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Socioeconomic Impacts of the Satellite Enhanced Snowmelt Flood Predictions in the Red River of the North Basin

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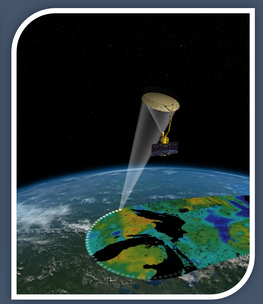
Project Overview

This proposed project will conduct an impact assessment on the enhanced snowmelt flood forecasts developed by Jacobs et al. (2014, 13-WATER13-0036) which use satellite remote sensing to improve snow water equivalent (SWE) and snow-covered area (SCA) estimation as well as snowpack ripening in the Red River of the North Basin (RRB). The Jacobs et al. (2014) project is a joint effort of the University of New Hampshire (UNH), North Dakota State University (NDSU), the North Central River Forecast Center (NCRFC), the USACE Cold Regions Research and Engineering Laboratory (CRREL), and the USDA Hydrology and Remote Sensing Laboratory. Economic benefits and broader societal impacts from improved flood forecasts are the primary driver of this satellite enhanced snowmelt flood prediction application.

The Red River Basin is approximately 124,000 km^2 with about 80% of the basin within the U.S. border, while the remaining 20% lies within Manitoba, Canada (Red River Basin Commission, 2011). On the U.S. side, the RRB borders eastern North Dakota and western Minnesota, and 18 Minnesota counties and 22 North Dakota counties lie either entirely or partially in the basin (Red River Basin Commission, 2011). Agricultural economy is important and vibrant in the basin; 90% of the land use is for agricultural production (Red River Basin Decision Information Network, undated). One-third of the basin's population or approximately 247,000 people reside in Grand Forks-East Grand Forks and Fargo-Moorhead where jobs, education, financial and medical services and agri-businesses are located, and the population and metropolitan sizes have increased in recent years (Red River Basin Commission, 2011; U.S. Census Bureau, 2015). The recent oil boom has witnessed rapid population growth and escalating housing demand in these metropolitan areas that have historically suffered from recurrent flooding events.



NASA Satellite-enhanced Snowmelt Flood Prediction Product

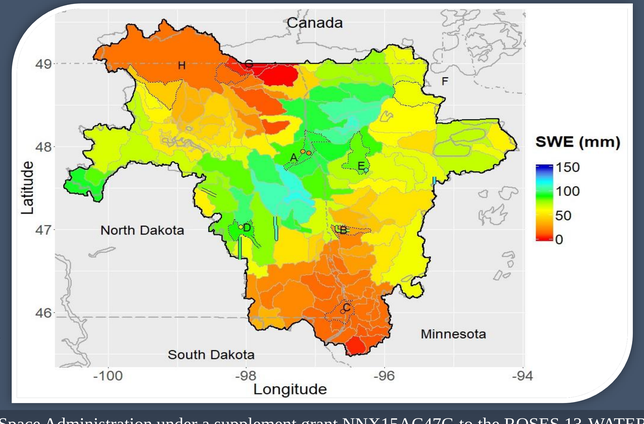
The NASA satellite enhanced snowmelt flood predictions make use of NASA satellite instruments to improve flood predictions in the Red River basin of the North. These new satellite sensors can monitor the amount of snow and soil water stored above and within the soil surface anywhere in the Red River basin. This information is sent to the trusted forecasters at the River Forecast Center who will use this information to make improved snowmelt flood predictions.

Through the use of NASA satellites and recent advancements in satellite technologies, flood forecasters are now able to receive satellite-transmitted signals that provide real time snow and soil water information for the entire Red River basin. This service has not been available to the River Forecast Center previously, which has led to inaccurate flood forecasts. Forecasters relied on information from emergency managers and local weather stations that did not cover the entire river basin, was not adequate, or simply could not be made available when and where it was most needed.

Examples of the products delivered to the River Forecast Center are the snow water equivalent (SWE), soil moisture content and the onset of snowmelt throughout the basin. SWE is the depth of water that would result if one melted the entire snowpack instantaneously. This satellite service will provide the flood forecaster with up-to-date snow and soil information anywhere in the basin.

An example of this service is shown in the figure above which displays the maximum SWE across the Red River basin during this year's spring season. The map also shows SWE information from field (dots) and airplane surveys (lines). Airplane and field surveys require a substantial amount of personnel and favorable weather conditions that can make them costly and dangerous. The satellite information covers the entire basin every day no matter the weather conditions.

Integration of this new satellite information technology into the river forecast model will improve snowmelt flood predictions in real-time operations. Improved flood predictions can reduce the loss of life and property damage for the citizens living in the Red River basin. Also, it uses resources more efficiently and reduces unnecessary cost.



A Survey-informed Contingent Valuation Analysis

Research Design

The Flood Control Act of 1936 establishes the criterion that the benefits of flood control projects must exceed the estimated costs (Durden and Fredericks, 2009). This project applied the stated preferences valuation to quantify the socioeconomic impacts of the NASA flood forecast product developed by Jacobs et al. (2014). Under this method, a survey-informed contingent valuation (CV) analysis was employed to estimate the socioeconomic values of the improved forecast model.

The purpose of this survey is to evaluate the socioeconomic benefits of the abovementioned NASA's flood information product to the region (see more details about the snowmelt flood forecast product at the project website https://www.ag.ndsu.edu/floodforecastimpact). Like weather forecast, the new NASA satellite-enhanced snowmelt information product is a public good to enhance the wellbeing of the region. It is funded by taxpayers' dollars, and it will not be marketed as a private good. We would like to find out if the public would support the product use as well as to measure the significance of the product in socioeconomic terms.

The self-administered mail survey was distributed in four waves to 1,500 randomly selected households from the most populous areas in the RRB, namely the West Fargo-Fargo-Moorhead and Grand Forks-East Grand Forks metropolitan areas, in September to October 2018. In total, 310 mails were collected with 291 valid responses, resulting in a 19.5% valid response rate.

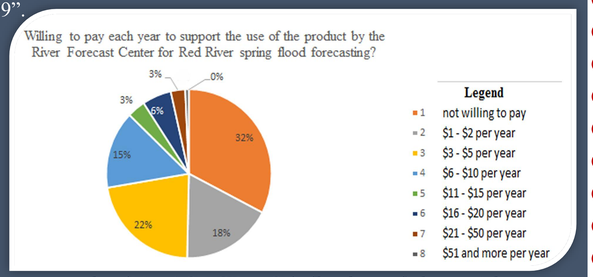
Survey Results

Demographics

The survey participants shared demographic characteristics as follows – age averaged in "45-64 years old", 28% being female, 99% being White, highest level of education between "some college/vocational school" and "college graduate", yearly household income close to "$75,000-99,999", 95% being homeowner, and current home value a bit above "$200,000-299,999".

Perceived Benefits of and Willingness to Pay for the Forecast Product

A generally high degree of supporting the use of the NASA flooding forecast product was reported by the survey respondents (mean, M = 3.99, in a 1-5 Likert Scale; standard deviation, SD = 1.17). However, the household financial contribution each year was very low (M = 2.71, in a 1-8 Likert Scale) on top of the local government funding to support the use of the forecast product, 87% respondents selecting less than $10 per year.



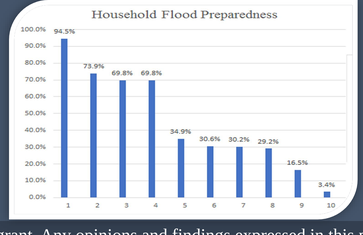
Their WTP was also relatively low for building/land elevation as part of your property value (M = 1.87, SD = .95), flood-proofed material installation in basement and/or exterior (M = 2.02, SD = .98), and flood insurance (M = 2.32, SD = 1.19) in a 1-5 Likert Scale. Consistently, the perceived benefits by adopting the improved flood forecast product were relatively low as well (below the midpoint of a 1-5 scale) – reduced damage to your home from flooding (M = 2.17, SD = 1.00), reduced injury or death to yourself or members of your household (M = 2.00, SD = 1.12), reduced disruption of your job that prevents you from working (M = 2.05, SD = 1.09), and reduced disruption of electrical, telephone or other basic services (M = 2.45, SD = 1.04). Nonetheless, positive perception of the improvement of local flooding warning system was found from the survey (M = 3.14, SD = .94).

Psychological Variables about Flood Risk

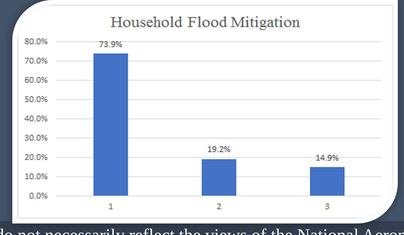
The low level of WTP for the improved flood forecast product may be explained by the residents' low degree of psychological variables with respect to flood risk. First, *hazard knowledge* was rated relatively high (means above the midpoint of a 1-5 Likert Scale) about the chances of being impacted by a flood (M = 3.62, SD = 1.00), the types of damage your home may sustain from a flood (M = 3.71, SD = 1.08), and what you may do to prevent the flooding damage (M = 3.54, SD = 1.07). Second, *hazard intrusiveness* was, on the contrary, negatively rated (means below the midpoint of 3) for how often to think about flooding events (M = 2.50, SD = .72) and flooding safety issues (M = 2.45, SD = .73). Third, *flood experience* was reported very high as 93% respondents had experienced a flooding event while only 33% had lived in a flood-damaged home. Last, the *likelihood of a major flood in the next five years* was very negatively perceived on major damage to your home (M = 1.97, SD = .71), injury or death to yourself or members of your household (M = 1.40, SD = .56), reduced disruption of your job that prevents you from working (M = 1.94, SD = .87), and reduced disruption of electrical, telephone or other basic services (M = 2.48, SD = .87).

Household Flood Preparedness and Mitigation

Preparedness and mitigation are two key proactive functions to build resilience to disasters at the household and community levels. At the household level, the self-reported preparedness for flood emergencies showed a broad range from 95% having flashlight and spare batteries to 16% having a flood insurance in place. For flood mitigation efforts, 74% of the respondents lived in an elevated building, but only 19% dry flood-proofed (so water cannot get in), and 15% wet flood-proofed (so water can get in but equipment is above expected flood level).



1 - Flashlight and spare batteries
2 - A complete first-aid kit
3 - A battery powered radio with spare batteries
4 - At least 4-day supply of dehydrated or canned food for yourself and your family
5 - A household emergency plan
6 - A gas powered electric generator
7 - At least 4 gallons of water stored in plastic containers
8 - A battery-supported sump pump
9 - Flood insurance
10 - Sandbags and sand to protect your house from flooding



1 – Elevated so it is less likely flooded in regular years

2 – Dry flood-proofed so water cannot get in

3 – We flood-proofed so water can get in but equipment such as the furnace, air conditioner, washer, and dryer is above expected flood level

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