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The use of remotely-sensed snow, soil moisture and vegetation indices to develop resilience to climate change in Kazakhstan

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Kazakhstan is a major producer of grain. Large scale grain production dominates in the north, making Kazakhstan one of the largest exporters of grain in the world. Agricultural production accounts for 9% of the national GDP, providing 25% of national employment. The south relies on grain production from household farms for subsistence, and has low resilience, so is vulnerable to reductions in output. Yields in the south depend on snowmelt and glacier runoff. The major limit to production is water supply, which is affected by glacier retreat and frequent droughts. Climate change is likely to impact all climate drivers negatively, leading to a decrease in crop yield, which will impact Kazakhstan and countries dependent on importing its produce.

This work makes initial steps in modelling the impact of climate change on crop yield, by identifying the links between snowfall, soil moisture and agricultural productivity. Several remotely-sensed data sources are being used. The availability of snowmelt water over the period 2010-2014 is estimated by extracting the annual maximum snow water equivalent (SWE) from the Globsnow dataset, which assimilates satellite microwave observations with field observations to produce a spatial map. Soil moisture over the period 2010-2016 is provided by the ESA Soil Moisture and Ocean Salinity (SMOS) mission. Vegetation density is approximated by the Normalised Difference Vegetation Index (NDVI) produced from NASA's MODIS instruments. Statistical information on crop yields is provided by the Ministry of National Economy of the Republic of Kazakhstan Committee on Statistics.

Demonstrating the link between snowmelt yield and agricultural productivity depends on showing the impact of snow mass during winter on remotely-sensed soil moisture, the link between soil moisture and vegetation density, and finally the link between vegetation density and crop yield.

Soil moisture maps were extracted from SMOS observations, and resampled onto a 40km x 40km grid, and analysed to produce monthly averages. The monthly maximum snow water equivalent estimates for March were resampled onto the same grid, to approximate the total snow contributing to snowmelt. The MODIS MOD13A2 1km 16-day NDVI product was resampled onto the same 40km grid, and aggregated into 32-day averages. Annual crop yield is available in terms of kg of yield per hectare for each region in Kazakhstan between 2004 and 2015.

To show the connection between the snowmelt and soil moisture, the cells within the snow and soil moisture grids were compared to calculate correlation. Data were aggregated per region. Regions in northern Kazakhstan showed the strongest correlations, because more of the soil water supply is derived from snowmelt than rain, and the southern regions showed poor correlation because of the greater influence of rainfall and irrigation. Correlations between soil moisture and vegetation density, and crop yield are ongoing, and results will be presented. It is envisaged that this research will assist the Kazakh farming community, providing real-time soil moisture data from SMOS.