Section 10

Science and Innovations

10.1. Innovations in 2018

Drones and Robots in Agriculture

AgResearch, one of the largest research institutes in New Zealand, has started exploring the possibility of using drones with lasers for weed control. The idea is to mount specialist cameras on the drone or UAV (Unmanned Aerial Vehicle) that can first identify the weeds based on their unique chemical signatures and how they reflect light. The weed's locations will be mapped using GPS and the drone would then identify and eradicate the pest plant using a laser.

Tactical Robotics Ltd. announced the launch of development of an agricultural use derivative of its **Cormorant Unmanned Aerial Vehicle** (UAV). Cormorant has completed 250 successful flights. Focused pesticide spraying ensures maximum crop coverage. It operates almost silently, making it possible to work at night without disturbing neighboring farms.

A group of scientists from the UK is conducting a research, where energy-powered drones help farmers sow, treat soil, monitor crops and harvest. As part of the research, the field was sown with barley by means of drones; special drones monitored conditions of plants, treated them and delivered samples of plants to the farmer so that he could determine their status and the time when harvesting should begin. Self-driving combines were used for harvesting.

Panasonic unveils autonomous tomato picker in Tokyo. Panasonic's new robot relies on a combination of camera, range image sensor and artificial intelligence technologies. First, it recognizes which tomatoes are ready to be picked. Then, it performs a precise cut-and-catch technique to move each tomato from vine to bucket.

Innovations in Greenhouses

Fifth-generation greenhouses allow supporting a microclimate and an illumination mode, which is optimal not only for plant development but also for personnel. Heat re-use significantly reduces energy costs, while excessive internal pressure prevents from insect pests.

China is making its vegetables grow bigger, faster and stronger using electricity. The Chinese Academy of Agricultural Sciences and other government research institutes released the findings of nearly three decades of study in areas with different climate, soil conditions and plantation habits. The technique has boosted vegetable output by 20 to 30 per cent. Pesticide use has decreased 70 to 100 per cent. And fertilizer consumption has dropped more than 20 per cent. The vegetables grow under bare copper wires, set about three meters (10 feet) above ground level and stretching end to end under the greenhouse roof. The wires are capable of generating rapid, positive charges as high as 50,000 volts, or more than 400 times the standard residential voltage in the US. The high frequency electricity kills bacteria and virus-transmitting diseases in the air or soil. It also suppresses the surface tension of water on leaves, accelerating vaporization. Within the plants, the transport of naturally charged particles, such as bicarbonate and calcium ions, speed up and metabolic activities, like carbon dioxide absorption and photosynthesis, also increase.

The Aisheng Biotechnology Company has presented its fully-automatic aeroponic plantation system, which functions in an isolated room without soil, pollution sources, or insect pests. The production includes more than 70 varieties of such vegetables and fruits. The plantation installation produces agricultural crops year-round through an efficient, precise, and strictly controlled system. The first "aeroponic" plantation installation was presented in Shanghai.

In Kostanay province of Kazakhstan, the first thermal greenhouse was built by Zh. Abishev, resident of Kostanay district. The 'greenhouse-thermos' is more economically viable than traditional ones: there is only a roof on the surface and beds are under the ground. Tomato, radish and herbs have already been planted here.

Singapore announced the development of an 8-greenhouse rooftop farm to provide pesticide-free, sustainable food to this Island Nation. This rooftop farming complex will consist of 8 rooftop greenhouses. The first farm (phase 1) will be 6,930 square feet, capable of producing over 332,000 plants (approx. 90,000 pounds of fresh food) per year. The entire project, when complete, will total over 35,000 square feet.

Hydroponics will be the primary growing method, due to a lack of fertile soil in urban

areas. Circular processes like the harvest of rainwater and solar power and reuse of industrial CO_2 are examples of sustainable proven technologies that will be included in the overall design of the urban farm.

Called the World Food Building, the project is currently under construction in the **Swedish town of Linköping** and is due to be completed in 2020. The tower will operate based on hydroponics, which means that the vegetables (mainly green vegetables) grow without soil in a water-based solution enriched with nutrients. The crops will grow using both natural light and LEDs. Except that the LEDs will be calibrated to specific frequencies of light to maximize production. According to his projections, the tower will also save a total of 1,100 tons of CO_2 emissions and 13 million liters of water per year.

The energy efficiency of vertical farms could soon be boosted by as much as 20 per cent, thanks to a new system developed by a **student from Brunel University London**. vFarm, by design student Jonny Reader, 21, uses OLEDs – organic light-emitting diodes – and smart automation to significantly reduce the amount of power used in vertical farming. vFarm also aims to increase efficiency and yield through the use of automation, using a series of sensors to help control factors such as temperature and humidity. It can read the current temperature, how much water there is in the reservoir, light intensity and how much power it's drawing.

The staff and students of the Don State Technical University have developed an installation that creates optimal conditions for rapid seed germination, allowing for stronger and viable plants. The new installation simulates seed germination conditions thanks to the LED matrixes with different light spectra. Lighting conditions vary depending to key parameters: temperature, humidity and duration of exposure. Such intensified seed preparation will substantially reduce the vegetation period and help use greenhouse areas as efficiently as possible.

The Dutch tomato grower Rimato is growing honey tomatoes on 14.6 hectare in Honselersdijk, and is officially a 'zero-waster': water that is not used by the plants is collected in gutters and reused. Tomato plants are grown on rock wool mats, wrapped in plastic. At the beginning of a new growth, they are filled with water. After a few weeks the roots need air: the water that is not used has to be drained quickly. The growers make small holes in the plastic. The water is drained more evenly into the gutters, and they prevent overflowing. The gutter transports the water to large silos. UV light and a special filter is used to remove dirt and any diseases from the water. This 'drain water' is then mixed with rainwater, which we collect in three rainwater basins totaling 32,000 m^3. It is then returned to the plant with the right recipe of fertilizers. The gutters with rock wool mats are not attached to the ground: in this way the grower can closely monitor if there is any leakage. One time a year, all plants and rock wool mats are replaced. To prevent waste of water in the end phase, it is essential to remove these as dry as possible. Shortly before the end, the growers are already reducing irrigation.

Monitoring of Agricultural Processes

The South Korean system allows controlling crop growing remotely with the help of a smartphone. The system involves installation of dozens of automated sensors to measure wind direction and speed, temperature and humidity in an indoor environment and in the soil, solar radiation, rainfall, carbon dioxide, light and soil acidity. In addition to the sensors in the greenhouse, an advanced controller is needed to collect the data from sensors and transmit them to mobile phones or personal computers via the Internet. With the help of a special application, it is possible to remotely adjust the automatic water delivery, open or close ceiling of the greenhouse for sunlight and maintain the temperature inside the greenhouse. The system can be installed at different scales and can operate in any climatic conditions. Moreover, it is cheap and easy to install.

Bees with mini sensor backpacks might help farmers monitor crops in the future. The **University of Washington engineers** have developed a sensing system that's small enough to place on bees. Because bees can fly on their own, each sensor only requires a tiny rechargeable battery that could last for seven hours of flight. Plus, the tiny sensors would charge when the bees are in their hive at night. Unlike drones and other flying objects, bees don't need to be charged and the tiny sensors would allow them to collect data for hours at a time. The example backpacks can only store about 30Kb of data, limiting them to collecting basic info like humidity, light and temperature.

The Iowa State University scientists developed a graphene-based, sensors-on-tape that can be attached to plants and can provide data to researchers and farmers about water use in crops. The technology could have many other applications, including sensors for

biomedical diagnostics, for checking the structural integrity of buildings, for monitoring the environment and, with modifications, for testing crops for diseases or pesticides. The graphene-on-tape technology in this study has also been used to produce wearable strain and pressure sensors, including sensors built into a "smart glove" that measures hand movements. The plant sensors are so tiny they can detect transpiration from plants, but they won't affect plant growth or crop production. The technology could "open a new route" for a wide variety of applications, the authors wrote in their paper, including sensors for biomedical diagnostics, for checking the structural integrity of buildings, for monitoring the environment and, after appropriate modifications, for testing crops for diseases or pesticides.

A team of University of Minnesota researchers led by Alex Susko developed the system to capture videos of plant movement under very windy conditions as well as stem failure or lodging. Lodging occurs when a plant falls or bends over due to high winds, disease, wet soil, excess nitrogen in the soil, machinery, or animals and can lead to losses in crop yield. The U of M camera-tracking upgrade allows researchers to record real-time plant traits at different locations in the experimental field. The camera track system is made of commercial hardware and electronics accommodating 360-degree cameras. It can be adapted to various field dimensions, crops, and sensor systems to get high throughput phenotypic data unmeasurable by other systems.

More than 100 installations with IoT sensors monitor the condition of fields in 24 countries in Europe and South America. Each product is inserted into the soil, leverages a SIM card that works anywhere in the world and takes measurements from the soil providing real-time data to growers, farmers, and farming businesses of both small and large scale. The measurements include soil moisture of soil at different depths, soil temperature, air temperature and humidity, soil radiation, rain intensity and beyond. It is able to predict irrigation by providing information on how much water is in the soil. This saves 50-60 % more water and thus snowballs in saving electricity, resource usage (such as pesticides and fertilizers), and reduces the likelihood of devastating fungi that can result from miscalculated water irrigation.

Increased Yields, Reduced Pesticides and Pest Control

Bacteria-based agriculture is starting to become big business.

Indigo startup helps farmers improve the health and productivity of their crops with microbial products that protect against the environment, disease and pest stress. Now, the company is expanding its suite of digital tools with the launch of Indigo Marketplace, a digital market that directly connects farmers and buyers. Using Indigo Marketplace, buyers can purchase grain directly from farmers. They can filter by protein content, milling quality or by production practices, i.e. whether it's organic or not. Growers are paid based on the quality of their crop, which is determined by a sample sent to a third-party lab for analysis. Indigo manages the testing, transportation of the crop and payment through its new platform.

Kazakhstani scientists propose using living organisms (entomophages) for destruction of pests. They offer such insects as aphidius, oriuse, macrolophus, etc. as entomophages for greenhouses. This biological protection of plants is much better than chemicals.

Agricultural Research Service (ARS) scientists in Albany, California have found a way to streamline the process that scientists use to insert multiple genes into a crop plant, developing a reliable method that will make it easier to breed a variety of crops with vastly improved traits. The technology is expected to speed up the process for developing new varieties of potatoes, rice, citrus and other crops that are better equipped to tolerate heat and drought, produce higher yields and resist a myriad of diseases and pests. Crops with greater resistance to pathogens and insects could greatly reduce pesticide use and prevent billions of dollars in crop losses.

Researchers at the University of Oxford and the Chinese Academy of Sciences have discovered a new gene that improves the yield and fertilizer use efficiency of cereal crops such as wheat and rice. The discovered gene variant increases the amount in plant cells of a protein called GRF4. GRF4 is a 'gene transcription factor' that stimulates the activity of other genes – genes that themselves promote nitrogen uptake and assimilation.

A3TECH Ukraine presented a brand-new fire-powered cultivator at the AGRO-2018 Exhibition. This machine may save 80 % of costs for plant protection agents and especially will be useful for organic growers. The inventors use liquefied propane-butane, which is evaporated in the burner developed by the company and released from nozzles under pressure. Such a design allowed getting a "rigid" torch with

temperature control limits of 1 100-1 800° C. This range of temperature resists all possible weather patterns (dew, wind up to 6-8 m/s, wet soil after precipitation, as well as the densest weeds). When the cultivator moves, the flame reaches the weed only within a fraction of a second. The growth point of weeds is destroyed. The fire-powered cultivator provides for three types of treatment: pre-seeding, pre-emergence, and final.

Combating Desertification and Climate Change

After successfully cultivating grapes in the desert, **China** is combating desertification by adopting advanced scientific methods to boost sustainable farming in the region, a senior official maintained. Trials for reviving algae, moss, and lichen are underway in an attempt to control the spread of desert terrain and also boost agriculture in the Tengger desert at Shapotou district in Ningxia Hui Autonomous Region. Shapotou alone cultivates around 350 hectares worth of grapes. Nearby Zhongwei City, which is facing the worst impacts of desertification, is growing grapes in approximately 600 hectares of land. Corn and wheat crops are cultivated on a rotational basis to maintain the soil's fertility.

Jackson Family Wines is running a five-year experiment to try to increase the carbon held in its soils. The company "wanted to participate in research to determine whether a working vineyard can in fact serve as an active carbon sink" to absorb carbon dioxide from the atmosphere. Farmers can address climate change by producing smaller amounts of greenhouse gases, but also through practices known as carbon farming or "sequestration." The terms basically involve agricultural practices that remove carbon dioxide from the atmosphere and hold it in the soil.

Water Conservation

Buried clay pot irrigation is applied at the small family farm Urban HomeStead in California on a 4-acres plot. According to the farmers, such irrigation technique is 80 % more efficient than drip irrigation. Water directly penetrates the clay, giving the plants the moisture they need.

According to FAO, some integrated agri-aquaculture farms using aquaponics technology can reduce water consumption by 90 % compared to purely traditional agricultural farms, with combination of new technologies and good practices to reduce agriculture's "waterprint" and make smart and efficient use of natural resources. In aquaponics, water serves a dual purpose: hosting fish and growing crops, generating two products at once. This isn't the only benefit; the waste from the fish fertilizes the water used to irrigate the plants, and the plants clean the water for the fish. It is a win-win situation. Production of more food with fewer resources: this is part of the future of agriculture.

Tree Hog can cut an orchard's water consumption by up to 70 %, with minimum savings starting at 50 %, says its inventor Louis Loubser, a farmer in Robertson in the Western Cape. The device is an injection-moulded plastic case with a micro sprinkler which encloses the base of a tree. It combines the benefits of micro and drip irrigation and long hours of irrigating turn into roughly twenty minutes. Because Three Hog encloses the base of a tree, it drastically reduces typical evaporation, and keeps the soil temperature constant helping a young tree's development. Unlike conventional drip irrigation systems, Tree Hog wets a much larger area at the base of a tree, helping the tree develop a strong root system. It also reduces the need for weeding around young trees.

Kyrgyz scientists have patented a water-measuring structure comprised of diversion and discharge channels, measuring site, a diaphragm with a rectangular orifice at the bottom, a right angle plate vertically movable between the walls of the rectangular pressure channel, and a level gage. There is also a short open rectangular channel, parameters of which correspond to those of the pressure channel. The level gage is installed in the short channel. The bottom of the control section is higher than the bottom of flume by the height of threshold of the control section; moreover, the tail of the control section has the sloping bottom to connect the bottom of pressure channel with the discharge site of flume.

The Zhaushykum village (Shardara district, South Kazakhstan province) apply innovative methods in growing onions: the seeds are sown in shredded soil every 3 cm, with buried drip irrigation tubes. Thanks to high quality seeds of the Dutch onion and even seeding, the yields are high. Application of the new technology contributes to 5 times reduced inputs by and increased productivity.

Scientists of the Department of Plant and Soil Sciences, University of Delaware, determined that Bacillus subtilis (Ud1022), which live on the

surface of roots and in the surrounding soil, trigger pore-like openings on the leaves, called stomata, to shut tight to keep pathogens out and to protect the plants from dehydrating. The research conducted jointly with the National Institute of Standards and Technology (NIST) confirms that the beneficial microbe UD1022 reduces evaporation and increases the soil's ability to hold water. Using state-of-the-art techniques, the study provides detailed analyses of how microbes interact with soil particles to physically change the underground ecosystem and help plants tolerate drought.

The research, from an **international team of scientists led by the University of Illinois**, discovered that a specific protein called Photosystem II Subunit S (PsbS) can be increased to force a plant to partially close its stomata. The stomata, tiny pores in a leaf, open and close to either let carbon dioxide in or oxygen out, regulating the process of photosynthesis. The initial hypothesis was that by limiting the stomata opening a plant would not lose as much water through transpiration, and subsequently not need as much water to grow. By increasing PsbS expression stomatal openings were reduced, and the ratio of carbon dioxide going into a plant to water escaping improved by 25 percent. This effectively meant the plant would need 25 percent less water to achieve the same rate of photosynthesis. The experiment with tobacco crop showed no significant difference in overall yield or size between modified and non-modified plants. Increased PsbS expression allows crop plants to be more conservative with water use, which we think will help to better distribute available water resources over the duration of the growing season and keep the crop more productive during dry spells.

Andros Engineering, the California based company that manufactures the single use drip tape recycling system, has partnered with RDO Water to expand on their current offering. The company supplies the machinery to collect the drip tape and haul it off for recycling. Using tractors with specially-designed lift bars, RDO Water's team lifts the drip tape at the end of the season. The RDO Water crew then uses the Andros Engineering Mega-Binder to roll up the tape, efficiently and neatly. The service includes haul-away and recycling of the tape, too – growers no longer need to store and repair the tape for use the following season, or coordinate disposal. Additional benefits of single-use drip tape include reduced water use for flushing and leaks, improved food safety, and eliminating off-season drip tape storage.

Wastewater Treatment, Desalination, and Improved Water Quality

A team of engineers from the Department of Energy of Politecnico di Torino (Italy) has devised a new prototype to desalinate seawater in a sustainable and low-cost way, using solar energy more efficiently. The working principle of the proposed technology is very simple: a special floating device is able to collect seawater using a low-cost porous material, thus avoiding the use of expensive and cumbersome pumps. The collected seawater is then heated up by solar energy, which sustains the separation of salt from the evaporating water. This process can be facilitated by membranes inserted between contaminated and drinking water to avoid their mixing. The developed technology is in fact able to double the amount of water produced at given solar energy.

The Siberian Federal University scientists developed a river cleaning biosorbent based on raw materials derived from Siberian Larch (Larixsibirica). The chemical modification of natural matrix allows us to produce a water-soluble material (sulfated arabinogalactan) for creating polyelectrolyte complex that cleanses the pollutants and helps the disposal of wood processing industry products. In addition to raw materials of vegetable origin the biosorbent will also include a component of animal origin – chitosan. The new material can be efficiently used in sewage treatment filters and can be recommended for major production facilities use.

Engineers from Tomsk Polytechnic University developed an unusual and inexpensive technology of water treatment. The innovative technology will allow cleaning contaminated drinking and waste water from toxic, chemical substances, including combustible impurities and salts. This technology makes it possible to purify water qualitatively and cheaply. The explosive cleaning method is simple: water is converted into emulsion or suspension by adding insoluble liquids or solid impurities, and then placed in a heating chamber where it is heated to 300-500 degrees. Explosive destruction of interphase boundaries is caused precisely by the pressure drop, and the process itself acquires a chain character. Water evaporates, non-combustible mixtures precipitate, and combustible mixtures burn out. Then the steam condenses, at the output we get purified water.

Researchers at the University of Alabama in Huntsville have been studying a new type of plasma generator for water purification. The new generator pulses voltage signals to ionize gas at atmospheric pressure and produce many useful byproducts, including hydroxyl radicals, which cause a cascade of reactions that lead to purer water samples. The plasma and ensuing chemical reactions release energy and chemical species that can kill even though microcystin bacteria, one culprit in algal blooms. The end goal is to develop something that can be mass-produced and distributed to places that need it the most.

Nano Sun, a water technology start-up founded by a scientist from Nanyang Technological University, Singapore (NTU Singapore), has launched a 3D printing plant to manufacture a new type of water treatment membrane. Nano Sun 3D prints millions of nanofibers layered on top of each other, compressed into a thin membrane. This gives the membrane a much bigger surface area to trap or repel pollutants while allowing water molecules to pass through at a faster flow rate.

The French company Marine Tech offers a technologically simple device in terms of production and operation. This device is able not only to purify water unsuitable for drinking but also to disinfect it. The transparent ball, one meter in diameter and made of durable heat-resistant material, is able to generate clean water in any point in the world with hot climate and lakes and seas. Seawater is filled into a special container in the sphere. Evaporation occurs under the sunlight and the condensed water appears on the walls and flows down the special tubes. The collected clean water may be delivered to consumers.

A new surface-active substance has been developed; the substance gives ordinary irrigation water the properties of rainwater, which is much more useful for irrigation of fields. The substance reduces pH level of irrigation water, making nutrients more accessible to plants and increasing efficiency of chemicals and fertilizers sprayed over the surface of plants. Inventors assure that such adjuvant is much more effective than other salt-based analogues designed for control of pH level.

Alternative Energy

Researchers at the University of California, Los Angeles (UCLA) have developed a double-layer solar cell that generates more energy from sunlight than typical solar panels. The device is made by spraying a thin layer of perovskite– an inexpensive compound of lead and iodine that has been shown to be very efficient at capturing energy from sunlight – on to a commercially available solar cell. The solar cell that forms the bottom layer of the device is made of a compound of copper, indium, gallium and selenide, or CIGS. In tests, the cell was able to convert 22.4 per cent of the incoming energy from the sun, a record in power conversion efficiency for a perovskite-CIGS tandem solar cell. The development has proven to be the most efficient of all the solar panels currently available.

Scientists at the Faculty of Physics and Information Technologies of the Gomel State University are developing new luminescent coatings for solar panels using the sol-gel method. This invention will be useful for the energy sector as it will increase the efficiency and service life of solar panels.

Researchers of the University of British Columbia (UBC) have found a cheap, sustainable way to build a solar cell using bacteria that convert light to energy. They genetically engineered E. coli bacteria that use dye to convert light into energy in order to create a so-called "biogenic" solar cell (a cell made of living organisms).That dye is very good at gathering sunrays and converting them into energy. The researchers coated the bacteria with a mineral to act as a semiconductor and applied the mixture to a glass surface. Solar powers of the near future could operate at far higher efficiency in cloudy regions.

Scientists from the University of Exeter have developed a method that has the potential to harvest three times more photovoltaic (PV) energy compared with traditional systems by funnelling the energy more efficiently. The technique "funnels" the sun's energy directly into power cells, such as solar panels or batteries. The idea is similar to pouring a liquid into a container, as we all know it is much more efficient if we use a funnel. They used the atomically thin semiconductor hafnium disulphide (HfS_2), oxidized with a high-intensity UV laser, to engineer an electric field that funnels electrical charges to a specific area of the chip, where they can be more easily extracted. While current solar cells are able to convert into electricity around 20 per cent of the energy received from the Sun, the new technique has the potential to convert around 60 per cent of it by funnelling the energy more efficiently.

Meeting our growing energy demands without continuing to destroy the planet might be one of the biggest challenges of our time, and it calls for some pretty creative solutions. **Swiss company Energy Vault** has just launched an innovative new system that stores potential energy in a huge tower of concrete blocks, which can be "dropped" by a crane to harvest the kinetic energy. Unlike dams, the new solution doesn't require water. When a wind or solar farm makes more energy than the grid needs, an automatic crane on the battery uses the extra electricity to lift a giant brick, weighing 35 metric tons, up to the top of the tower. When that tower's stacked, that's all potential energy. When the grid needs power, the crane automatically lowers a brick, using the kinetic energy to charge a generator. Indian utility Tata Power, Energy Vault's first announced customer, will be installing one of the towers later this year.

Japanese company Ibasei Ltd. developed a small hydro-kinetic power generator Cappa. There is no need to build a dam with Cappa compact hydropower generator – a system that's designed to be installed along a river or waterway. The basic design of the Cappa is nothing new – blades rotate as the water flows through the unit, which drives a turbine to generate electricity. However, the unit is encased in a special diffuser that is designed to increase the velocity of the water at the point where it passes over the blades, thereby increasing the unit's electrical output. The unit produces 100 V AC electricity at 50/60 Hz, so it can be used to power appliances around the (Japanese) home. The unit itself is also 100 percent recyclable and has an uptime of virtually 100 percent.

The **South Australia Labor government** has unveiled plans to build a 250MW "virtual power plant", linking household rooftop solar and battery storage, in what it says will be the world's biggest. The project will ultimately bring together 250MW of capacity and 650 MWh of storage, allowing the combined resource to be pooled to help provide grid stability and extra capacity when supply is short.

Atmospheric Water Generator

A **team of scientists from the Massachusetts Institute of Technology** developed a device that can extract potable water from even the driest of desert air. The researchers say the system based on metal-organic frameworks (MOFs) may operate with relative humidities as low as 10 percent. Its output would be equivalent to more than a quarter-liter of water per day per kilogram of MOF.

Scientists from the University of California, Berkeley have developed a device that can harvest fresh water out of the air. The device is made of MOF that's housed within a clear plastic box. In simple terms, water vapor from the atmosphere condenses on the MOF material, which absorbs it like a sponge. As the water evaporates, it gets trapped and collected by the device. The MOF material is made up of metal- and carbon-based organic molecules, and is designed to have many tiny pockets of air between the different types of molecules. The problem with the UC Berkeley scientists' new technology, however, is that it's expensive to produce. The MOF used in this test was made from zirconium, a costly metal. However, the team is working to develop MOFs out of aluminum, which is cheaper to produce and can actually absorb more water.

China is engineering the biggest project yet to force rainfall. The country plans to build tens of thousands of combustion chambers on steep Tibetan mountainsides. The chambers would burn a solid fuel, which would result in a spray of silver iodide billowing towards the sky. The particles, much like those already sprayed from planes, would provide something for passing water vapor to condense around, forming clouds. And the clouds would bring the rain. It is intended to force rainfall and snow over 1.6 million square kilometers. The system was developed by the state-owned China Aerospace Science and Technology Corporation.

Application of space technologies

A team of scientists from the Arizona State University (ASU) and the Jet Propulsion Laboratory (JPL) are using the latest space technology to look underneath Earth's surface to measure this precious natural resource. They've focused their efforts on one of the world's largest aquifer systems, located in California's Central Valley, measuring both its groundwater volume and its storage capacity. They measured land subsidence (when land above and around an aquifer shifts downward) using space-borne Interferometric Synthetic Aperture Radar (InSAR) and added that to data on groundwater levels sampled at thousands of wells across the Central Valley. The team analyzed data from 2007 to 2010 and 2012 to 2016 drought periods. During the 2007 to 2010 drought, up to two percent of storage capacity

was lost entirely when the water level declined and the clay layers in the system were permanently compacted. Now researchers are developing new methods for monitoring groundwater levels using satellite-based measurements of Earth's surface, providing a more comprehensive picture of the health of our nation's groundwater. These studies will enable authorities and decision makers to accurately manage water resources and plan for future water allocations. Water managers need to know about the irreversible processes taking place and how to act to prevent a future crisis.

10.2. Online Information Products and Services

10.2.1. An Interactive Map of Best Practices on Water, Land and Energy Use and Environmental Protection in Central Asia

In 2017, an interactive map of best practices on water, land and energy use and environmental protection in Central Asia was developed by SIC ICWC under Project "Promoting dialogue for conflict prevention related to water nexus in Central Asia (CAWECOOP)" implemented by CAREC and financed by European Union. This online resource contains information on successful application of approaches, technology, models, techniques, instruments, and other tools that have proven to be effective in the use of water, land, and energy resources and in the protection of environment in Central Asia.

In 2018, additional 50 IWRM practices were added to the database and interactive map of best practices on water, land and energy use and environmental protection in Central Asia*, including 12 practices for Kazakhstan; 12 practices for Kyrgyzstan; 7 practices for Tajikistan; 6 practices for Turkmenistan; and 13 practices for Uzbekistan (SIC administered population of the database).

The map is available on
http://riverbp.net/innovation/map-bestpractices/en/base/index

10.2.2. New Databases and Portals

SERVIR, a joint initiative of the National Aeronautics and Space Administration (NASA) and United States Agency for International Development (USAID), has released a new global geospatial dataset for agriculture and food security around the world. The dataset, called the Evaporative Stress Index (ESI), is available for analysis and download, and produced weekly at 5-km resolution for the entire globe. SERVIR's ESI is capable of giving soil moisture data without using observed rainfall data. The index is based on satellite observations of land surface temperature, which are used to estimate water loss due to evapotranspiration – the loss of water via evaporation from soil and plant surfaces and via transpiration through plant leaves. Variations in land surface temperature enable the ESI to calculate how the current rate of evapotranspiration compares to normal conditions.

To analyze Evaporative Stress Index (ESI) data, a user simply has to go to ClimateSERV.servirglobal.net, choose Get Started, draw a polygon or choose a feature on the map, and then select the ESI as data source.

A new World Water Quality Portal, **launched by UNESCO's International Hydrological Program (IHP)**, provides information on freshwater quality at the global scale using remote sensing data. The Portal addresses an urgent need to enhance the knowledge base and access to information in order to better understand the impacts of climate- and human-induced change on water security. It provides data on five key indicators of the state of water quality: turbidity and sedimentation distribution, chlorophyll-a, Harmful Algal Blooms (HAB), organic absorption and surface temperature. These indicators also provide information on the impact of other sectors

* Interactive map was developed by SIC ICWC upon request of CAREC as part of the Project "Promotion of dialogue for conflict prevention related to water nexus in Central Asia (CAWECOOP)" financed by EU.

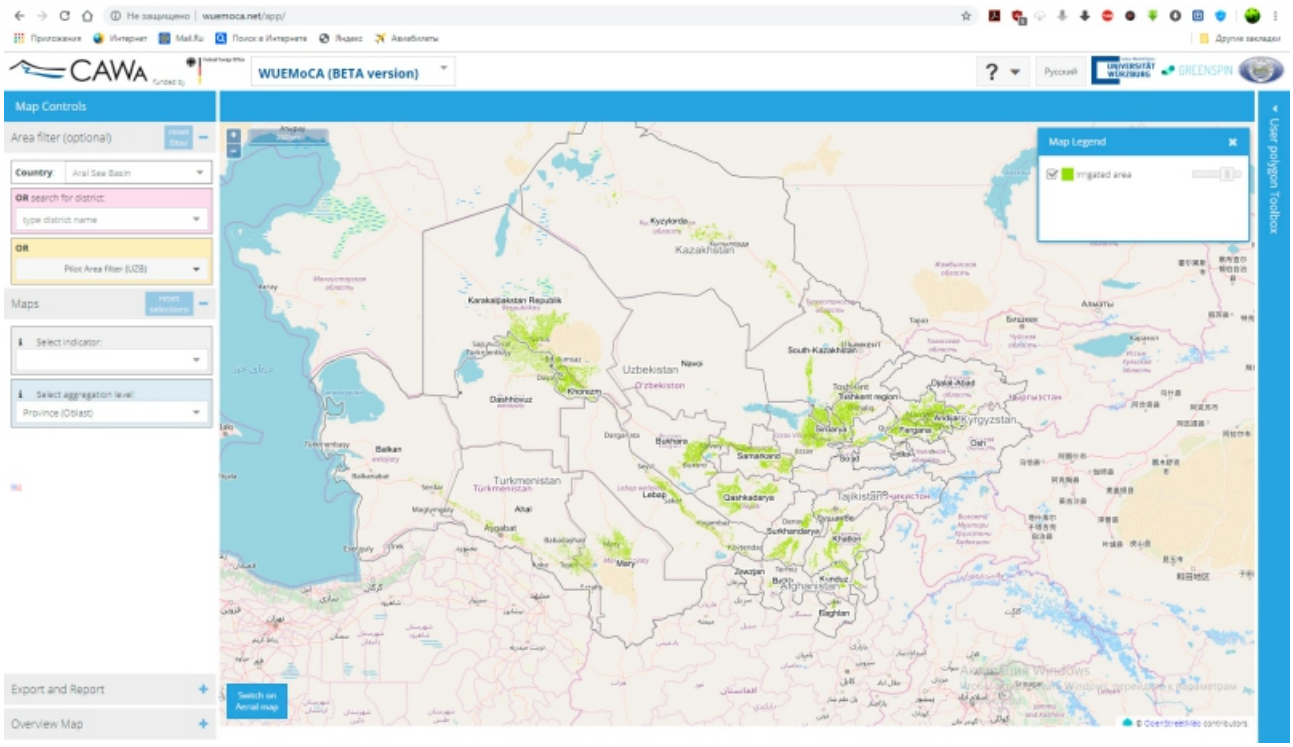
and land uses such as urban areas, fertilizer use in agriculture, climate change or dam and reservoir management. The Portal uses optical data from Landsat and Sentinel-2 satellites, which are open access, and a computational system, developed by EOMAP, Germany.

Kazakhstan launches a large-scale project on agrochemical soil analysis – an interactive map of soil conditions over the whole territory of the country (http://www.goldau.kz/, developer – JSC Information and Accounting Center. With such map it would be easier for farmers to apply for subsidies for fertilizers, set operation-order cards for modern equipment for land treatment and use an "agro-consultant robot".

The website of the **Uzbekistan's State Committee for Land Resources, Geodesy, Cartography and State Cadastre** informs about the development of a mobile application that provides information about farmlands, including the way fields are used, names of farmers, etc.

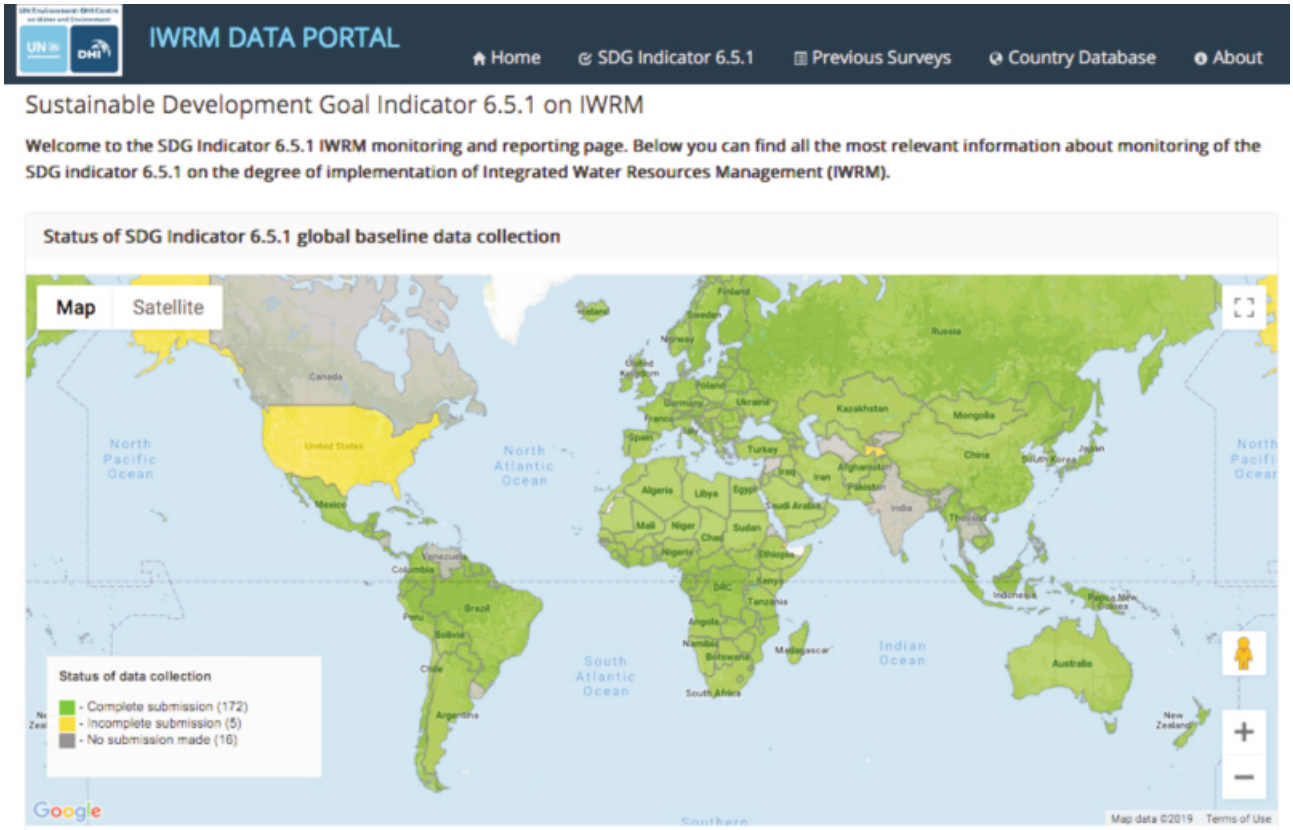
A **Beta Version v18.12 of the WUEMoCA** (Water Use Efficiency Monitor in Central Asia) information tool was launched. It constitutes a continuous and automated monitoring platform that provides free access to spatio-temporal agricultural geoinformation such as land use and crop types, yield estimations, and evapotranspiration assessments. This information is derived from open-source optical satellite remote sensing MODIS imagery and freely available global climate data. Spatial focus of WUEMoCA lies on the irrigated cropland area in the Aral Sea basin: Uzbekistan, Northern Kazakhstan, Turkmenistan, Tajikistan, Western Kyrgyzstan, and Northern Afghanistan. Predefined key indicators allow for the identification of marginal lands with low productivity, the localization of areas with lowest or highest land use intensity, and for assessments of the water use efficiency. WUEMoCA will contribute to the current database at the scale of the Aral Sea Basin and thus to informed regional decision-making. The tool addresses national governments, regional and transboundary authorities as well as specialists at water management institutions. Potential users also include educational institutions and the scientific community. The tool may be used in study programs on geoinformation technology and remote sensing, as well as in environmental and ecological research in Central Asia. The tool was developed under the Regional Research Network "Water in Central Asia" (CAWa) by SIC ICWC in cooperation with the SME green spin GmbH in Würzburg (Germany), and the Department of Remote Sensing at the University of Würzburg (Germany).

The **IWRM Data Portal** provides access to the results of the global baseline reporting on SDG indicator 6.5.1 – Degree of IWRM Implementation. It contains the global assessment results and analysis products, as well as the national



Source: http://wuemoca.net/app/

submissions of the 172 reporting countries. The global baseline assessment of SDG Indicator 6.5.1 and its future reporting cycles will help track the global progress towards better management and achievement of SDG 6 target 6.5. In addition, the IWRM Data Portal offers a comprehensive collection of national IWRM implementation progress data drawn from two previous global IWRM implementation surveys undertaken in 2007 and 2011. While not directly comparable with the SDG indicator 6.5.1, these previous global assessments can help examine the overall progress of IWRM implementation dimensions within the individual countries to date.



Source: http://iwrmdataportal.unepdhi.org/index.html

Uzbekistan launched a mobile application (MA) TOMCHI developed by the National Water Resources Management Project in Uzbekistan funded by SDC. The TOMCHI application is designed for farmers, employees of water management organizations and other water users, including entrepreneurs who produce and install water-saving irrigation technologies. It provides instant access to information on water-saving irrigation technologies and explains their benefits. During the presentation, project specialists noted that the application is compact, broad-ranging, illustrative, and user-friendly. TOMCHI may calculate the cost of introducing water-saving technologies, such as drip irrigation, sprinkler irrigation, irrigation using hydrogel, etc. It serves as a unified communication platform for producers and users. It is important to note that the MA will be linked to the knowledge portal of the Ministry of Water Management of Uzbekistan, where comprehensive information on water-saving technologies as well as information and data on all aspects of water management will be posted. The TOMCHI app can be downloaded for free from the Apple Store and Google Play

(https://play.google.com/store/apps/details?id).