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Key Messages

- Climate change will further exacerbate the situation for Mongolian farmers.
- Wheat and potato yields are expected to grow slower, while annual yield variability will increase.
- Climate change induced *yield variations* pose the greatest threat to Mongolian farmers and national food security.
- Responsible use of all available adaptation options needs to sustainably push the productivity of Mongolia's agricultural area and increase the resilience of its arable farmers.
- The concept of Climate Smart Agriculture can provide guidance.
- Other measures include the development of the plant breeding sector, organizing substantial knowledge transfer, and improving the meteorological system.

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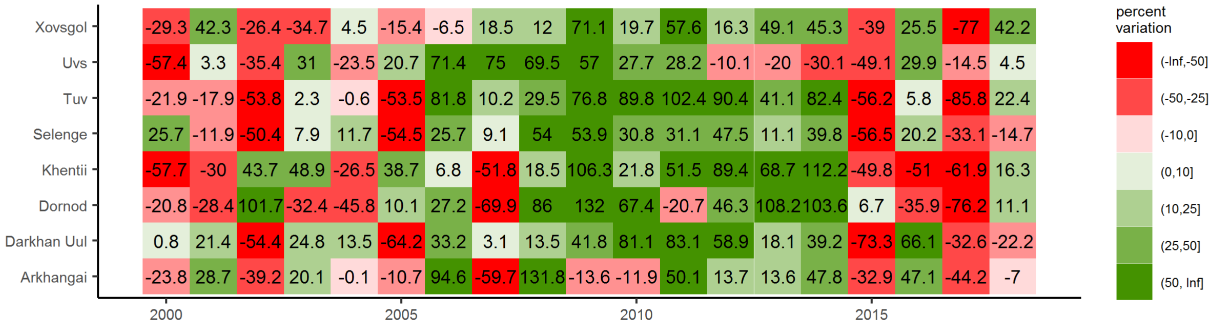
Assessing the impacts of climate change on the arable farming sector of Mongolia

Mongolia's harsh and continental climate combined with a high regional and temporal variability of precipitation patterns presents a huge challenge for arable farmers in the country. Droughts occur regularly and are a main cause for some of the huge production losses experienced in recent years (MET, 2018). Between 2000 and 2018, wheat and potato yields have increased on average by 3.3 and 3.2 % per year, respectively. However, yield trends on the Aimag level vary strongly from region to region, and annual production volumes are characterized by strong intertemporal and regional variations (Figure 1). Especially the occurrence of longer dry periods i.e. periods with comparably higher temperatures and/or less precipitation have strongly negative effects on the country's crop yields.

Climate change is expected to further exacerbate the situation for Mongolian arable farmers

Mongolia has experienced an increase in annual mean near-surface temperatures of 2.24 °C between 1940 and 2015 and a small decrease of 7 % in annual precipitation during the same time horizon (MET, 2018). Both developments act to increase the risk of drought and unfavourable conditions for agricultural production. The rising temperatures and uncertainties in rainfall associated with global warming in Mongolia are also likely to increase the frequency and magnitude of climate variability and extremes, increasing the risk of negative impacts on agriculture and other economic activities in the country. The increasing variability of precipitation patterns is a particular threat for arable farming, as water availability is essential during specific growth stages of the crop.

Figure 1: Variations of observed yields vs. yield trends for spring wheat in eight Mongolian Aimags from 2000 to 2018



Source: Own calculations and figure

Modelling of expected yield developments: How will Mongolian spring wheat and potato yields be influenced by climate change until 2050?

Both the *frequency* as well as the *intensity* of precipitation variability and weather extremes are expected to increase in Mongolia. To forecast the potential yield developments, a standard agricultural economic modelling approach was used, proven to be powerful for future-oriented simulations under limited data input. The following two scenarios were defined[1] to evaluate the potential development of crop yields in eight Mongolian Aimags[2]:

- Business as usual (BAU) scenario with climate change <u>(“BAU with CC”)</u>: average spring wheat and potato yields are assumed to increase by 1.15 and 1.10 % per year until 2050, respectively. The frequency of droughts as well as their relative intensity are expected to increase by 15 % until 2050. Regional differences between Aimags are taken into consideration.
- BAU scenario without climate change <u>(“BAU w/o CC”)</u>: yields are assumed to additionally increase by 0.2 and 0.25 % per year for spring wheat and potato between 2020 and 2050, respectively. The frequency and intensity of droughts is left unchanged. The difference in yield growth between the two scenarios is the trend-related climate change effect over time.

The results, including three randomized climate change runs (“CC-Runs” A, B, and C), were calculated for wheat and potato production in eight Mongolian Aimags. An exemplary result for wheat production in Selenge is shown in Figure 2.

Analysis results: yields will grow slower – while annual yield variability will increase

Results show that Mongolia – and here specifically the Selenge Aimag (Figure 2) – would probably have experienced considerable wheat yield growths of more than 40 % by 2050[3] if climate change

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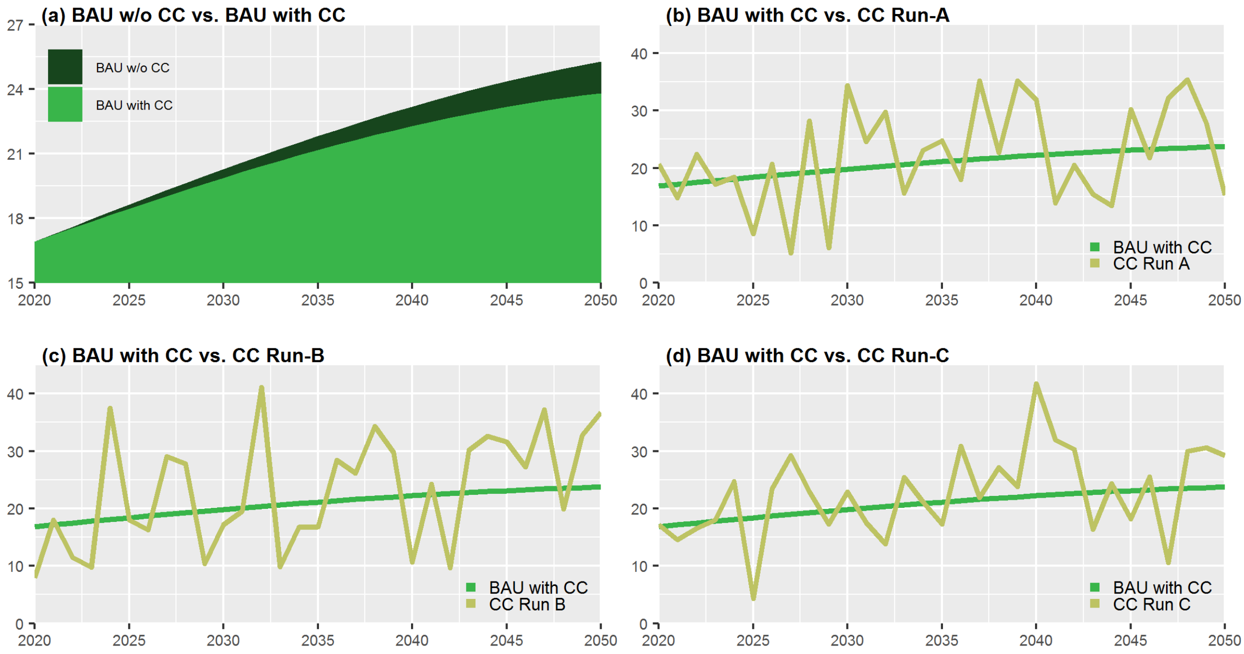
[1] The scenarios were defined based on an extensive literature research and including data from FAO and IFPRI. Please refer to the full version of the study (Noleppa and Hackenberg, 2019) for a more detailed description of the methodology applied.

[2] The study focused on the following eight Aimags: Uvs, Dornod, Xo’vsgol, Khentii, Darkhan-Uul, Tuv, Selenge, Arkhangai.

[3] It is assumed here that the adaptation of technological progress would continue at current rates.

was not present. However, climate change will act to partly decrease this growth. In the case of Selenge, by 2050 the effects of climate change are expected to lead to an average wheat yield reduction of 6 % compared to the levels without climate change (Figure 2 (a)). These production losses would amount to approximately 150 kilograms per hectare by 2050. The results are similar for other Aimags, and for potato production as well. As an example, in the Tuv Aimag, yield decline in potatoes is expected to accumulate to 1.7 tons per hectare in 2050, which is 7 % less than the amount potentially achieved without climate change.

Figure 2: Expected spring wheat yield developments in the Selenge Aimag from 2020 to 2050: its trend (a) and three runs of randomized annual variations (b), (c), (d) in 100 kg per hectare.



Source: Own calculations and figure

Climate change-induced yield variations pose the greatest threat for Mongolian farmers

The randomized climate change runs for wheat in Selenge (Figure 2 (b), (c) and (d)) show that annual yields are expected to vary strongly around the prognosed average “BAU with CC” trend line. Each CC-run leads to potential expected outcomes for wheat yields in Selenge over the next 30 years. For example, in “CC-Run A”, a rather low spring wheat yield of approximately 0.6 tons per hectare in 2029 would be contrasted by a comparably high yield of more than 3.4 tons per hectare in 2037. The latter being 70 % higher than the expected trend value.

The food security impacts of climate change in Mongolia will largely depend on the ability of individuals and households to cope with increasing negative yield shocks

Food security is a multidimensional concept encompassing the availability, accessibility, utilization, and stability of food (supply) (FAO, 1996). A changing climate with higher risks and amplitudes of yield fluctuations could have a range of impacts on all four dimensions of food security. On an annual basis, the effects of climate change may therefore heavily affect food security in Mongolia, especially through negative yield shocks on important staple foods (such as wheat and potatoes). Ensuring a productive and climate-resilient local food production can thus be an important part of the food security equation. It is very important not only to be aware of the risks posed by climate change, but also to find solutions in order to better manage these risks. Therefore, it will be very important to enable farmers and the agricultural sector to meaningfully adapt to climate change, i.e. to better cope with the decreasing growth trends and the increased uncertainty of weather conditions such as droughts.

A straightforward conclusion: make responsible use of all existing adaptation options

In order to sustainably push the productivity of Mongolia's agricultural area and increase the resilience of its arable farmers, the following "no regret" options are highlighted:

➢ **Implement options related to the concept of climate-smart agriculture**

Climate-smart agriculture (CSA) is defined as agriculture that sustainably increases productivity and resilience (adaptation), reduces/removes greenhouse gases, and enhances achievement of national food security and development goals (FAO, 2018). CSA options can be key in helping farmers to adapt by targeting, among others, the following challenges present in Mongolia:

- Sustainable water use and improvement of water use efficiency: Water in Mongolia is a highly limited resource, and the competition for water is expected to increase not only among farmers but also among the different sectors of the Mongolian economy. Appropriate monitoring and governance of water resources is urgently needed to ensure a long-term and sustainable water availability.
- Improvement of soil fertility through better fertilization management: Nutrients lost due to crop harvests are currently neither replaced by natural input sources nor by the application of chemical fertilizer (Hoffmann et al., 2016). As a consequence, agricultural soils currently have considerable nitrogen and phosphorous deficits. The identification and implementation of more sustainable land and fertilizer management practices is of high priority in order to achieve higher crop yields in Mongolia.
- Minimization/stop of soil erosion: Wind erosion of soils has been predicted to increase in Mongolia, further exacerbating the soil erosion problem that is already pronounced across the region. Stringent measures are therefore needed to protect (agricultural) soils from the effects of winds and prevent further losses in agricultural productivity.

➢ **Exploit the potential of plant breeding and modern seed production**

Capacities to enhance the climate-resilience of the agricultural sector need to be improved locally. Especially research, knowledge and technologies are needed to breed new crop varieties that are adapted to the challenging local conditions. This might lead to the (re-)discovery of local crop varieties, or to increased use of foreign genetics that are better adapted to droughts and heat spells. Strengthening and technologically improving the national production of crop seeds will also be necessary.

➢ **Promote the installation of sustainable and water saving irrigation technologies**

Irrigation can mitigate parts of the effect of high temperature extremes on yields and can act as a safety net during prolonged periods of drought. However, water is scarce in Mongolia and any effort needs to be made to not overuse this natural resource, as an overuse would make agriculture even more difficult in the future. High-tech and digital irrigation solutions could help in this regard and should be installed whenever and wherever possible.

- **Organise substantial knowledge transfer**

Guidance needs to be provided to farmers in many terms: the selection of suitable seeds and crops, a more diverse crop rotation, the overall crop management, an efficient water management, the proper use of irrigation technologies, etc. These are only some of the factors that will be critical for farmers to successfully adapt to changing climatic conditions. Therefore, agricultural extension services need to be trained and equipped with the necessary knowledge and technology to pass on these technologies and new information to farmers. Also, learning from other countries' experiences with arable farming in semi-arid and arid conditions will be important, as well as adapting best practices to the local needs of Mongolian farmers.

- **Collect more and better climate information and forward it to farmers**

The adaptation of agricultural practices to climate change is largely driven by decisions at the farm level. Therefore, improving the accessibility of farmers to sound weather and climate (change) data is a necessity. Research has repeatedly highlighted the need for comprehensive monitoring and forecast systems, especially for better predicting drought events. Both short-term and long-term monitoring are needed to improve decision making, reduce risk and develop adaptive management strategies. These weather and drought forecasts would assist producers and government in taking precautionary actions towards drought and extreme weather events. The provision of information to farmers will especially be key for adequate adaptation to increased rainfall variability.

- **Install early warning systems and further develop the meteorological systems**

Early warning systems in the country are primarily directed at livestock herders and focused on predicting *dzud*. Some of this information could also be useful to increase the disaster preparedness of arable farmers, however, the provision of more targeted information will require further development of the meteorological system in the country. Also, while installing the necessary technical infrastructure and obtaining more suitable data is important, it is at least as important to invest in training and communication efforts targeted at making this information as useful – and therefore also as usable – as possible to the individual farmer.

- **Provide sufficient financing**

Adequate financial mechanisms that ensure the establishment of the aforementioned measures are needed. This also applies to farmers' access to loans which can help them to better cope with climate-related shocks, while they can also be key to ensure sustainable transformation of the sector towards higher climate resilience.

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