy:

> They use Magnicide to kill the moss in the ditches up in Valley View and Round Butte. The BIA put three projects together. We had our money in January to get our Magnicide. The other two projects didn't have their money in, didn't have their paperwork in, and didn't have their people licensed to administer it. The BIA put the FIP, the Wapato and Ft. Belknap together. Instead of having each project separate they put all three projects together to get this Magnicide, supposedly to save paper work. The other two water districts or projects didn't get their paperwork in. Well the people that have the Magnicide said they are not releasing the Magnicide until they get the money… So we never got our Magnicide when we needed it. Three years ago a bottle of Magnicide was 900 dollars and today a bottle is 4000 dollars. The moss is so bad over in Camas. It was so bad that they didn't think the Magnicide was going to do it any good. So they dried the canal up, took an excavator, scooped all the crap out that they could scoop out and then put a little layer of water in and then shoot it with Magnicide and hopefully they can get it filled for a year. So the canal has been down for ten

> days, those people have been without water for ten days. Well that is part of the system, the system that the project is being managed [under] right now. (MD2)

Another issue of note has been the incompatibility of federal employee work schedules with those of irrigators. FIP employees work on a federal employee schedule, which is typically an 8-hour day with weekends and holidays off. Some irrigators noted that this type of schedule is not efficient, as it does not always meet the needs of irrigators. In contrast to the BIA schedule, irrigators often work long hours without days off during the irrigation season. One irrigator noted how this has caused some inefficiency in water management on her farm:

> The fact that they [the BIA] don't work on our schedule is probably the biggest one... If a ditch blows out we want it fixed right now because our crops are getting stressed and they work from eight to five or eight to four thirty... When we want water turned off and on we have to do it from Monday morning at eight to Friday at five. That isn't a farm schedule. So those are probably the biggest issues. They are timing issues aren't they? Being government they don't work on what may be our best irrigation management schedules. But other than that they are nice people, they work hard, and they deal with the regulations that they have and we try to work around it. We try to make sure that we sure ask for our water to be turned off. That can create waste now if a guy doesn't get it called soon enough and his crop is watered up and soon water is going to run down the creek for a couple days and I'm sure that that happens but that just... like we said they are nice people working hard, doing their job and they work within their rules and we wish they could work more on our schedule. (FD1b)

Another policy issue referenced by several irrigators on the FIP was the BIA hiring procedures to which the FIP must adhere. Specifically, irrigators perceived ditch rider hiring procedures to be considerably more rigorous and time consuming than should be. One irrigator noted:

> Here we have a recession you've got eleven vacancies this year. In order to hire somebody you have follow BIA rules. You have to advertise nationally and that can take weeks if not months then if they have candidates they have to go through security clearance which can take another three to four weeks and by then you are through the season. (FD3)

Ditch riders are an important part of an irrigation project as they are responsible for managing flows in the canal and lateral systems. When an irrigator wants water on the FIP they request it from the ditch rider who then releases the allotted flow, records water use, and then stops the flow when irrigation is done. The shortage of ditch riders has meant that the existing FIP ditch riders must be responsible for flows on larger areas of the project. Many irrigators believe that this has led to inefficiencies in FIP water management such as slow response rates for flow release and shutoff.

Another management issue often noted by irrigators on the FIP has been the implementation of instream flow requirements for bull trout habitat. Instream flow requirements have historically been unpopular with irrigators on the FIP as they have been perceived to reduce water availability without actually providing any improvements in actual bull trout habitat. For example, husband and wife irrigators in the Camas area believed that instream flow requirements in their area of the FIP were useless as irrigators adjacent to the project, who are not subject to FIP instream flow policy, end up using the flows for irrigation anyways:

> We don’t have the problem with like say the bull trout. They are just not here and they don’t end up in the canals because our canals go dry. They go ahead and they schedule x amount of feet of water for these fish when you know even if they go past our part of the project they still doesn’t see the Flathead River. For us those minimum flows and those instream flows they make very little sense, very little sense. (FD5b)

> If you kick out of the ditch for a six cfs intream flow which is actually 12 ac-ft it only makes it this far before someone on the crick down there with a Montana junior water right is going to pump it all up on their field anyways. (FD5a)

While many irrigators on the FIP acknowledged that, at some point, instream flows had reduced water availability, several pointed out that instream flow policy was here to stay and that it is something that irrigators must find a way to deal with. Further, one irrigator in the Mission Irrigation District believed that recent management decisions and an increasingly collaborative management atmosphere have helped to make flow requirements considerably more bearable for irrigators:

> Like I said, the bull trout deal is starting to affect us a little bit but it's one of those things, "what do you do about it?" It's an endangered species, it's there, you have to work with it, there is nothing you can do to fight it. You just hope that whoever is managing the project is on the ball enough to manage it to where it doesn't really affect the irrigation season. And most of the time they do a pretty good job at it… People at the project have to regulate Tabor reservoir very delicately to try and keep the levels where they want it so the bull trout can get up stream and spawn and stuff you know. They've been trying some different things the last few years. They tried a new thing last year. It seemed to work pretty well if the project people will maintain it and hold the water back there for us. It would be a benefit for us because it would make a little more water later in the season for us on the south side of the creek here… There have been years where there really isn't enough water for stock water but we have talked to the fisheries people and they think most of the bull trout have spawned or whatever it may be and they will say, 'you can go ahead and release x amount of water for stock water.' We all try to work together pretty well to keep everybody happy and the fisheries guys realize that environmental situations every year are different. It's not going to be the perfect situation every year. They are like us, it's no different. They try to make it as close to being how they want it but if you work with them they will work with you too. For the most part it all works pretty well. (MD2)

Several irrigators on the FIP noted that, in response to these perceived policy constraints, they had made deliberate efforts to improve the efficiency of their operations. For example, one irrigator noted that he had made a conscious effort to give FIP ditch riders ample time to respond to his requests for water before the date when he intended to irrigate. In addition, he also tried to let the FIP staff know several days in advance when he intended to stop irrigating. This improved communication worked to both increase the reliability and timing of FIP flows, and cut down on "wasted" water flowing by his ditch when he decided to stop irrigating.

In contrast, many FIP irrigators believed that these constraints would not be addressed without project turnover to a CME, which, at the time of the interviews, had yet to be authorized by the Department of the Interior. One irrigator noted:

> If the government was running this farm, it wouldn't run as efficiently as those people personally involved, and that is just the nature of government. They don't live in the same world and they don't follow the same rules. They have their chain of command, which is huge. If the water users, which would be the Tribes and everyone involved, were involved they would probably do things in a lot more timely manner… We can use our resources. The resources could be utilized better with less management, and over-management, and that's what our wish has been and it's been going on... they have been trying to turn the project over for forty years and we are finally starting to see that that might happen. (FD1b)

Several irrigators noted that, besides the perceived benefits associated with eliminating the BIA bureaucracy from FIP management, turnover would also provide additional benefits. For example the infrastructure of the FIP dates back to the early 20th century and has not been updated significantly since this time. It was hypothesized by several irrigators that the transfer of project management to a CME would make the FIP eligible for a number of high value grants that could be used to update the project infrastructure. According to one irrigator, this would include the installation of measurement devices and ditch turnout gates, which would in turn improve the ability to efficiently manage flows:

> One of the objectives in the whole transfer process and, looking to the future, is to get better water measuring devices in diversion points and basic points of entry into kind of the lateral ditches and also at individual farms. Get better measurement and get better gates to control the flow of water into ditches form the main canal into the side ditches and from the side ditches into individual farms. (FD3)

However, FIP turnover was not seen as a cure all. A few irrigators, although optimistic were cautious to say that transferring the FIP to a CME would provide drastic improvements in project management. For example, one irrigator noted that there might be a steep learning curve for the new management team:

> I kind of think that [turnover] would hurt us for a couple of years. Any time you make a change in a system, it's going to affect a whole lot of people. Because the people who you are putting in charge have never done it before [and] don't know what the hell they are doing. These people who are running this system now, they've been doing it for 20 years so they know everything that's going on. But if you put somebody new in there, what happens? (JD2b)

As compared to other policy and management issues in the basin, the current negotiation of the CSKT federal reserved tribal water right received relatively little attention. However, several irrigators did comment on the negotiation process and its potential effect on irrigation water use in the basin. One irrigator located on the FIP noted that the process seemed to be entrenched in a power struggle as opposed to an equitable distribution of water. Further, this irrigator was concerned with this aspect of the negotiation and how it might affect future access to irrigation water:

> I think that the Tribe and the state and the federal government, with their water issues and rights, have made it worrisome, a worrisome problem for the irrigators in this part of Montana because it's been a major issue in the headlines now for quite a number of years. Nobody has really wanted to sit down and really [negotiate], at least with the knowledge that I have. It has been a struggle and it seems to be a power struggle… I guess it worries us all at some point here. I have thought about selling out and still think about it that maybe this is not a good place to be because of the water right issues. If it were all being done for the land and the people and shared equally without a power struggle… I would say if it were done for the good of all then I wouldn't worry about it, but I'm not sure how it's going to work out. So it can sure change what goes on here and the farm and ranch land as far as that goes. It could change the valley with the land and things and our investment. (JD1)

In contrast to the above statement, another FIP irrigator noted that a compact could possibly benefit irrigators on the project. He believed that the CSKT were likely to be compensated financially in their federal reserved water right settlement and that this money would be used to improve water management which, in turn, could ultimately help irrigators:

> The whole compact negotiations is deciding how much water will be available, measuring that water better… All of the previous reservation negotiations have gotten money… mitigation. And in most cases it's been a lot of money to invest into projects to improve the management of water flows. Here the Tribes are also talking and seeking mitigation with water from Hungry Horse dam so the Tribe could then get more access to water for a variety of uses that they want to put it in. (FD3)

The potential impacts of the compact negotiations were not just a point of concern for FIP irrigators. One Flathead County irrigator commented on the negotiations from an upstream prospective. He noted that the compact negotiation could impact irrigators in Flathead County as they are upstream of the potentially large, and still uncertain CSKT federal reserved water right:

> I think if most people really thought about it they would be more worried about the Hellgate treaty, that the Indians have with respect to the water [Federal reserved water right]… They have water rights to most of the basin just below Flathead Lake up this way in the northwest. (FC2)

## **Conclusion**

This chapter first included an overview of the interviewees' characteristics and then reported the interview results. Both manifest and latent content embedded in the interview data were organized into themes and documented. A comprehensive discussion of these themes and how they relate to drought vulnerability is provided in the following chapter.

# CHAPTER 6 - DISCUSSION

The purpose of this study was to explore how irrigators in the Flathead River basin are vulnerable to drought and how that vulnerability has changed over time. More specifically, the following four research questions were outlined at the onset of the study: 1) How have irrigators in the Flathead River basin experienced drought? 2) How do these experiences relate to drought vulnerability? 3) How have irrigators adapted to drought through time? And 4) How have those adaptations affected drought vulnerability? In this chapter, each question is addressed specifically in relation to the themes presented in Chapter 5 and the literature explored in Chapter 2.

## Irrigator Drought Experience in the Flathead River Basin

Risk-hazard geographers have long argued that the severity of a hazard's impact on a society is a due to both extreme environmental conditions and the way in which humans use resources (White 1974; Burton et al. 1978). While irrigators interviewed in the Flathead River basin conceptualized drought primarily as a physical phenomenon, themes from Chapter 5 indicate that their resource use may also be affecting how they experience drought.

Both Wilhite and Glantz (1985) and the National Drought Mitigation Center (2006) note that drought, at its root, is a function of climatic abnormalities. This also proved to be the primary way the irrigators interviewed in this research conceptualized drought. For example, below normal precipitation, high temperatures, and high wind were the three physical variables at the root of most irrigators' drought definitions. Irrigators' drought definitions, along with their descriptions of drought events, also explained how these physical variables manifested themselves in drought conditions. Here, drought conditions refer to the various ways in which irrigators reported drought physically affecting their agricultural operations.

At one level, irrigators reported that low growing season precipitation coupled with high heat and high wind can impact their non-irrigated crops and even, if conditions were severe enough, their irrigated crops as well. These conditions have largely been the focus of research studying agricultural drought. However, agricultural drought cannot solely account for the overall physical impacts of drought on irrigators' crops. As to be expected, irrigators also saw drought as a function of irrigation water availability. Here drought conditions consisted of low surface water flow, diminished reservoir levels, and, in one case, low groundwater levels. These conditions, as described by irrigators, are generally caused by low winter precipitation and/or fast snowpack melt rates resulting from high temperatures. Lastly, irrigators noted that drought could create habitat for weeds and pests like grasshoppers, which in turn can impact crop yields.

In respect to these physical drought conditions, normative conceptualizations of drought do not adequately describe the physical dimensions of irrigators' drought experiences. In the National Drought Mitigation Center's (2006) progression of drought framework, agricultural drought and hydrological drought are seen as two separate phenomena. This is not the case for irrigators in the Flathead River basin. As themes in Chapter 5 have illustrated, the physical impacts of drought on irrigators' crops are, in part, a function of these two types of drought. Further, no normative drought definition addresses the impacts of pests and weeds on agriculture, which, in the experiences of Flathead River basin irrigators, was a salient theme.

As noted in this chapter's introductory paragraph, themes in the interview data indicate that irrigators' resource use may also be affecting how they experience drought. The first trend of note is that FIP irrigators reported proportionally more occurrences of drought impacts than irrigators in Flathead County. This trend points to distinct spatial differences in the both the supply and demand of precipitation and irrigation water (a resource whose availability is conditioned by institutions). Further, this trend was evident regardless of the type of agricultural operation as irrigators who operated both farms and ranches reported being financially impacted by drought on the FIP. The second significant trend, or more appropriately, lack of trend, was that an occurrence of a drought impact was not related to the significance of the impact. This indicates that while FIP irrigators seemed to incur more drought impacts, there may be other factors influencing the relative severity of these impacts and its overall effect on their livelihoods.

## Drought Vulnerability

Trends in the human dimensions of the irrigators' drought experiences discussed above reveal an interesting multilevel structure of drought vulnerability. At one level, irrigators on the FIP seemed to be more vulnerable to drought occurrences than Flathead County irrigators. However, not all FIP irrigators seemed be equally vulnerable as the significance irrigators placed on these occurrences varied from case to case. This section explores some potential factors that may be contributing to drought vulnerability at each of these levels.

The apparent difference in drought vulnerability between irrigators on the FIP and those located in Flathead County may be explained, in part, by the changing vulnerability context in these two areas of the basin. The FIP was built in the early 1900s to provide security from the pitfalls of dry land agriculture and the hardships of drought. While the project succeeded in providing this security for a large number of white homesteaders, it also created an agricultural landscape where irrigators developed an early dependence on irrigation water. The irrigators of today have inherited both the irrigation structures that these original homesteaders used, as well as their dependence on irrigation water to operate profitable agricultural operations. However, these new farmers and ranchers are irrigating under a much different set of institutional arrangements which have affected how they can use water. Instream flows and bureaucratic BIA policies and practices have made it difficult for irrigators to utilize the same amounts of water that they have historically depended on. Relative to the historic demand on water resources, this reduction in "usable" water may be making FIP irrigators more sensitive to drought induced fluctuations in irrigation water supply.

This process can be conceptualized with an economic analogy: As the long term supply of a good (i.e., irrigation water) is reduced relative to a constant demand (i.e., irrigation), short term fluctuations in that good's supply (i.e., drought), which previously may have been trivial, tend have a greater impact. Often times termed socioeconomic drought, drought's effect on the supply and demand of goods has been noted as significant factor in determining how the impacts of drought are realized (Wilhite and Glantz 1985).

In contrast to the vulnerability context of irrigators on the FIP, irrigators in Flathead County have historically used less irrigation water and depended on it less to run successful agricultural operations. Additionally, Flathead County irrigators have not been subject to institutional change directly affecting water availability, as the irrigators from the FIP have. While an analysis of water availability relative to irrigation demands for Flathead County in comparison to the FIP is far beyond the scope of this study, it is not unrealistic to propose that this may be an important factor in understanding why Flathead County irrigators are seemingly less sensitive to drought.

This comparison of the vulnerability context shows that, for FIP irrigators, a relatively higher dependence on irrigation water, coupled with institutional change affecting the availability of water resources, may be at the root of the observed difference in drought vulnerability. In the literature, the effect of institutions on the vulnerability of groups and individuals has been emphasized from within the political economy perspective. Following Wisner et al. (2004), vulnerability occurs when a person's access to resources is diminished by structures of dominance and is not just a product of their socioeconomic status or individual decision-making. For irrigators on the FIP, inefficiencies in water management seem to be impacting the amount of irrigation water available regardless of the actual decision-making or socioeconomic status of the irrigator.

While this argument helps to explain why FIP irrigators may be more vulnerable to drought than Flathead County irrigators, it does little to explain why, despite reporting similar drought impact occurrences, some irrigators seem to be more vulnerable to drought than others. While no interview data point explicitly to an explanation of this variation, it might be argued here that this trend is largely a product of the struggle to cope with the economic challenges of agriculture. In broader terms, Cannon et al. (2002) address this concept in their sustainable livelihood approach to vulnerability. At its core, they argue that sustainable livelihoods are more likely to have a better capacity to withstand a hazardous event.

The economic reality of agriculture in the Flathead River basin is that it is becoming increasingly unprofitable to farm or run a cattle operation. Irrigators noted that the value of their agricultural outputs have not been able to offset the increasing cost of farm inputs. This is not a new trend in agriculture. The National Agricultural Statistics Service has reported that, since 1900, "the prices farmers receive for their production have gone down when compared to the costs associated with producing agricultural commodities" (National Agricultural Statistics Service 2009). While economies of scale have allowed many farmers and ranchers to remain profitable, it has pushed the ones who cannot employ these to the economic margin. In this margin, the impact of a drought related income loss is likely to be more significant.

In the Flathead River basin, this process of marginalization has likely been aided by several local factors. For example, in Chapter 5 it was reported that reduced labor availability was adding to the economic challenges of farming and ranching. Additionally, other less obvious factors might include the fact that the homesteading history of the FIP has left a legacy of small land parcels. Many technological advances in farming are not economical at this scale. For instance, one FIP irrigator noted that he couldn't afford to put in a center pivot on most of his land because his field sizes are not big enough to see a return the initial investment of the system.

However, unlike many marginalized people and groups, irrigators in the Flathead River basin have the ability to more freely change the structure of their livelihood. In fact, most irrigators in the basin are in agriculture because they enjoy the lifestyle. This is an important difference between the irrigators interviewed in this research and many other studies of vulnerability that focus on issues in the developing world. For many of the irrigators interviewed here, the ability to restructure their livelihoods has resulted in engaging in off-farm work. While this topic was not specifically addressed in the interviews as a factor tied to drought impact reduction, it became evident through both manifest content in the interview data and field observations that off-farm wages had become an important aspect of many irrigators' livelihoods. Off-farm wages allow irrigators to collect supplemental income, which can, in turn, offset reductions in the profitability of their agricultural operations. Subsequently, drought related income losses are likely less significant relative to overall income.

In the end, variations in the significance of drought impacts seem to be caused by the continual cycle of economic struggle and economic adaptation. For some irrigators, the successful transformation of their agricultural operations into more efficient and economically sustainable farms has allowed them to buffer themselves against the financial impacts of drought. However, those who cannot cope with the economic challenges associated with an agricultural lifestyle have been pushed to the economic margins. In turn, this marginalization may be at the root of why some irrigators in the basin perceive the impacts of drought to be more significant than others.

## Adaptation

Irrigator responses to both drought and future climate change were reported in the previous chapter. Further, the drought and climate change responses of the irrigators interviewed in this study can be analyzed in terms of adaptation and adjustments. Following White and Haas (1975), adaptation refers to purposeful long-term changes in behavior made in response to a hazard and adjustment refers to short-term responses used to cope with hazardous events. By analyzing the responses of irrigators presented in Chapter 5, it can be seen that the majority of drought responses that irrigators reported making can be classified as adaptations (Table 6.1). This section analyzes these responses in order to understand what factors may be influencing these adaptation responses.

**Table 6.1 Irrigators' Adaptations and Adjustments**

| Adaptations | Adjustments |
|---|---|
| Improve sprinkler nozzle efficiency | Selective irrigation |
| Purchase center pivots | Sell cattle |
| Deep wells | |
| Change crop patterns | |
| Change crop timing | |
| Keep hay reserve | |

Examining the adaptations of irrigators more closely, it can be seen many parallel the responses that irrigators reported in relation to economic and policy/management constraints presented in Chapter 5. This indicates that drought adaptations may be highly influenced by their perceived effectiveness in responding not only to drought, but to other contextual factors that irrigators perceived to be challenging to live with. More specifically, irrigators seem to be making decisions using what Burton et al. (1978) termed a bounded rationality. For example, the purchase of a center pivot may reduce the impacts of drought. However, it also reduces labor needs and, for irrigators on the FIP, it reduces the uncertainty associated with inefficient FIP flows. In other words, the decision to purchase a center pivot in response to drought was bounded by its effectiveness in resolving other perceived constraints on their livelihood.

The response of “do nothing” was also a prominent drought response. Further, this response was highly influenced by the perception that drought was a phenomenon that you cannot do anything to prevent. Following Tversky and Kahneman (1974), this appears to be the anchoring and adjustment heuristic at work. Throughout history, as noted by Smith (1996), the dominant view of hazards has been that they are the will of Mother Nature or God and there is nothing that humans can do to prepare for them. While, in many cases, there are known steps that can be made in order to reduce the impacts of drought, irrigators failed to respond due to their “anchoring” on this dominant perception of drought hazards.

In regard to climate change, a much different explanation seems to be behind why irrigators overwhelmingly reported that they had not or were not planning on taking any action against the potential impacts of climate change. Climate change, for most irrigators interviewed, took on a very political connotation. Further, it was strongly associated with a liberal political agenda which many perceived not only skeptically, but with downright distrust. At work here may be some of the processes introduced by Kasperson et al. (1988) in their Social Amplification of Risk framework. This framework helps to explain hazard perception and response by incorporating the effects of societal perceptions on individual decision-making. Here, an individual “tunes in” to society’s collective perceptions in order to form his or her own perceptions of risk. In the Flathead River basin, irrigators seem to be tuning into the political connotation society is attaching to the issue of climate change and the level of risk attached to that ideology.

## **Adaptation and Vulnerability**

In hazard research there has traditionally been a strong relationship between purposeful hazard response and reductions in vulnerability. Risk-hazard geographers like White (1974) and Burton et al. (1978) emphasized that the adaptations and adjustments of an individual to a hazard were the predominant determinants of their hazard impact. However, hazard and vulnerability researchers from the political economy perspective have argued for a different conceptualization of vulnerability that focuses more on the underlying political processes that affect economic interactions and the distribution of resources (Adger and Kelly 2001; Wisner et al. 2004). In this theoretical perspective, individual actions can rarely affect the higher-order institutional processes that are at the root of vulnerability (Brooks 2003).

Based on the irrigator interviews conducted for this thesis, the conceptualization of vulnerability presented in this chapter leans more toward a political economy perspective. Trends in irrigators' vulnerabilities to drought did not seem to be due an inability to adapt or change. In fact, drought for irrigators in the Flathead River basin was only a small uncertainty associated with the bigger challenges of agriculture in the basin. In contrast, the challenges of dealing with water policy or economic struggles associated with agriculture were often an irrigator's primary concerns. Further, it was these challenges and the struggles of coping with them that end up best explaining patterns in irrigators' vulnerabilities.

Given these higher-order economic and policy/management issues that seemed to be at the root of drought vulnerability, individual drought adaptations, as reported by irrigators, do not seem to be major factors influencing the long-term trajectory of drought vulnerability in the basin. This is not a major surprise as the political economy perspective in vulnerability emphasizes that adaptation at the individual level rarely has a large effect on the higher-level processes that are often at the root of hazard vulnerability.

However, it should be noted that the discussion of drought vulnerability described thus far in this chapter is based on a simplified view of the irrigator drought experience. While adaptations may not be directly "fixing" the root causes of vulnerability, they are still part of a complex set of variables and factors affecting how irrigators experience drought. As noted by Burton et al. (1978), the absorptive capacity of a society can be reduced by one factor while at the same time increased by another. In this respect the adaptations of irrigators in the Flathead River basin are, at some level, still likely to be playing an important role in improving irrigators' capacity to absorb the impacts of drought.

# CHAPTER 7 - CONCLUSION

This thesis presented four research questions aimed at exploring the drought experiences, drought vulnerability, and the drought adaptations of irrigators in the Flathead River basin. A qualitative methodology was used to collect primary data through semi-structured interviews. The results of these interviews were reported and then discussed in relation to the research questions presented at the beginning of this thesis. This chapter reflects on this research and highlights both the empirical and theoretical implications of the findings. Additionally, it notes both the limitations of this study and possible avenues for future research.

## Implications

The primary empirical implication of this study is that several patterns in the drought vulnerabilities of irrigators in the Flathead River basin appear to be driven by the political economy of irrigation water use and agriculture. More specifically, water resource management on the FIP and the world agricultural market may be acting as structures of dominance for irrigators in the basin. Further, these institutions seem to be negatively affecting access to resources during drought and, in turn, creating drought vulnerabilities. Introducing institutional change that minimizes these structures of dominance in order to reduce drought vulnerability is not likely to be within the power of an individual irrigator. However, local policy makers and water managers can play a role in changing these structures of dominance and, in turn, reducing drought vulnerability in the basin.

On the FIP, where irrigators reported more occurrences of drought relative to Flathead County irrigators, improving water resource management in order to reduce drought vulnerability is a very doable task. For example, the May 2010 decision by the Department of the Interior to transfer management of the FIP to a new management structure made up of both FJBC and CSKT representatives seems to be a step in the right direction. While this decision was not based on concerns over drought, the knowledge that such changes in management could have beneficial reductions in drought vulnerability could provide an incentive to continue to improve water management on the FIP and into the future.

In regards to the effect of the agricultural economy on drought vulnerability, it would be unrealistic to believe that there is much that can be done locally to reverse the continuing economic marginalization of agriculture in the basin. However, as noted in the discussion, many irrigators have structured their lives in a way that has made them less financially vulnerable to the impacts of drought. For example, engaging in off-farm employment has allowed many irrigators to remain in agriculture and subsequently increase the sustainability of their livelihood. Further, this type of income diversification may be responsible for a reduction in drought vulnerability for irrigators. This type of economic resiliency should be encouraged.

Lastly, the empirical implications of the lack of individual adaptation to future climate change should also be noted. While this thesis emphasizes that drought adaptations are not “fixing” the higher level institutional processes at the root causes of drought vulnerability, it still notes that these adaptations are most likely playing a role in allowing irrigators to cope with drought. The unwillingness to make additional adaptations in response to future drought as they are affected by climate change may render irrigators unprepared and less able to cope. However, this does not have to be the case. Irrigators strongly associated climate change with political ideologies. Better communication between climate change scientists and irrigators may work to remove this political barrier and earn the trust of irrigators who, as noted in the introduction, are the sector likely to be the most affected by drought given projected climate change.

The findings in this thesis also have theoretical implications. Vulnerability theory has been influenced by a wide range of scholars coming from a number of different academic traditions. While this has allowed vulnerability theory to grow, it has also led to a complex understanding of how vulnerability is constructed. The findings in this thesis drew primarily from the political economy tradition in vulnerability. This view, which emphasizes the role of institutions in creating vulnerability for certain people or groups, was largely developed though case studies of disasters in the developing world. This thesis showed that, although people in the developed world are often thought to hold more power over the circumstances of their own livelihood, they can still be affected by institutional processes that inhibit their ability to absorb hazardous environmental conditions.

## Limitations

This study used a qualitative methodology in order to develop themes based on irrigator interviews. While this methodology revealed important themes regarding the experiences of the irrigators interviewed, they should not and cannot be generalized to all irrigators in the Flathead River basin. In this regard, the findings presented in this thesis should not be viewed as definitive but as exploratory.

Further, the interview sample for this research may not portray the "average" Flathead River basin irrigator. For example, the purposive sample excluded small-scale irrigators and sampled heavily from prominent irrigators in the community that were prominently involved in basin water policy. This was, in part, a product of the interview sampling technique employed. In particular, the use of FJBC meeting minutes to identify potential interviewees may have biased the sample toward interviewees who are more concerned with policy issues than the typical irrigator.

## Future Research

This thesis, due to its exploratory nature, has opened up many areas for additional research. First, much of the drought vulnerability discussion in this thesis is based on themes observed in qualitative data. Future research is needed to validate these themes and assess to what degree they can be generalized. Specifically, the incorporation of a randomized sample that takes into account both the spatial and socioeconomic variations in an irrigator's livelihood should be used.

Additionally, a more thorough exploration into the role of adaptations in hazard reduction, and specifically climate change hazard reduction, may be useful. In this thesis it was found that adaptation and/or the lack of adaptation were not directly related to the root causes of drought vulnerability. However, it was theorized that adaptation still plays an important role in allowing irrigators to cope with drought, given these larger vulnerability issues. Understanding to what degree these adaptations play a role in allowing irrigators to better cope would also provide valuable insight into the nature of drought vulnerability in the Flathead River basin.

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## APPENDIX 1 – INTERVIEW GUIDE

How are you today? Before we start I'd like to ask you if you have any questions.

You can stop the interview at any time or refrain from answering a question if you would not like to answer it. If you have any questions during this interview session please let me know.

Please read through and sign the informed consent waiver. Also at the end of the consent document there is a statement of consent to be audio taped. I would like to audiotape this interview so I can more accurately transcribe your statements at a later time. Do you have any questions about the consent form?

*Warm up questions*

Where do you irrigate?
What do you irrigate?
How much land do you irrigate?
What kind of irrigation methods do you use (wheel line, center pivot, etc.)?
How long have you been farming?
What kind of water rights do you hold (if applicable)?

*Defining water shortages*

Q.1 How important is your irrigation water supply to your farming operation?

Q.2 Have you experienced water shortages in the past?

Q.3 What kind of water shortage issues have you encountered?

Probe: Water delivery issues?
Probe: District's allocations?
Probe: Do you think the irrigation community (District or otherwise) experiences similar issues?
Probe: How important are these issues to your farming operation?

Q.4 Have these issues gotten better or worse over time?

Probe: what has caused this change or changes?

*Drought experiences*

Q.5 How would you define drought?

Q.6 Has drought affected your access to irrigation water?

Probe: Is irrigation water supply your main drought concern?

Q.7 Can you remember any specific drought events that affected you?

Probe: How did these events affect the community (District or otherwise)?
Probe: Why were these events so damaging?
Probe: Did you take any steps to better prepare for drought after those experiences?
Probe: Are there any other drought events that you can remember?
(Repeat drought experience questions in order to record multiple drought events)

Q.8 How worried are you about future drought and/or climate variability?

*Policy constraints*

Q.9 Is there any specific legislation, policy, or management rules or regulations that have made getting the water you need for irrigation more difficult?

Probe: Why have these policies (legislation, regulations etc.) been challenging to deal with?

Q.10 Have there been any policy changes that have improved your access to water?

Probe: How did these changes improve access to water and/or water management in the community?

*Future mitigations*

Q.11 How have you prepared for possible water shortages and drought?

Probe: What kinds of changes in irrigation practices have you engaged in?
Probe: What kinds of policies have been helpful?
Probe: What kinds of policies would be helpful?

Q.12 What still needs to be done to better prepare for water shortages and improve irrigation water management?

Probe: For yourself?
Probe: For the community?