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Risk assessment in new drought environments

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There are now few doubters that Earth's temperature, especially in the Northern Hemisphere, is warming at a much faster rate over the last 100 years than at any equivalent period in the past thousand. There is also a consensus within the scientific community that this phenomenon, widely referred to as global warming, is being driven by greenhouse gases pumped into the atmosphere from anthropogenic sources. Arguably, the greatest impacts of global warming on land will be felt within water systems. Because water is the web of life, those impacts will flow through other areas of life support systems including terrestrial ecology, agriculture, industry and hygiene. Yet, global warming-water resource connections are among the areas of climate science where uncertainty prevails in spite of considerable research efforts directed at them. Understanding global warming-induced change in precipitation could go a long way towards reducing that uncertainty.

Based on convergence of several reputable models, two broad patterns of change in precipitation are indicated. 1. Land areas in the northern hemisphere where precipitation is at present adequate or better, should receive more. 2. Semi-arid and arid lands where precipitation is currently short will receive even less. Both scenarios represent challenges which must be overcome to maintain or achieve environmental sustainability in affected regions. A first step towards either goal lies in estimating the risk posed by the anticipated change. The second step is to design strategies to reduce the risk. Here we consider the 2^{nd} of the two challenges, i.e. reduced precipitation in semi-arid areas. We select a potential increase in drought frequency as the hazard represented by the expected decline in precipitation and agriculture as the exposed system. We demonstrate a methodology for estimating risk to agriculture due to higher drought frequency and validate it. Finally, we consider strategies for risk reduction in drought-threatened agricultural systems. The methodology is tested with western Canadian data.

Risk of a given outcome of a hazardous event to an exposed system is a function of the event and the vulnerability of the system to it. Vulnerability is the potential impact of the event mediated by the adaptive capacity and resilience of the system. We quantify risk as potential loss of farm income due to a higher frequency of severe droughts. Exposure is the product of probability of a drought and the time window 2050-2080, both obtained from projections made by the Canadian climate centre coupled AOGCM. Spatial distribution of drought intensity in the time window is derived via downscaling in a GIS-Statistical environment based on comparable data from the major drought events of the 1930s and 1980s. Pre-1930 average farm income (all monetary values are adjusted to 1999 USD) is the base income for measuring impact. The difference between revenue during the events of the 1980s and 1930s coupled with trends in farm income since is used to quantify adaptive capacity/resilience. Risk is subsequently determined as a function of the hazard, exposure and vulnerability. The resulting data validated with farm income during the drought of 2000-2001 are subsequently scaled to produce a risk map for 2050-2080. We show that vulnerability, and consequently risk, can be reduced over the time window through an extension of lesson learned from 20^{th} century drought events.