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POLICY BRIEF

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GERMAN-MONGOLIAN COOPERATION PROJECT "SUSTAINABLE AGRICULTURE"

GFA CONSULTING GROUP
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Key recommendations

- Develop plant factories with controlled environment
- Develop technologies for control and regulation of the environment of plant growth with sensors, and adopt ready-to-use technologies
- Develop vertical farming
- Determine parameters such as nutrient deficiencies and pest spreads via remote sensing, and apply fertilizers or pesticides on the right spots
- Development of an information system to urgently reach farmers with information such as snow cover, summer vegetation, drought and surface temperature
- Increase the use of genetic engineering and mutation in plant breeding
- Increase fodder crop resources through development of plant biotechnology and genetical engineering
- Provide policy support to research and development work on precision and smart farming systems, facilitate interdisciplinary research, and introduce incentives to reward farms and entities making related efforts
- Provide policy support for public-private partnerships focused on introduction of technological progresses in crop and horticulture farming

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Needs and solutions for smart crop and horticulture farming technologies in Mongolia

Government policies are emphasizing the development of the crop sector for securing the supply of healthy and safe foods grown on domestic soil and making Mongolia a food-exporting nation. Yet, the productivity, profitability and competitiveness of the crop and horticulture sector are still low and its risk vulnerability is high. Crop production heavily relies on the use of natural resources, utilizes low technology and causes substantial ecological damages. Moreover, the sector's performance is increasingly and negatively affected by the impacts of climate change such as deterioration and decrease of vegetation cover and declining soil fertility. These problems must be solved through integrated efforts of developing ecologically sound, climate change adapted and sustainable agriculture based on knowledge economy. Measures for increasing the productivity and profitability of crop and horticulture production, introducing biotechnology and smart technologies and ensuring science-based production are urgently needed.

1. Overview of efforts to introduce smart crop and horticulture farming technologies

Agricultural scientists, in collaboration with domestic and international partners, have been intensively implementing a range of R&D and technology transfer projects during the recent years aiming to facilitate the introduction of precision farming and smart technologies and facilitate digital transformation in the crop and horticulture sector of Mongolia. Selected examples are briefly described below.

The MULS professor team led by Prof. B. Munkhbat and the Department of Physics and Electronics are jointly implementing the project “Development of machinery and technologies for smart crop farming in Mongolia” since 2019. The project has, among others, developed the normalized difference vegetation index (NDVI) for Mongolia, and preliminarily established that 1) plants growing actively absorb red light and reflect infra-red light, 2) the extent of absorbing red light and reflecting infra-red light depends on plant type and growth stage, and 3) based on these characteristics and using satellite data, vegetation can be measured and yields estimated.

Also, Dr. B. Odgerel, senior officer of the Research and Innovation Division of MULS, has been conducting, with support from the United States Department of Agriculture (USDA), research on introducing smart technologies in wheat farming since 2019. The research project has developed a methodical framework for monitoring and determination of yield development in each growth stage using quantitative satellite data and drones.

Development of plant factories: A researcher team of the School of Agroecology led by Associate Profession J. Oyungerel has been implementing the project “Establishment of a plant factory” in order to demonstrate the possibility of mitigating yield risks and enabling year-round delivery of fresh vegetables to the market through growing of vegetables in a closed facility that allows automatic control of the supply of nutrients, air, water and warmth. In October 2018, the team installed a plant factory consisting of two blocks with the dimension of 18m×4.5m×4m per each on the MULS campus. The facility allows year-round horticulture production on 20 shelves placed on a 32.4 m² area that provide a soilless and automatically controlled environment for plant growth.

Furthermore, research on advanced technologies for horticulture production on protected soil has been pursued by Dr. T. Nasanjargal and other researchers from the School of Agroecology through the implementation of the Korea-funded project “Development of fully automated and smart greenhouses based on a system solar energy production” since 2020. This project is working on the construction of a 2000 m² solarly heated greenhouse that utilizes renewable energy technologies in its cooling system. With a total investment of approx. MNT 10 billion, the project is expected to play an important role in year-round supply of inhabitants of UIaanbaatar city with fresh vegetables.

Prof. A. Bakey, director of the Center for Agricultural Economics and Innovation Development of MULS and member of the Academy of Science, has recently carried out a study on “Improving economic incentives for introducing advanced technologies in crop production”. The study concludes that supporting policies and economic incentives are required for facilitating the development of crop and horticulture production in accordance with the strategy to adapt to climate change, modernization of cropping technologies and utilization of smart technologies.

In addition, MULS is planning several collaborative projects focused on introduction of smart technologies, acceleration of digital transformation and use of cloud computing. Examples include the project “Implementation of the main technologies of smart crop and livestock production on the basis of the Mongolian-Chinese model innovation park” for collaboration with China, the “Elaboration of the rationale for designing the platform of a multifunctional robot for controlling crop growth and care”, which will be implemented jointly with the Institute of Agricultural Engineering of the National Academic of Science of the Republic of Belarus, and the project “Research on development of smart technology solutions for plant protection in potato farming” that will be funded by the Korean Program on International Agriculture (KOPIA). In conclusion, a considerable amount of research and development and technology transfer work aimed at development of precision farming, elaboration of the rationale for use of smart technologies, and adoption of technologies for cultivation on protected soil and in fully automated facilities will be conducted, and expanded during the next years.

On the producers’ side, there are also initiatives for using smart technologies. A sound example is the company Arvin Khur in Selenge aimag, which has demonstrated a three- to six-fold yield increase during the last three years through the practice of collecting data on important parameters such as soil fertility, nutrient supply, moisture accumulation at annual, quarterly, monthly and daily scales, and weather prognoses directly from the wheat fields, evaluating the data and implementing adequate technology measures as needed. Also, several greenhouse farms in the peri-urban areas of the Ulaanbaatar city have introduced automized plant care with the necessary equipment. There is also the experience of Green Vegetal LLC, which grew leaf vegetables in a closed facility with 1- hectare area and 400 shelves.

2. Needs and possibilities for introducing climate-smart crop and horticulture farming solutions

Compared by the index of long-term climate risk, Mongolia is included in the 10 countries with the highest risks. The intensity of warming has been three times the global average and almost reached the tolerable maximum (2.4^{0}C) while precipitation during the vegetation period is expected to decline.

Climate change involves positive and negative impacts. Positive impacts include, for example, increase in the length of the warm period by 9 to 15 days, improvement of warmth supply and increase of winter precipitation by 20 to 25 percent, which allow an increase of crop diversity and result in improved soil moisture during the sowing period. However, facts such as a 7 to 25-fold increase of the intensity of soil erosion, decrease of soil humus by 37 to 52 percent, mineralization of 0.5 to 1.5 tons of humus per hectare and year, and that variety parameters of some crops and varieties are no longer applicable while plant pests have increased are a proof that negative impacts of climate change prevail.

The main objectives regarding adaptation of crop and horticulture production to climate change include creation of drought-tolerant, pest-resistant and early-ripening varieties, development of a system for producing quality seeds of adapted varieties, introduction of conservation and zero tillage and other resource-saving technologies, systematic use of mineral and organic fertilizers, improvement of soil fertility through crop rotation, increasing yields, renewal and enforcement of irrigation farming technologies and adoption of precision farming.

3. Smart farming solutions, and implementation measures

It is possible for crop and horticulture production to be compliant with the principle of sustainable development, knowledge-based and risk-free but this requires mechanization, automation and the use of electronics and ICT. In accordance with the need for adaptation to climate change, the following fundamental problems need to be urgently solved.

The following steps are decisive for the success of introducing smart farming solutions:

1. Development of plant factories: harvesting stable yields in closed facilities that are specifically equipped for automatic control of nutrients, air, water and heat supply required for plant growth;

2. Development of technologies for control and regulation of the environment of plant growth with sensors, and adoption of selected ready-to-use technologies;
3. Development of vertical farming: shelves providing hydroponic or aeroponic environment for year-round growing of leafy vegetables can be placed under the roof of large food markets and supermarkets;

4. Determination of parameters such as nutrient deficiencies and pest spreads via remote sensing, and application of necessary fertilizers or pesticides on the right spots;
5. Development of an information system to urgently reach herders and farmers with information such as snow cover, summer vegetation, drought, pasture biomass, surface temperature and forest fires that are generated through environment and weather monitoring and available in the environmental database of the Institute of Information and Research Institute of Hydrology, Meteorology, and Environment;
6. Increased use of genetical engineering, roentgen, ultra-violet ray, fast neutrons and other types of physical and chemical mutagens in plant breeding (IPAS selected 2523 mutants with agronomic value out of 11046 mutants in total). It has been proven that through the use of chemical mutagens new varieties that are adapted to certain agroecological conditions, high-yielding, high-quality, drought- and heat-tolerant, and pest-resistant can be created, and breeding material with value for cultivation can be generated and used in wheat breeding. The institute has also been using a genetically castrated mutant (7B-1) as mother in tomato breeding since 2010.
7. Increase fodder crop resources through development of plant biotechnology and genetical engineering (the plant biotechnology researcher team of MULS created the first transgenic plant, in which the *AtGRF2* gene was introduced, and which, compared to initial plants of the variety “Burgaltai”, demonstrate increases of 8.1 cm in length, 0.8 in number of sprouts, 8.5 in number of nodes, 62 in number of leaves, 0.4 cm in leaf length, 0.1 cm in leaf width and 0.7 cm^2 in leaf area).

Conclusions:

1. An important and feasible approach to development of sustainable cropping systems that supply diverse healthy and safe foods and enable food exports is the use of certain elements of the 4th industrial revolution and the digital revolution in crop and horticulture production in Mongolia in connection with policies and actions targeting smart agriculture.
2. Universities, research organizations and some crop farms have made efforts to introduce precision and smart farming solutions in crop and horticulture farming in Mongolia, and achieved considerable results meanwhile.
3. The government should provide policy support to research and development work aiming to develop advanced technologies, smart systems, cloud computing and precision farming in crop and horticulture production, expand interdisciplinary research, and introduce

incentives to reward farms and entities making efforts to introduce advanced cropping technologies.

4. Policy support should also be provided to initiatives aiming to foster public-private partnerships for strengthening the linkage between science and production and establishing the use of advanced technologies in crop and horticulture production.
5. The chemical and biological characteristics of natural and biological resources of plant and animal origin in Mongolia should be determined with modern analytic methods, and organic and functional foods processed with advanced technologies should be supplied to international markets.

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Author:

Gantulga Gombo, Prof. Dr.
Vice-Rector for Science and Innovation of Mongolian University of Life Sciences
Email: gantulga@muls.edu.mn

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