SOCIO-ECONOMIC VULNERABILITY OF PRAIRIE COMMUNITIES TO CLIMATE CHANGE

SUMMARY DOCUMENT

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*This summary derives from a much larger study. If you wish to see the full study, you can access it at by clicking on the link to "**publications**".*

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INTRODUCTION

The potential impact of climate change on the Canadian Prairies will vary from region to region and among different economic sectors (Cohen et al. 1997; Watson et al. 1998). Our understanding of these potential impacts is limited by a number of critical uncertainties, including those inherent in economic and social models (Kates et al. 1985; Stabler et al. 1988). These uncertainties limit our ability to identify the full impacts of prescriptive adaptation measures. In almost all cases, the effects of climate change have been examined either from the perspective of their impact on specific sectors of the economy, or on a regional basis. Research into the socio-economic impacts of climate change on individual Prairie communities has not previously been undertaken and represents an important gap in the scale of spatial coverage.

In order to determine the potential effects of climate change on the social and economic fabric of a region, and to develop effective adaptation strategies, quantitative measures of both the degree of vulnerability as well as adaptability of a region, must be developed. This is a necessary first step for developing policies aimed at mitigating the social and economic dislocations that may result.

This study was designed specifically to address the vulnerability and adaptability of Prairie communities to climate change by means of a comprehensive model (termed the Socio-Economic Vulnerability, or SEV model) utilizing standard and widely applicable data sources.

CLIMATE CHANGE IN THE CANADIAN PRAIRIES

The present climates of the three Prairie provinces are characteristically dry-continental, and range from cold-temperate in the southwest to sub-arctic along the shore of Hudson Bay. This region has been divided into two main regions, the Prairie region with an average precipitation of 300-500 mm, and the North-Western forest region, with 400 to 550 mm average precipitation. Past climatic fluctuations can be classified into 3 phases over the past 100 years: a warming trend from the 1890s until the 1940s, a cooling trend from the 1940s to the 1970s and a warming trend from the 1980s until present.

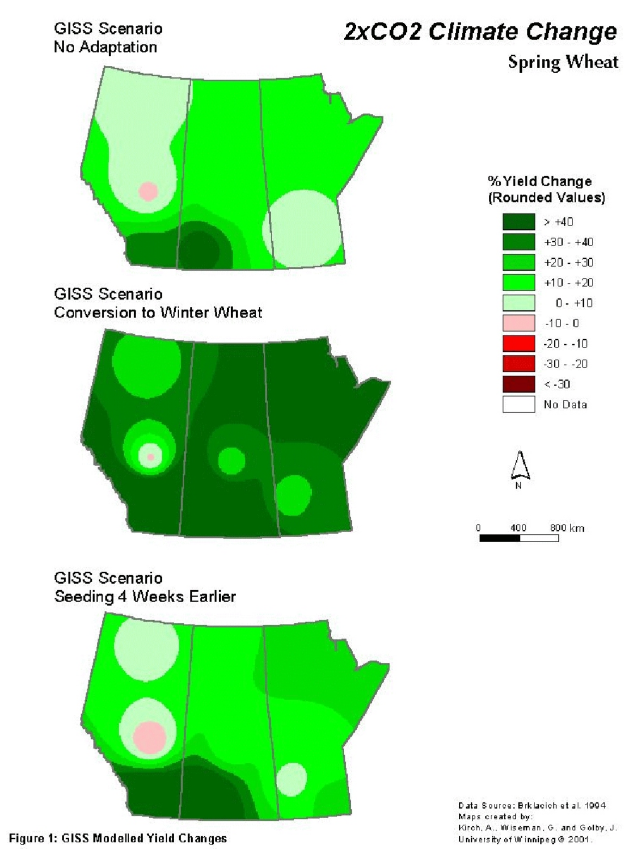


Figure 1. Predicted changes in spring wheat yields as examples of SEV model outputs for various climate change and adaptation scenarios (GISS model).

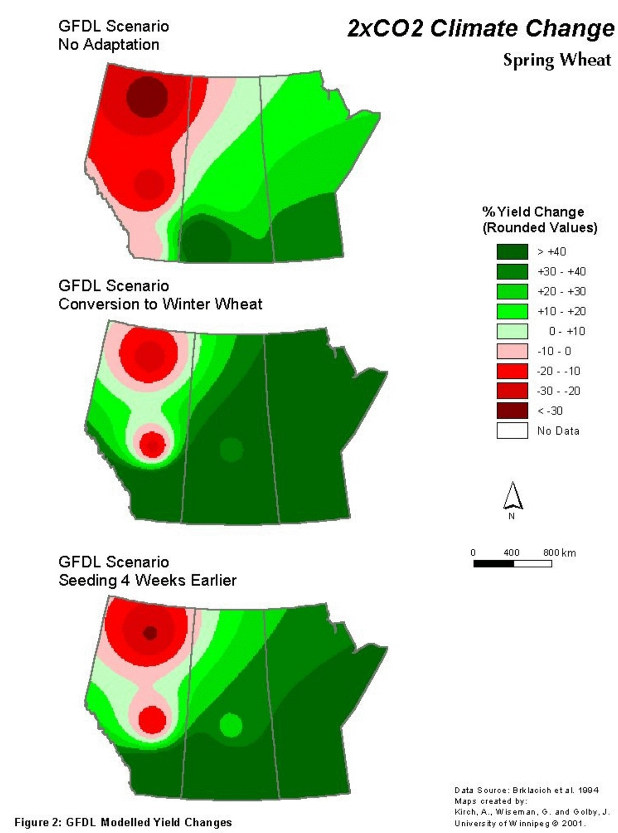


Figure 2. Predicted changes in spring wheat yields as examples of SEV model outputs for various climate change and adaptation scenarios (GFDL model).

The impacts of climatic change are numerous. It affects the biophysical settings of individual areas and can result in a shift of existing biophysical zones. In addition to focussing on shifting climate and biophysical zones, climate change impact can be assessed in terms of risk within biophysical zones or in terms of vulnerability at the spatial, economic, or social margins.

Climate change trends have been modelled using various Global Circulation Models (GCMs). Model results used in publications pertaining to this study originated from the Geophysical Fluid Dynamics Laboratory (GFDL) Model, developed at Princeton University, the GISS model, developed by the Goddard Institute of Space Studies (NASA), the United Kingdom Meteorological Office Model (UKMO), and the Canadian Climate Centre General Circulation Model (CCC GCM) of Environment Canada. The models assessed the effect of twice the amount of CO_2 in the atmosphere, as compared to pre-industrial standards.

All GCMs predicted an increase in precipitation, which would offset the moisture stress resulting from the increased temperatures. However, historical periods of warmer weather did not coincide with increased precipitation. In order to accommodate the uncertainty of elevated precipitation, most studies used two sets of GCMs: in the first run, temperature increases were calculated along with base-line precipitation, while in the second run, predicted (increased) precipitation was used.

IMPACTS OF CLIMATIC CHANGE ON AGRICULTURE

Agriculture is vulnerable to climatic change due to its strong dependence on climatic conditions. Temperature stimulates plant growth through daily variations as well as through the length of the growing season. Increased temperature usually indicates higher growth rates although it may also increase evapotranspiration, water demand, and the risk of insect infestations. Precipitation can be a limiting factor to plant growth due to either excess or lack of moisture. Droughts, especially severe ones such as those in the 1930s and 1980s, have the most obvious, drastic, and immediate effects on agriculture. Effects are usually exerted through changes in crop yields.

However, impacts on agriculture exceed the effects within agricultural zones due to the shifting of the boundaries of these zones. An increase of 1° C may move the boundary of a high-latitude cereal-growing region several hundred kilometres north under late 1980s technology and economic constraints, assuming the soils are suitable.

THE SEV MODEL

The SEV model which was developed in this project largely benefits from the use of a geographic information system (GIS), which provided a means of spatial and non-spatial database management. The GIS also provided a platform for visual display of model results. An interactive submodule within the initial agriculture model, which allows extensive user interaction, was developed for six test locations: in Manitoba, the rural municipalities (RMs) of Stanley and Swan River; in Saskatchewan, the RMs of Indian Head and North Battleford; and in Alberta, the Counties of Stettler and Athabasca.

Impacts of climate change on the agriculture sector in a RM or county were evaluated by calculating changes in producer surplus for various crops (using a particular year as a baseline). Net revenue from agriculture in a RM was based on crop production costs, crop prices, acreage and crop yields. Yield changes published by various authors simulated changes in revenue from agriculture. The net revenue effect of climate change on the RM income from agriculture was then assessed by calculating the difference in net revenue before and after climate change. In order to assess the combined effect of each scenario on all crops, the net revenues before and after climate change and the revenue effects were summed for all assessed crops in the RM.

Given the large number of climate change scenarios that are available, the various climatic parameters that can be varied, and the number of biophysical models available, the various model runs which were undertaken yielded a range of possible outcomes in terms of crop yields. As an example,

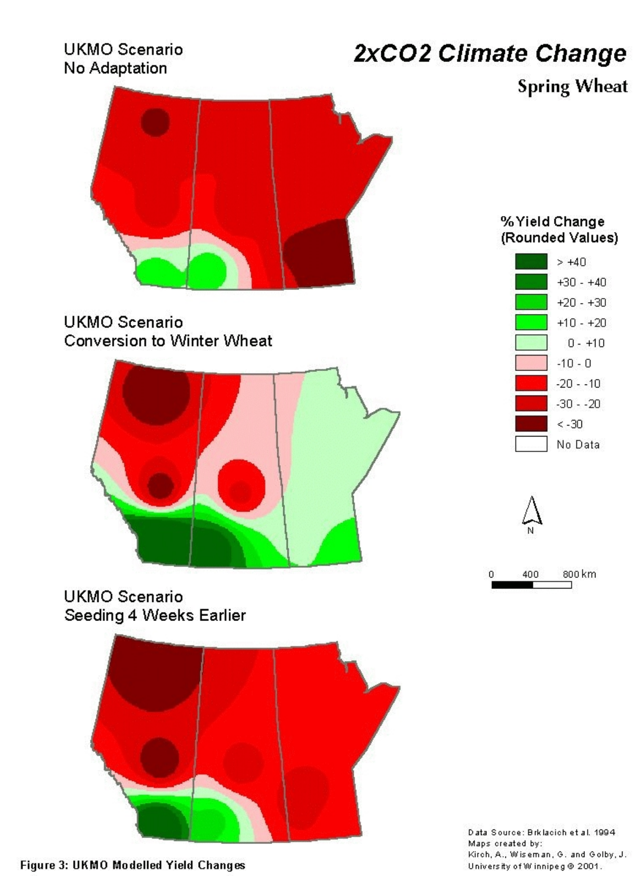
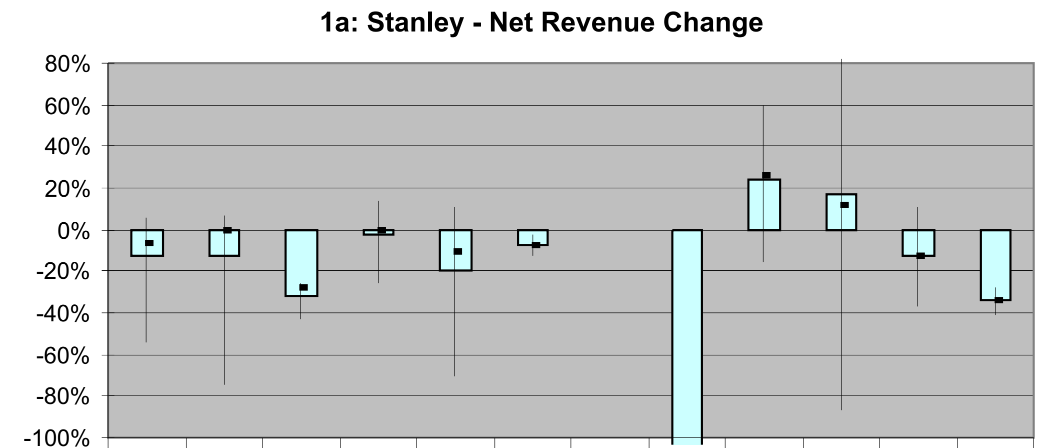


Figure 3. Predicted changes in spring wheat yields as examples of SEV model outputs for various climate change and adaptation scenarios (UKMO model).



	Barley	Canola	Corn (Grain)*	Flax	Oats	Potatoes*	Soybean*	Sunflower*	Tame Hay	Wheat	Cereal	Oilseeds
Average	-13%	-13%	-32%	-2%	-19%	-8%	0%	-208%	24%	17%	-13%	-34%
Max	5%	7%	-26%	14%	10%	-3%			60%	127%	11%	-28%
Min	-55%	-75%	-43%	-26%	-70%	-12%			-16%	-87%	-37%	-41%
Median	-7%	0%	-28%	0%	-10%	-8%			26%	12%	-13%	-34%

Figure 4. Predicted changes in yields of various crops, as expressed by percent change in net revenues, for the Rural Municipality of Stanley, Manitoba for the full range of climate change scenarios examined.

Table 1 shows the predicted changes in crop yields for various locations across the Prairie Provinces (from an earlier study) assuming conversion to winter wheat and seeding 4 weeks earlier.

The main output of the SEV model is a series of maps of the Prairie provinces colour-coded to show expected changes in crop yields under the various climate change and biophysical models. Figures 1-3 show the SEV model outputs using three different global circulation models (GCMs) for spring wheat. It is apparent that predicted yields are sensitive to the particular climatic scenarios selected and it is expected that the results derived from the various models will increasingly converge as the accuracy of the global circulation and biophysical models improves. Nevertheless by incorporating a high degree of user interactivity into the model, users can select from among various scenarios.

Figure 4 shows the range of predicted changes in crop yields for various crops from one of the six Rural Municipalities (Stanley, Manitoba) selected for detailed model development. It can be seen that using the full range of available global circulation and biophysical models results in a large range of predicted impacts on end yields. Figure 5 shows a more detailed assessment of the individual SEV model runs for a single crop (wheat) in the RM of Stanley, Manitoba. By embedding these economic models in a geographic information system and providing a high degree of user interaction, it is expected that such models will become increasing useful and important for decision makers, stakeholders, and as a public education and outreach tool, as the results of climate change can be brought down to the local level and the results, being displayed in map format, have a greater impact.

Table1: Yield Changes in % Using Various Climate Change Models and Adaptation Strategies (Conversion to Winter Wheat and Seeding 4 Weeks Earlier).

Scenario:	GISS			GFDL			UKMO		
Location:	No Adaptation	Winter Wheat	Earlier Seeding	No Adaptation	Winter Wheat	Earlier Seeding	No Adaptation	Winter Wheat	Earlier Seeding
Winnipeg	10	39	22	40	62	56	-40	13	-15
Lethbridge	40	200	92	-7	145	90	17	139	68
Fort Vermillion	6	22	6	-35	-25	-31	-31	-42	-42
Ellerslie	-2	-1	-10	-26	-23	-20	-25	-39	-41
Swift Current	50	132	75	66	167	117	19	48	24
Prince Albert	14	23	12	13	35	27	-26	-25	-25
Dauphin	2	21	5	31	49	41	-32	2	-28

Source: Adapted from Brklacich et al. (1994).

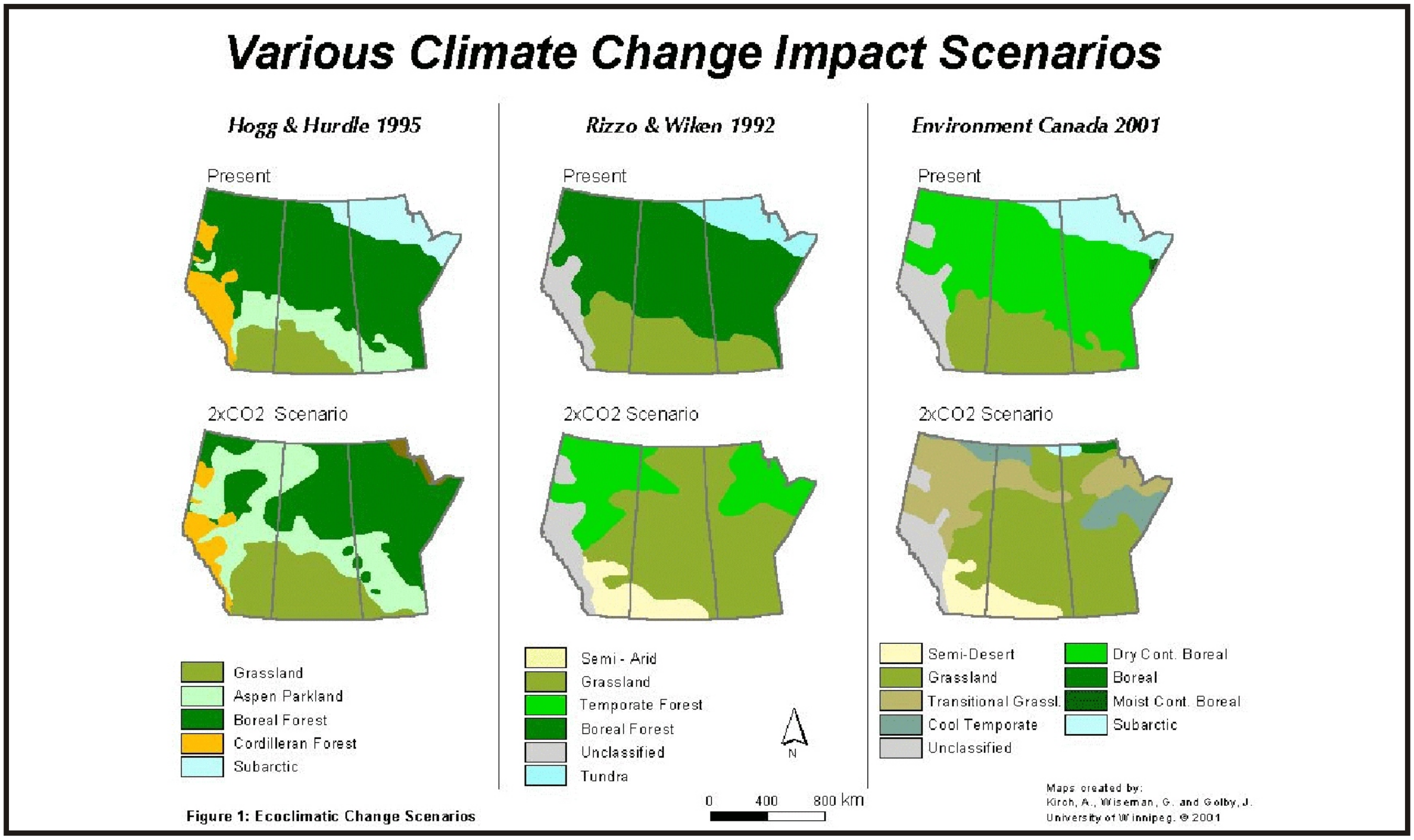


Figure 1: Ecoclimatic Change Scenarios

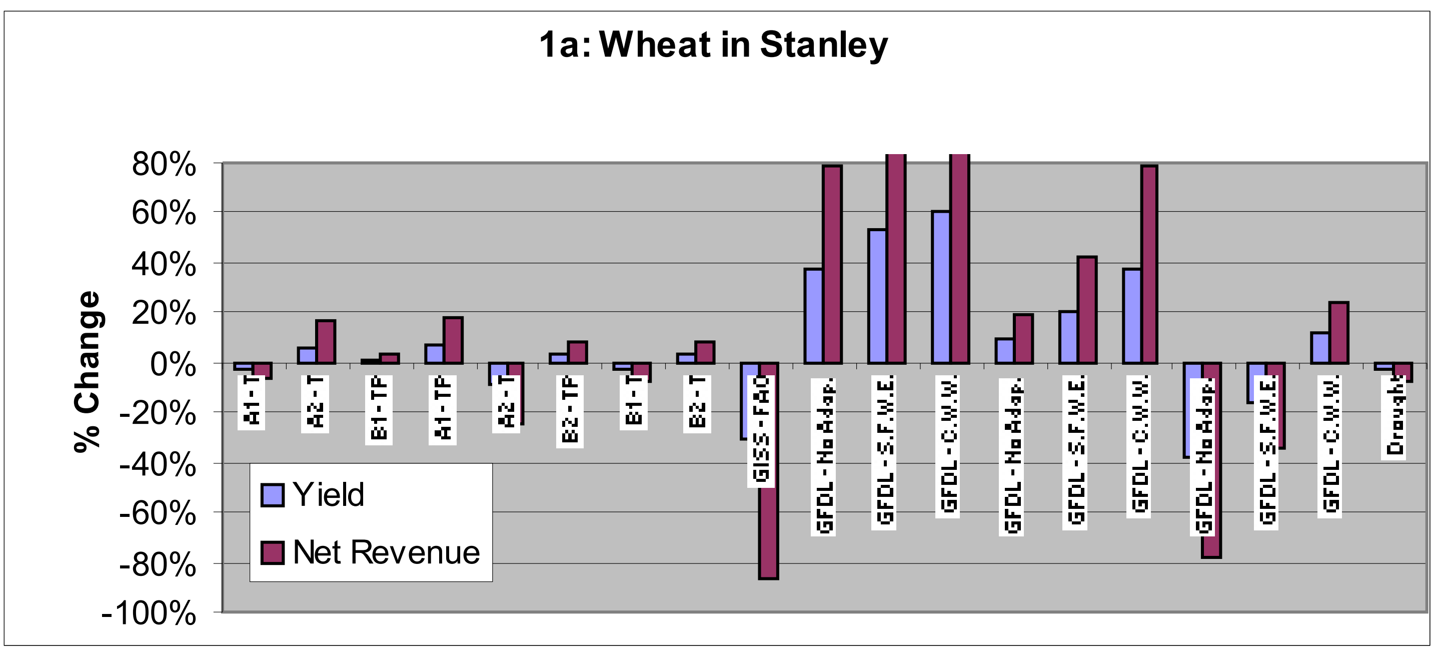
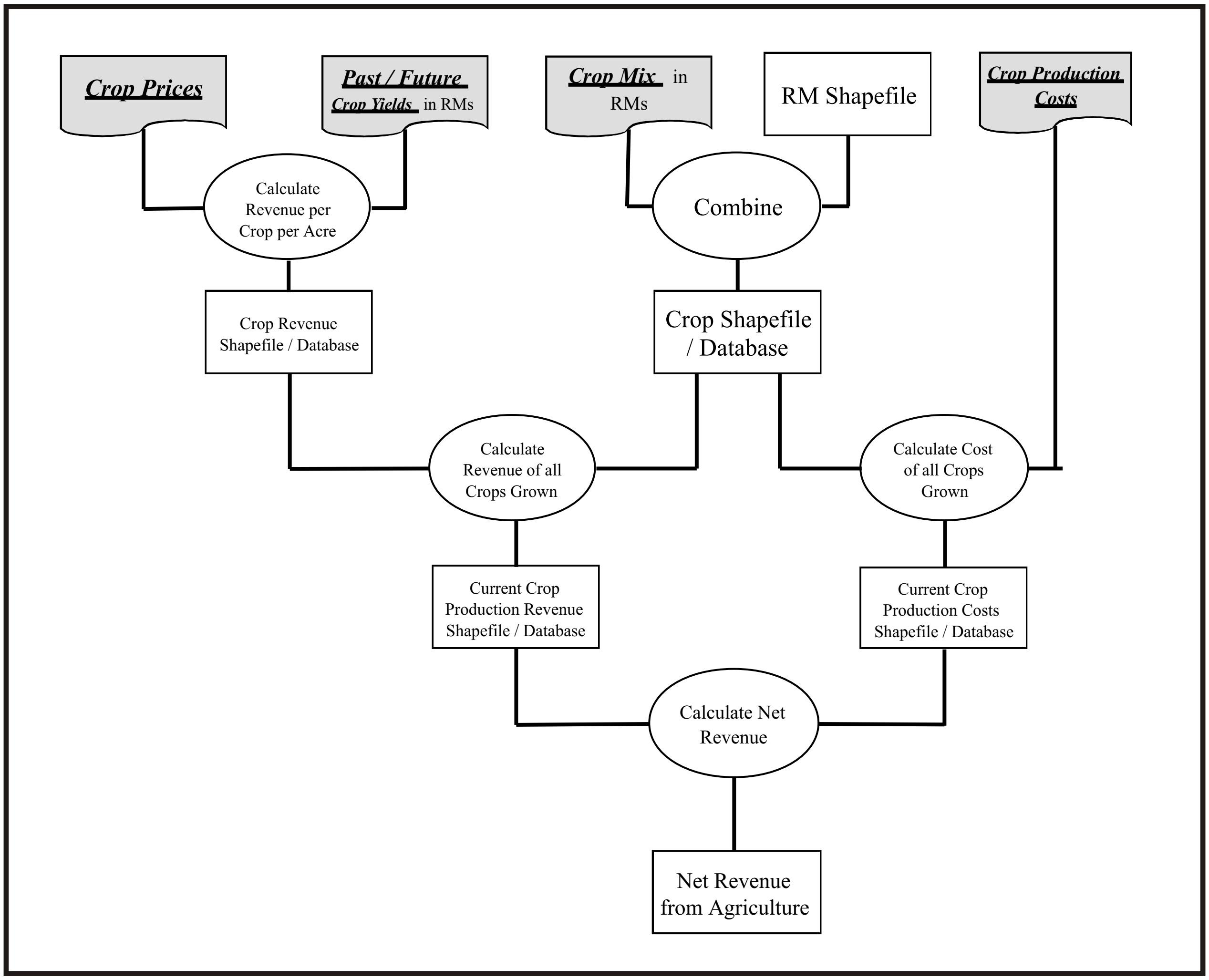
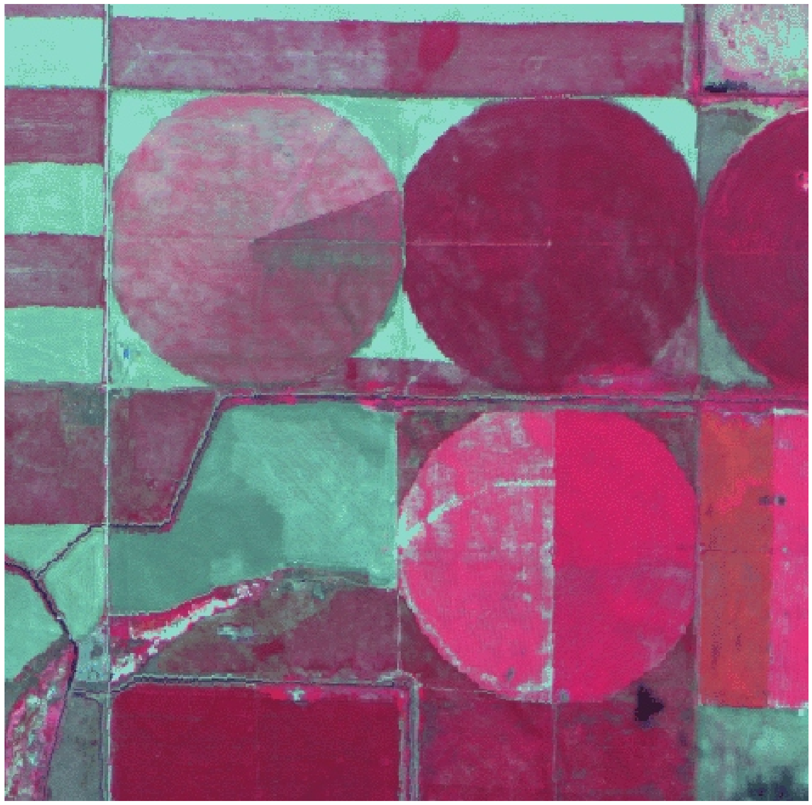


Figure 5: Predicted percent change in wheat yields for the Rural Municipality of Stanley, Manitoba for various climate change scenarios.



FUTURE DIRECTIONS

The results obtained to date in the development of the SEV model amply demonstrate the utility of a GIS-based framework for exploring and visualizing the impacts of climate change on the Prairie provinces. Future model developments will include refinement of a forestry submodel, as well as the development of additional models for other economic activities. The open architecture of the SEV model also allows for new GCMs and biophysical models to be readily incorporated in the future. The ultimate goal is to develop a comprehensive SEV model which captures the full range of economic activities in Prairire communities. When coupled with a high degree of interactivity, the full SEV model will provide a very powerful tool for decision makers, stakeholders, and the general public, as it will be able to assess the economic impacts of changes in the fabric of Prairire communities associated with various adaptation strategies.



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