Project "Mainstreaming adaptation into planning processes to reduce vulnerability to climate change at local and central levels in Moldova's Agriculture Sector" (AgSAP)

REPOSITORY OF AGRICULTURE ADAPTATION TECHNOLOGIES

Project #1	Capitalization of the trophic potential through interspecific polyculture
Problem and Project Description	
The ambition level for implementing this technology is proposed at long-term, full-scale level. A total of 37 ponds currently used for aquaculture will be developed into polyculture for a total of 6,770 ha. The ponds are distributed throughout the country, namely 14 in the Northern part of Moldova, with a cumulated area of 1,252 ha, 15 lakes in the Central part having a cumulated area of 3,015 ha, and the remaining 8 lakes are found in the South and have a total area of 2,510 ha. Currently, these lakes are stocked with juvenile - body weight 20 g – non better-defined phytophagous fish at a density of 1,200 – 1,500 pcs / ha and native European carp at a rate of 700 - 800 pcs / ha (e.g. Sarata Noua Lake) or, as in the case of Badragi Lake, with juveniles of two summers of phytophagous fish at a density of 300 -500 pcs / ha and carp at 800 pcs / ha. The productivity of these lakes is on average 550 kg of fish per ha with variations from north to south comprised in the 400 -700 kg / ha range. Current harvest volumes total value of around 3,720 tons per year. The ambition of this TAP aims at modifying the species composition in these lakes in order to better exploit the trophic potential of the ponds increasing species count from 3 to 6 and harvest volumes from 3,720 t/year to 4,670 t/year. This goal will be achieved through the introduction of pikeperch - 120 pcs / ha, European wells - 100 pcs / ha, and European bream at a stocking rate of 170 pcs / ha. The increase in fish production at the second year of growth due to the introduction of additional species is expected to be between 100 and 160 kg/ha in total, and specifically 40 - 60 kg/ha from pikeperch, 50 - 60 kg/ha from European wells, and 10 - 30 kg/ha from breams. Total fish production in these 37 lakes can increase by almost 1,000 tons annually and reach 4,670 tons/year. The creation of the enabling environment to the implementation of this technology encompasses the building of a governing structure that acknowledges the potential benefits of fish polyculture, governs its planning also by providing technical and financial support, especially for the construction of nurseries and the logistical structure that accompanies aquaculture entrepreneurs in obtaining and raising multi-species fish fry from those nurseries. The enablers for these changes are primarily policy-driven, as emerged from the analysis of the barriers (see BAEF report), but relevant emphasis is on capacity building to manage the polyculture and the production of multiple species broods and provide the existing workforce with the means to operate these resilient farms. Initial investments will require external support since a major barrier to the development of domestic self-sufficient supply of hatchlings and fry is the lack of investment capital of private aquaculture farms in Moldova. Subsequently, awareness raising on the potential of climate-resilient aquaculture is necessary to foster market access and demand for aquaculture products.	

Project #2	Restoration and conservation of the gene pool of native fish populations

Problem and Project Description

The increase in the volume of fish production is due to the population of water basins with high-quality stocking material and the development of the national genetic pool.

In the bream fish culture in the country, use the strategy of improving fish genetic resources in the long term - through the selection method and in the short term - through hybridization. Industrial hybrids, recommended by researchers in the field, which allow the use of the heterosis effect (15-30% of additional products) are widely applied in commercial fish farming. This reduces the self-cost of consuming fish.

In the conditions of the activity, many small and medium-sized fish farms, which use one or two small hatcheries, the two-level structure of the organization of selection and reproduction work (breeding farms - production fish farms) was introduced, justified from the point of view from an economic point of view, since the costs of acquiring larvae are insignificant compared to the costs required to maintain the broodstock, raise the breeders and organize mass breeding.

In order to prevent the risks of loss (genetic and due to the deterioration of the conditions of maintenance, including ichthyopathology) of the fish genetic fund, it is necessary: Creation of a bank of live collections of fish, including rare and endangered species/ farm of live collections of fish genetic resources , including: the fish nursery and incubator, where approved breeds will be concentrated, the lines created, for the reproduction of the selection material, the fish stocking material, which will allow to increase the production volume of fish for consumption; reproduction of rare and endangered species in artificial conditions and restoration of natural populations, carrying out compensatory repopulation.

The restoration and reintroduction of 2 watermelons Drochia and Dubăsari into the aquaculture sector.

The technology will enable the selective breeding and sustainable use of breeds approved for higher temperature tolerance and the use of early broodstock rearing technologies. The formation of the informational database on the aquatic genetic resources that will allow the systematic registration, analysis and monitoring of the results of the official control of the bonito and the compliance with the requirements of the breeding material / fish breed standards. Improving the awareness and competence of fish producers regarding the potential benefits of selection programs and their implementation; promoting breeding achievements and their role in the conservation and restoration of fish genetic resources, facilitating investment and supporting the strengthening of technological development, innovation and knowledge transfer to aquaculture gilt farms.

Project #3	Increasing water flow in the ponds used for growing fish in polyculture
Problem and Project Description	
The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale. At demonstration level, the increase in water flow will be applied in 30 ponds located in the 3 aquaculture areas of Moldova (10 ponds each in the northern, central and southern fish areas) Currently, in these ponds mostly cyprinids are grown (singer, novac, moose and carps) at the stocking density of 1,500-2,000 pcs/ha of one-year-old juveniles (80-120 kg/ha) and 1,000-1,200 pcs/ha of two-summer juveniles (250-320 kg/ha). The ambition of this TAP at demonstration level is to increase the volume of water flowing to the ponds via drainage and desilting works will increase the volume of water in ponds by approximately 20-25%. This will allow to regain the volume of water loss in recent years, as in the case of Nisporeni lake, where the water level decreased by 60 cm. This objective will be achieved by the removal of about 18,000-20,000 m3 of silt, sand, overgrow vegetation and other debris, and through the development of dedicated capacity building program (6-8 million lei for each fish basin) to train staff to maintaining increased water flow in case study ponds. At full-scale implementation, this technology is going to interest a total of up to 2,400 aquaculture ponds with a total area of approximately 400,000 ha located in the north (35%), center (40%) and south (25%) of the country. The removal of barriers to the implementation of techniques for increasing water flow in streams and aquaculture ponds requires firstly policymaking actions. The understanding of the responsibilities and requirements of land concessions over aquaculture water bodies is a key starting point to develop sound and agreed policies and consequently to implement them in the field. Once the gaps in regulation surrounding water basins ownership are defined, a sound planning of roles and responsibilities can be rolled out. As in the case of all technologies prioritized for aquaculture, capacity building of the workforce employed is another key aspect of intervention in this Technology Action Plan. Labor, equipment and management of operations to increase water flow will require adequate financial resources, especially upfront. This TAP, however, considers the generation of value from the application of this technology too. In fact, if the upfront capital investment in the form of working capital will be necessary to build up a National Water Flow Management Program, which institutes a management infrastructure to govern for a 10-year timeframe the cleaning of watersheds and the maintenance of their operations and functions, including the procurement of workforce to accomplish the actual work needed. The removal of sand, gravel and silts from the channels and the floodplains that interferes with aquaculture activities however, also generates a resource, which is to be appropriately marketed as a co-product of this intervention. Construction and cement industries in fact are hungry for materials such as sand and gravel and an action to link the removal of these materials with existing markets is envisaged. Initial investments will require external support since a major barrier to the development of this technology is the lack of capital of private aquaculture farms in Moldova, but the co-benefits of the sale of sand and gravel will mitigate these initial cost by an appreciable margin. Awareness raising on the potential of climate-resilient aquaculture and the role of sound watershed management is necessary to long term sustainability of the actions implemented and dedicated activities are foreseen in this TAP.	

Project #4	Fish protection system and ensuring food security in the conditions of climate change
Problem and Project Description	
The fish protection system presents a complex of measures regarding the improvement of conditions for the growth and wintering of fish, the prevention and use of stocking material with genetic resistance and ensuring food security by increasing fish productivity and obtaining healthy food. Changes in the conditions of increased temperatures above the optimal range of tolerance, changes in the regime of precipitation and extreme phenomena - drought have a significant impact on water retention, changes in the pattern of precipitation create the uncertainty of maintaining the necessary amount of water for aquaculture. Therefore, it is necessary to develop the pisciological-biological foundations (FPB) for the water bodies based on the inventory, mapping and assessment (evaluation of hydrological, hydrochemical indicators, trophic potential) and the classification according to the existing climatic conditions of the water bodies (aquaclimatic zoning) in the fishing areas of Moldova to predict water availability in water bodies, allowing farmers to adapt to existing climate changes. The technology will allow you to: - determine the real situation of the aquaculture sector under climate change conditions; - identify the active production units and the number of water users for aquaculture; - determine the productivity of natural fisheries and the volume of fish that can be produced under conditions of water scarcity and drought; - determine the volumes of the meliorative works to clean the water supply channels of the ponds. - ensures the health of the fish for consumption in the fishponds as the factor that most clearly reflects the ecological situation, related to the health of the population living near the fishponds. Morbidity and mortality in fish, caused by anthropogenic eutrophication of the basin, statistically truthfully reflect the state of health of the population, the intensity and quality of agricultural, industrial, urban, transport and other activities in the basin region. For this reason, the data on the dynamics of epizootological control and water quality in fish farms in the Republic of Moldova in the current climatic conditions are capable of showing interest for many other fields of activity. The impact will be felt by increasing the volume of fish production and will allow the creation of new job opportunities for local communities and overcoming the impact induced by climate change which will ensure the sustainability of the growth of fish for consumption, capitalizing on the potential of aquatic biological resources by addressing the effects of climate change and managing the sustainable development of competitive aquaculture and supporting market development for aquaculture products; Strengthen the capacities of relevant institutions to forecast the future incidence of climate change and to identify action plans and improve resilience capacities in rural communities. Identifying methods of breeding breeds and lines of valuable fish species to overcome the shortage of juvenile stock due to climate change and disseminating knowledge through an effective knowledge transfer program. Fisheries-biological baselines (FPBs) will be developed for water bodies in Moldova's fisheries areas to predict water availability in water bodies, allowing farmers to adapt to existing climate changes. This technology will promote aquaculture with a high level of environmental protection and improve the infrastructure for the modernization of domestic aquaculture production. The technology will allow the strengthening of the administrative capacity at the national and regional level to carry out actions aimed at adapting to climate change in the sector, improve the compatibility between the production systems and the characteristics of the fishing areas.	

Project #5	Mapping and crediting of the trophic potential and aqua-climatic zoning of water basins
Problem and Project Description	
The technology will allow to carry out the inventory, mapping and crediting (assessment of: hydrological, hydrochemical indicators, trophic potential) of water basins used in aquaculture: - determine the real situation of the aquaculture sector under climate change conditions; - to classify according to the existing climatic conditions the water bodies (aquaclimatic districting) in the North, Central and South fishing areas. - identify the production units active in aquaculture and the number of water users for aquaculture; - determine the productivity of natural fisheries and the volume of fish that can be produced under conditions of water scarcity and drought; - determine the volume of meliorative works to clean the water supply channels of the ponds. The technology will allow the strengthening of the administrative capacity at the national and regional level to carry out actions aimed at adapting to climate change in the sector, improve the compatibility between the production systems and the characteristics of the fishing areas. It will increase the capacity of farmers to respond to the effects of climate change by identifying, mapping and crediting fishing areas at the national level by productivity classes for aquaculture, it will contribute to increasing aquaculture production and increasing environmental benefits and services, by: • Determining the level of the natural forage base and forecasting and planning the volume of fish for each body of water; • Determining the real, factual and legal situation of all the land surfaces on which the fish facilities are located - the water bodies (ponds and lakes) used for fish production; • Identification of fish farms and businesses that have suffered as a result of climate change; • Elaboration of a legal framework for the regulation of aquaculture activity; • Drawing up the register of units active and water users in aquaculture; • Determining the natural fish productivity of the water bodies and the volume of fish that can be produced in the existing basins under the conditions of water shortage and drought; • Determining the required volume of water to supply these bodies in drought conditions; • Determining the number of water bodies whose sources and water supply channels are to be cleaned (improved).	

Project #6	Ensuring the food security of consumer fish in fish ponds under climate change conditions

Problem and Project Description

The state of health of fish for consumption in fishponds most clearly reflects the ecological situation, related to the health of the population living near the fishponds. Morbidity and mortality in fish, caused by the anthropogenic eutrophication of the basin, statistically truthfully reflect the health status of the population, the intensity and quality of agricultural, industrial, urban, transport and other activities in the basin region [Meyer, Barklay, 1990]. For this reason, the data on the dynamics of epizootological control and water quality in fish farms in the Republic of Moldova in the current climatic conditions are capable of showing interest for many other fields of activity.

The originality lies in the fact that, for the first time, recommendations will be developed for the ecological safety of fish for consumption in the country's fish ponds, which will allow improving the situation in the sphere of public health.

The realization of the technology will allow the improvement, essentially, the recovery of the ecological situation in the basins and the sustainable exploitation of aquaculture. In connection with the aggravation of the epizootological situation in the fish ponds under the conditions of water shortage, the need arose to restore the control system, permanent sanitary-veterinary supervision, the implementation of measures to prevent and combat fish diseases and ensure food safety.

As a result of the implementation of the technology, the epizootic status of consumer fish from fish ponds will be appreciated in the conditions of the development of aquaculture in sustainable ecosystems, the main causes of the unfavorable conditions of these ponds in the conditions of climate change and extreme drought and water shortage phenomena will be established; the inventory of the main anthropogenic factors, which aggravated the epizootological condition of fish and the quality of sanitary-veterinary control; determined the favorable and unfavorable basins for diseases, the species most infested with fish and the frequent location of pathogens; identify and assess the public damage caused by the disease of fish populations, the impact of the environment, especially climate change, on fish health.

Technology makes an essential contribution in the elucidation of some aspects of an applicative nature, aiming to increase the effectiveness of the use of aquatic resources, dependent on climate changes, in the breeding of fish through the use of advanced technologies and the rational exploitation of biological resources.

The present technology has commercial interest – reducing the self-cost of fish production by increasing the yield of cultivated objects and fish productivity; socio-economic importance - meeting the quality of production with market requirements will improve the conditions of operations and the sustainable development of fish producers by implementing food safety measures, increasing the demand and utilization of domestic aquaculture production per capita and this fact stimulates production growth, strengthens knowledge institutional of the governors and the implementation of the sanitary-veterinary activity program in the field of fish farming for the development of food safety regulations in fish farming.

Project #7	Shading of ponds
Problem and Project Description	
Aquaculture is affected by high temperatures, high solar radiation and the subsequent evaporation of water and increased concentration of pollutants (e.g. nitrates) in the remaining water. Pond shading is a low-capital technology that can bring important benefits in terms of climate change adaptation. Shade nets are available in various shapes and densities. Typically, they can block 8% to 85% of sunlight reaching the surface of the pond, while allowing lateral air flow and infiltration of precipitation. The nets are suspended on stainless steel structures anchored to the ground if the ponds are less than 10 mt wide or on floating posts or even on weighted concrete basement posts inserted into the pond. Supplemental pond shading systems use floating structures that support either nets (passive) or, in some cases, active equipment that provide additional functions other than just shading. This is the case with floating installations of photovoltaic panels. Reducing the amount of infrared and UV radiation reaching ponds can keep water temperatures at manageable levels. Consequently, dissolved oxygen levels will also remain high. Shading can contrast algal blooms and improve water quality and fish welfare. In turn, these effects return positive gains in fish yields and enable higher stocking rates in ponds.	

Project #8	Water aeration systems
Problem and Project Description	
Oxygen depletion refers to factors that create low dissolved oxygen (DO) levels that lead to fish health problems and even mortality. Increased temperatures and lack of precipitation are factors that agree with the decrease in DO content in ponds. Technologies for adapting to such changes in aquaculture encompass a variety of systems. Aeration of an aquaculture pond basically involves the transfer of gaseous oxygen from the atmosphere into the pond waters where DO concentrations have fallen to critical levels. In general terms, the rate of transfer of atmospheric oxygen in a pond depends on the amount of turbulence in the water, the ratio of the pond's surface area to its volume, and how far the measured DO concentration deviates from saturation concentration. Water aeration systems are composed of: 1) DO meters and control box; 2) water aerators; 3) an energy source (floating photovoltaic panels). There are 5 types of aerators on the market: vertical pumps, pump sprayers, propeller-vacuum pumps, paddle wheels and diffused air aerators. The most suitable for the case of Moldovan ponds are a) paddle wheels and b) diffuse air aerators. These are best suited for a) emergency venting and b) routine venting respectively. Increasing the DO content in the water of aquaculture ponds in Moldova will increase fish health and, consequently, yield, which, as a result of higher temperatures, is decreasing. Monitoring do (and other water quality parameters) is an essential step in assessing the need for increased pond aeration. When non-saturation events occur for only a few weeks per year, temporary/emergency systems can be implemented by using tractors to feed paddle aerators or diffusers. If the assessment reports continued low levels of DO, a stable off-grid aeration system may provide increased resilience to fish stocks and consequently higher yields despite the effects of climate change.	

Project #9	The use of lakes with a complex destination for growing consumer fish in polyculture

Problem and Project Description

The use of lakes with a complex destination for the growth of fish for consumption through grazing is determined by the need for the rational use of the Dubăsari, Costești Stânca and Ghidighici reservoirs (which are extremely vulnerable to the effects of climate change) through the introduction and subsequent fishing of valuable fish species. The reconstruction of the ichthyofauna of the lakes by choosing a complex polyculture allows the effective exploitation of the trophic potential of the basin as the main method of intensification and rational use of the natural productive potential.

Changes in the annual rainfall regime in the recent past have a significant impact on water retention in lakes and create uncertainty in maintaining the required amount of water for aquaculture.

The availability of fingerlings for Asian carp and cyprinid stocks can be ensured by bream companies and farms. Fish farms that use this technology should look for alternative means to cover the shortage of roach, pike and bream fry and develop a capacity for resilience to climate change. As climate change has direct influences on the artificial reproduction of fish, alternative techniques and/or improvement of existing technologies for reproduction of shad, pike are needed. Successful breeding of these fish species for aquaculture constitutes a major requirement in aquaculture in the climate change scenario.

Effective technology management will enable the use of natural trophic resources of reservoirs not used in aquaculture to increase a sustainable volume of fish production and generate additional income, protect and restore aquatic biodiversity and improve aquaculture-related ecosystems

The biological and fishery opportunity of this technology is the application of polyculture being a cost-effective method due to the use of all trophic levels, thus increasing the fish productivity of the basin.

Unexpected changes in precipitation and changes in the annual precipitation pattern in the recent past have a significant impact on water retention in lakes and create uncertainty in maintaining the required amount of water for aquaculture. That is why the technology will frequently monitor the water level in the bodies, the hydrochemical and intiopathological state of the fish growth conditions during periods with temperature variations and extreme meteorological phenomena - drought

The sustainable development of aquaculture in reservoirs with a complex destination in the conditions of climate change, represents a socio-economic necessity in the medium and long term, involving their integration in the system of raising fish by grazing in polyculture (carp and Asian cyprinids, American catfish, bream), simultaneously with the valorization of water surfaces insufficiently used in aquaculture and the trophic potential of economically viable and socially and environmentally sustainable reservoirs. The implementation of this innovative technology by creating a model that respects environmental conditions, as well as increasing the added value by increasing the productivity and diversification of fish production as a modern and innovative management practice in the conditions of climate change and extreme phenomena (drought).

Project #10	Increasing the production capacity by restoring, modernizing and setting up the dried complex ponds
Problem and Project Description	
The technology provides for the creation of infrastructure in the aquaculture sector by restoring, modernizing and arranging the ponds and lakes of complex use dried up during the water shortage to ensure the increase in the production of fish for consumption with the involvement of all interested decision-makers - users, aquaculture producers, authorities. At the same time, the users, both those from aquaculture and agriculture, will be included in the process of drawing up the management plans of the restored and modernized water basins In the process of implementing the technology, the interested parties will develop framework rules (guidelines, regulations) on the basis of which the risk management plans for each fishing area and the plans for corrective actions in the framework of regulation, restructuring and consolidation of fish holdings will be developed with the adoption of some modern and innovative management and adaptation practices in the conditions of climate change and extreme phenomena (drought). The technology will allow the modernization and rehabilitation of partially or fully dried up traditional aquaculture units by stimulating new investments to restore water bodies used for fishing purposes, cleaning water storage channels and fishing infrastructure, building and modernizing breeding hatcheries of valuable species in the purpose of diversifying products obtained through aquaculture in accordance with market demands ➢ Dredging ponds and bringing dry water bodies back into use, ➢ Dredging the water supply channels of the ponds, ➢ Increasing the efficiency of sharing water with primary users, ➢ Changing the terms and population density of water bodies. The direct benefits are those related to the increase in fish growing areas, which allow farmers to increase the production volume by 15%. The surface of the 780 bodies of water is 4500 ha, we assume that the average fish production before the implementation of the technology is 1000 kg/ha of which carp 300 kg x 70 lei = 2100 lei Asian cyprinids 700 kg x 40 lei = 2800 lei.	

Project #11	Technologies for feeding cyprinids

Problem and Project Description

The feeding (feeding) technology of cyprinids under the conditions of rising temperatures and water shortage must be oriented in the following directions:
- combating the excessive development of phytoplankton and especially green and blue algae, to avoid some trophic impacts (algae bloom);
- the stimulation of mono-specific cultures (algae, zooplankton, rotifers), especially for the stages of larvae, fingerlings and fry, when the bio-physiological requirements of the fish presuppose a sufficient quantity and quality of food;
- the application of complex popular formulas, in which the share of phyto-planktonophage species reaches up to 60%.

In current cyprinid feeding technologies, it is required that the establishment of feed rations be correlated according to the energy requirement, water temperature, age of the fish and growth rate of the carp. The additional feeding of the carp, raised in a semi-intensive system, is made according to the natural food existing in the pool.

The technology is expected to be implemented in 30 farms - the surface of water bodies 500 ha

The costs

• Activities to combat excessive phytoplankton 1 million lei.

 Conducting studies and drawing up regulatory instructions for phytoplankton combating procedures - 0.1 million lei

 Preparation of tools, equipment and machinery for processing with harmless chemical preparations - 0.2 million lei

 Works to combat phytoplankton by treating surfaces with harmless preparations -0.7 million lei

• Expenses for the procurement of harmless chemical preparations - 1 million lei
   - Procurement of harmless chemical preparations - 0.85 million lei
   - Transportation of chemical preparations - 0.05 million lei
   - Arrangement of warehouses for keeping chemical preparations - 0.1 million lei

• Expenses for procuring and populating the young of phytoplanktonophage species-3 million lei

 Procuring the young of phytoplanktonophage species

• Expenses for additional fodder 2 million lei

 Procurement of combined feed 50,000 kg of edible fish x 4.0 kg = 200,000 kg x 10 = 2 million lei.

Implementation of good management practices in the feeding process of cyprinids in order to reduce the risks related to unexpected climate change heavy blooms of harmful algae and reduced production due to negative effects on growing conditions

Strengthening capacities at government and sector level on improving the adaptability of aquaculture and its resilience to natural risks and reducing the uncertainty of fish growth due to climate change impacts

Project #12	Relevant risk management tools to support the subsidization and implementation of the aquaculture credit mechanism
Problem and Project Description	
The technology will enable the development and implementation of new risk management solutions to improve the access of aquaculture producers and scientific institutions to finance the modernization of farming systems, the adoption of climate-smart and sustainable aquaculture technologies and solutions, and value added activities. In particular, it will propose for elaboration drafts of normative acts for the inclusion in the state subsidy system of fish producers for the purchase of high-quality stocking material from bream farms; purchase of feed, fertilizers, medicines for the prevention and treatment of fish diseases, reimbursement of energy expenses, under the conditions provided by the other branches of the agro-industrial complex. Subsidies to aquaculture producers and businesses would be further boosted by reducing financial risks through financial instruments. These financial instruments are to be further supported by promoting development plans, investments in aquaculture, as well as the information platform and database that allow improved access to production, market, environment and climate data for both public institutions, as well as for stakeholders in aquaculture chains. • Development, adoption of technologies and sustainable solutions from the climate point of view and activities -3 million lei • Development of draft normative acts for including fish producers in the state subsidy system - 1 million lei • Subsidizing pig farms - 5 million lei • Subsidizing fish farms for the implementation of technologies beneficial to the environment - 5 million lei. An important aspect is the fact that investments in effective and sustainable technologies and solutions in the field of aquaculture would be prioritized, as well as in the development and production of new aquaculture products with greater added value, especially those proposed in the context of productive partnerships between producers and aquaculture buyers. Finally, specific insurance models for aquaculture producers and businesses will be developed and expanded by using commercial reinsurance markets to manage disaster risks. Draft normative acts for the inclusion in the state subsidy system of fish producers and scientific institutions in aquaculture that use technologies for adaptation to climate change conditions will be proposed for elaboration.	

Project #13	Creation of Climate Change Information System and Aquaculture Knowledge Platform
Problem and Project Description	

A central climate change information system and an aquaculture knowledge center would be established following the implementation of the technology. This would also include organizational capacity building services (eg assessment of new technologies and innovations, business management, standards compliance, etc.) as well as general information for entrepreneurs.

- Actions to create a central information system on climate change in aquaculture - 2 million lei
  - The creation of an interactive website that would bring together all available data on the aquaculture sector, technical and technological data, results of various research projects and information on recent aquaculture development projects.
  - Organizational capacity building services (assessment of new technologies and innovations, business management, compliance with standards, etc.)
  - Classification according to the existing climatic conditions of water bodies (aquaclimatic zoning) in the fishing areas of Moldova
- Creation of an aquaculture database
  - Creation of a central integrated aquaculture information system, which will include all aquaculture databases.
  - Carrying out the improvement of water bodies (evaluation of hydrological, hydrochemical indicators, trophic potential)

The cost of this study for 1000 bodies of water x 2000 lei = 2 million lei

- Data collection and periodic long-term monitoring of physico-chemical parameters and relevant instruments in case of disasters - 1 million lei

 Carrying out complex investigations (ichthyopathological, hydrochemical, hydrobacteriological, hydrobiological, histological, hydrotoxicological) of the producing surfaces.

In the absence of information on the influence of climatic conditions on aquaculture production, the technology will enable the creation of an aquaculture database, including data on production, technology adoption, pond infrastructure and water supply.

At the same time, a climate and environment database needs to be created to assess the impact of climate change, analyze the impact on growth, optimize the use of water resources and monitor climate change adaptation behaviors.

Involvement in research and development to improve climate risk information systems and accessibility and share knowledge and experience on the interactions of aquaculture technological processes with the environment and adaptation to climate change in fish farming groups and networks. Collecting data and conducting periodic long-term monitoring of physico-chemical parameters and relevant disaster tools to predict possible natural disasters in specific areas and the impact on aquaculture production.

Project #14	Creation of Climate Change Information System and Aquaculture Knowledge Platform
Problem and Project Description	

The implementation of the technology will encourage small producers to collaborate more with each other and with other stakeholders in the value chain to improve their efficiency and strengthen their marketing in existing markets for domestic fish products to create higher prices.. Consolidation of measures adaptation of aquaculture farmers to the existing and potential negative effects of climate change, which threaten aquaculture production and sustainable livelihoods through aquaculture education.

Improving small producers' access to strategic market segments

Improving coordination, collaboration and partnerships between aquaculture producers and other actors in the food chain, including knowledge generation and knowledge transfer to institutions, to increase public support, especially for innovations in applied research, as well as their dissemination and adoption, and invest in advisers' skills and knowledge, especially in relation to compliance requirements and transformative innovations (climate-smart and sustainable aquaculture, information sharing).

In the absence of information on the influence of climatic conditions on aquaculture production, the technology will enable the creation of an aquaculture database, including data on production, technology adoption, pond infrastructure and water supply.

• Actions to develop, implement and monitor comprehensive aquaculture management plans – 2 million lei.

- created a climate and environment database for climate change impact assessment, growth impact analysis,
- optimization modeling of the use of water resources,
- monitoring of adaptation behaviors to climate change.

• development and implementation of a mechanism to support and stimulate links between producers and buyers - 3 million lei

- Elaboration of a mechanism for adapting to climate change in fish farming groups and networks,
- Improving the access of small producers to strategic market segments.

• Specific educational activities to improve the perception and consumption of native fish, improving the access of small producers to strategic market segments. - 2 million lei,

- Data collection and periodic long-term monitoring of physico-chemical parameters and relevant instruments in case of disasters,
- Involvement in research and development to improve information systems,
- sharing knowledge and experience on the interactions of aquaculture technological processes with the environment.

The implementation of the technology will encourage small producers to collaborate with each other and with other stakeholders in the value chain to improve their efficiency and strengthen their marketing in existing markets for domestic fish products to create higher prices.

Project #15	Rainwater harvesting systems
Problem and Project Description	

In the absence of information on the influence of climatic conditions on aquaculture production, the technology will enable the creation of an aquaculture database, including data on production, technology adoption, pond infrastructure and water supply.

• Actions to develop, implement and monitor comprehensive aquaculture management plans – 2 million lei:

- created a climate and environment database for climate change impact assessment, growth impact analysis,
- modeling to optimize the use of water resources
- monitoring of adaptation behaviors to climate change.

• development and implementation of a mechanism to support and stimulate links between producers and buyers - 3 million lei:

- Elaboration of a mechanism for adapting to climate change in fish farming groups and networks
- Improving the access of small producers to strategic market segments

• Specific educational activities to improve the perception and consumption of native fish, improving the access of small producers to strategic market segments. - 2 million lei:

- Data collection and periodic long-term monitoring of physico-chemical parameters and relevant instruments in case of disasters
- Involvement in research and development to improve information systems
- sharing knowledge and experience on the interactions of aquaculture technological processes with the environment.

The implementation of the technology will encourage small producers to collaborate with each other and with other stakeholders in the value chain to improve their efficiency and strengthen their marketing in existing markets for domestic fish products to create higher prices.

Project #16	Increasing areas under irrigation for the production of feed
Problem and Project Description	
The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At demonstration level, technologies to increase areas under irrigation to produce feed will be implemented in 13 farms of an average surface of 50 ha each which currently produce forage and feed. The farms are in the northern part of Moldova. Currently, these farms produce maize silage with yields of about 30-40 tons/ha, but during drought years yields are reduced by up to 50%, down to 15-20 t/ha. However, the use of proper irrigation systems on maize can sustain yields of 25-35 tons/ha even in drought years. The ambition of this TAP at demonstration level is to sustain yields during drought periods. Irrigation infrastructures include water harvesting and banking operations, where areas are devoted to water storage, they are recharged during precipitation events, participate in protecting from flood risks and are capable of releasing the water when drought occurs. The cumulated volume of water banking should reach around 4,000,000 m3, enough to deliver some 6,000 m3 per ha per year. In addition to water banking works, the sustained yield goal will be achieved thanks to the introduction of improved feed production techniques (better varieties, crop rotations, etc.) for each farm, and the development of 4 programs to train personnel and maintain the increased productivity in the case study farms. At full scale level implementation, this technology is targeted to interest a total of 100 farms in Moldova, for a total surface of 15,000 ha, and an estimated volume of irrigation water of approximately 90 million m3 sufficient to ensure the production of some 675,000 tons of feed. These comprise established feed and forage farms in the southern and northern part of Moldova. Currently, these farms produce alfalfa with an average productivity of 5 tons of product per ha and maize silage is about 30-40 tons / Ha, and a decreasing yield trend is observed compared to 10-15 years ago, when yields were comparatively higher at 8-10 t/ha for alfalfa. The ambition of this TAP at national level is to increase yields from the current average of 8 t/ha for alfalfa to 15 t/ha, and maintain maize silage yields at about 40 tons/ha also during drought years. This goal will be achieved through the introduction of irrigation, fertilizers application, crop rotations, etc. and the development of 4 programs to train personnel and maintain the increased productivity in the Moldovan farms. The implementation of this technology requires the removal of some policy barriers and the organization of a Sustainable Irrigation Program for feed production in Moldova. The development of the program will ensure safe and resilient feed for Moldovan livestock farmers and will be the main Action of this TAP. Activities that compose this action look at assessing the baseline status with a nationwide survey of irrigation needs and conditions of established forage farms. This activity will be conducive to planning water banking works and related irrigation systems and networks interesting the 100 feed producing farms in Moldova to date. The planning will require assessing geological conditions of the sites, designing individual water banking schemes for each farm and the related irrigation network. Following this activity, the deployment of such systems can be enabled and will require naturalistic and civil engineering work in all farms enrolled in the program. Along the lines of the planning of water supply in drought years to existing and established feed crops, an activity dedicated to researching and testing best practices for input-efficient feed types diversification in the country is also necessary to complete the resilience of the sector to the impacts of climate change. In fact, this activity will offer important benefits including increased economic stability of feed producing farms as a result of the diversification of the offer of feed to the market. Livestock farms will maintain income levels despite the impacts of climate change in drought years thanks to increased feed availability.	

Project #16	Increasing areas under irrigation for the production of feed
In order to deploy the aforementioned activities, capacity building at both institutional and farmers level is necessary. In addition, to detect inefficiencies and correct management approaches a monitoring and reporting action and related activities has also been foreseen.	

Project #17	Construction of platforms for the accumulation and storage of manure and organic fertilizers production
Problem and Project Description	
The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At the demonstration level, the construction of platforms for the accumulation of manure and the production of organic fertilizers will be implemented in 5 farms. The farms are in the northern part of Moldova. Currently, each of these dairy farms produces about 140 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at demonstration level is to produce 5,500 tons of organic fertilizers in the form of composted, mature manure. This goal will be achieved through the construction of special platforms for each farm, and the development of 2 programs to train personnel and maintain the increased productivity in the case study farms. At full scale level implementation, this technology is targeted to interest a total of 100 farms. These comprise established livestock farms in the northern, central, and southern part of Moldova, distributed for a 45% percent in the North, 34% percent in the Center and 21% in the South of the country. Currently, each of these dairy farms produces about 650 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at the national level is to produce 941 000 tons of organic fertilizers per year after implementation. This goal will be achieved through the construction of construction of manure maturation and composting structures (e.g. pits) for each farm for a total of 100 platforms, and the development of training campaigns to maintain manure composting production in the farms. Properly designed and operated manure management systems prevent manure from overflowing or discharging from a facility, and allow for timely nutrient application for vegetative growth. Whether the manure is stored in a lagoon, earthen structure, tank or deep pit, similar principles exist to maintaining a sound manure storage structure. Frequent evaluation of the system and preventative maintenance reduce the risk of costly structural and/or environmental issues down the road. This TAP is designed around the maximization of the efficiency of manure storage and maturation processes and the construction of efficient platforms for these operations. An important component of the TAP involves the planning and execution of the logistics for organic fertilizer applications in the soils used to produce feed for the livestock sector. Capacity building of farmers enrolled in this program is crucial to train them on the sound management of manure for organic fertilizers production.	

Project #18	Improved animal sheds construction
Problem and Project Description	
This TAP involves two activities. The first is the planning and provision of guidance to build or retrofit animal shelters to ensure their welfare in the context of climate change. The guidelines and engineering drawings will be procured for the following livestock classes and farms: For dairy cattle - 20, 40, 60, 80 and 100 animals. For fattening pigs – 100, 300, 500, 700 and 1000 animals. For laying birds – 20 000 and 50 000 heads. For broiler chickens – 25 000, 50 000, 75 000 and 100 000 heads. Subsequently, these guidelines will be employed to retrofit existing farms. The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale level. At demonstration level, the construction of improved shelters (modernization of microclimate systems) for animals will be implemented in 4 poultry farms in total of which 2 layers (2 halls) and 2 broilers (6 halls) farms. Farms are located in the northern, central and southern parts of Moldova. Currently, these farms produce around 8,000 tons of poultry meat and 12 million eggs annually and there is a downward trend in production during the warm period of the year due to increased heat and cold stress. The implementation of this technology will require building 8 cooling systems to equip the 8 halls with climate control units and dedicated management software and perform a full thermal insulation of the halls. In addition to poultry farms, 2 cattle farms (one for 40 dairy cattle and one for 100 dairy cattle) will also be included in the demonstration phase. A dedicated procurement contract with a local design company will be issued. The estimated cost of each demonstration case study will be comprised between USD 45,000 and 100,000. At full-scale implementation level, the construction of improved animal shelters will be implemented in 100 farms nationwide (poultry farms, and pig and cattle farms). Farms are distributed equally in the northern, central, and southern parts of Moldova. Currently, these farms produce various animal products (eggs, milk, meat) and there is a tendency to decrease production during warm periods of the year because of increased heat and stress suffered by the animals. This TAP targets the creation of a national set of guidelines and their implementation in existing livestock farms to ensure animal welfare despite the impacts of climate change. Actions to implement mandating policies to enhance the requirements for animal welfare are envisaged. Also training of institutions and policymakers to develop such policies is included in the Technology Action Plan. Two key objectives of this TAP are the production of a set of national guidelines for animal welfare, including supporting documentation on how to built new animal shelters, and the retrofitting of existing halls and stables to ensure that existing farmers apply the principles of the guidelines. These two activities will form the bulk of Action 2., the Improved Animal Welfare Program for Moldova. Also farmers, in addition to policymakers will benefit from a dedicated capacity development program to ensure long-term sustainability of the interventions on the ground.	

Project #19	Creation of irrigation systems for feed production

Problem and description of the project

As a national priority, the reduction of greenhouse gas emissions and the implementation of climate change adaptation measures are established. The National Irrigation Sector Development Strategy 2030 emphasizes the need to reset and rehabilitate the irrigation sector, as well as the possibility of increasing suitable irrigation areas by 250 thousand hectares to 300,000 hectares by 2030.

Food security is periodically affected by weather conditions. Droughts, floods, and other extreme natural phenomena such as heavy rains, hailstorms, storms, and freezes occur regularly and have a significant impact on the overall standard of living and rural economy. Drought, as a consequence of climate change, has a major impact on livestock feed supply and subsequently on food supply for the population. During the drought period, which occurs practically every 2-3 years in our country, there is a shortage of fodder, especially for cattle breeders. Consequently, there are practices where, due to drought and fodder shortages, especially silage, farmers are forced to cull their livestock. This has been keenly felt in the past 5-10 years, resulting in a drastic decrease in the number of cattle both in the private and individual sectors. While it is possible to import feed for poultry and pigs (corn and wheat), importing silage for cattle is impossible due to complicated logistics.

Currently, in the Republic of Moldova, irrigation systems are mainly used for technical crops, vegetables, and fruits. Irrigation for fodder crops is practiced on a small scale (there is no widespread practice).

To address the issue, it is proposed to create irrigation systems for fodder crops. Initially, it is proposed to implement irrigation systems for fodder crops for farmers in the northern part of the country where the dairy sector is developed. Priority will also be given to those farmers who have access to water from rivers. Local irrigation systems for farmers are planned to be connected to centralized systems that are linked to water sources from rivers. According to MAFI data, approximately 50 cattle farms are located in the northern region of the country, some of which could implement this technology.

According to the strategy, approximately 11 thousand hectares of land suitable for irrigation connected to sustainable sources of quality water for irrigation will be constructed/developed annually by 2030. This would allow for an additional minimum of 108 thousand hectares to be developed for irrigation by 2030 in the service area of 77 rehabilitated irrigation systems. Additionally, it is proposed to increase the area of irrigation for fodder crops by 50 thousand hectares.

Project #20	Use of drought-resistant feed varieties
Problem and description of the project	
Food security is periodically affected by meteorological conditions. Droughts, floods, and other extreme natural phenomena such as torrential rains, hailstorms, storms, and freezes occur regularly and have a significant impact on the overall standard of living and rural economy. Drought, as a consequence of climate change, has a major impact on animal feed security and subsequently on food security for the population. During the drought period, which practically occurs every 2-3 years in our country, there is a shortage of fodder, especially for cattle breeders. Consequently, there are practices where, due to drought and fodder shortages, especially silage, farmers are forced to cull their livestock. This has been keenly felt in the past 5-10 years, resulting in a drastic decrease in the number of cattle both in the private and individual sectors. While it is possible to import feed for poultry and pigs (corn and wheat), importing silage for cattle is impossible (due to complicated logistics). It is proposed that in collaboration with research institutions, the use of various drought-resistant plant varieties be implemented in the territory of the Republic of Moldova. MAFI, together with subordinate research institutions, must develop a list of recommended plant varieties for cultivation in our country. At the same time, research institutions should focus on identifying and creating indigenous plant varieties adapted to the climate of the respective area.	

Project #21	Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures
Problem and description of the project	
Feeding animals is a key element in maintaining their welfare and achieving high productivity. In the period between 1990 and 2015, due to the dramatic decrease in the number of animal farms in the Republic of Moldova, there was a decline in the demand for specialists in animal nutrition. Over the past 5 years, there has been a gradual increase in the number of farms; however, the zootechnical sector still faces a chronic shortage of specialists in this field, particularly veterinarians and animal nutritionists. As a result, animals on farms are often not fed according to their nutritional requirements. To address this issue, it is proposed to train specialists who will develop these feed rations, including those adapted to climate change. It is proposed to acquire informational programs for the development of feed rations and the training of specialists in feed formulation. This includes developing training programs for farm specialists and extending extension services for their periodic training in this field. Training specialists will have a positive impact on animal health. Animals will be fed with feed adapted to farm conditions, thereby positively impacting their welfare. Farmers will also benefit economically by maximizing productivity.	

Project #22	Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions.
Problem and description of the project	
Food security is periodically affected by meteorological conditions. Droughts, floods, and other extreme natural phenomena such as torrential rains, hailstorms, storms, and freezes occur regularly and have a significant impact on the overall standard of living and rural economy. Drought, as a consequence of climate change, has a major impact on animal feed security and subsequently on food security for the population. Animals are also directly affected by climate change, especially by high temperatures recorded during the summer, when they exceed 30°C, the animals' comfort temperature, which directly affects their well-being. High-producing animals are particularly affected, as they are usually imported from other countries where ambient temperatures differ from those in the Republic of Moldova. As a technological solution, it is proposed that farmers use breeds adapted to the climatic conditions of Moldova. It is necessary to evaluate, in collaboration with the Scientific-Practical Institute of Biotechnologies in Zootechnics and Veterinary Medicine, the types of breeds and hybrids of animals used in our country, followed by the preparation of a specialized guide recommending which breeds should be used under changing climatic conditions. Breeds of animals resistant to climate change usually have lower productivity than breeds used in high-producing farms, such as Holstein, for example. It is necessary to evaluate which breeds should be used in the conditions of the Republic of Moldova and depending on the farmer's facilities (buildings, equipment) and provide the necessary recommendations. The selected animals will better withstand the climatic conditions of the Republic of Moldova, and farmers will be able to achieve maximum productivity without compromising the welfare of the animals. At the same time, the price of local genetic material will be lower, resulting in additional savings for farmers.	

Project #23	Improving and adapting to the requirements of livestock and poultry, farming and maintenance systems.
Problem and description of the project	
Drought, as a consequence of climate change, has a major impact on ensuring animal feed, subsequently affecting food security for the population. Additionally, animals are directly affected by climate change, particularly by high temperatures experienced during the summer, when temperatures exceed 30°C, the animals' comfort threshold, directly impacting their well-being. High-producing animals, which are often imported from other countries with different ambient temperatures than those in the Republic of Moldova, are especially affected. As a technological solution, the installation of fully automated climate control and monitoring systems in animal shelters is proposed. The system will consist of a central computer that controls the microclimate within the facility and automated cooling systems (air conditioning). The equipment will be compatible with the breeding and maintenance system of all types of animals (birds, pigs, cattle) and all types of productivity (meat, eggs, milk, reproductive stock).	

Project #24	Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs
Problem and description of the project	
Drought, as a consequence of climate change, significantly impacts the provision of animal fodder, subsequently affecting food security for the population. Similarly, animals are directly affected by climate change, particularly by high temperatures experienced during the summer, when temperatures exceed 30°C, surpassing the animals' comfort threshold and directly affecting their well-being. High-producing animals, typically imported from other countries with different ambient temperatures than those in the Republic of Moldova, are especially affected. Another major issue for animal husbandry in the Republic of Moldova is the dramatic increase in energy prices. High energy prices pose a significant problem for the zootechnical sector, affecting farmers' incomes. Moreover, the use of fossil energy resources directly contributes to an increase in greenhouse gas emissions, which in turn affects climate change. As a technological solution, thermal insulation of animal premises is proposed. It is suggested that insulation primarily be applied to the roof. Changing the construction material is proposed, as currently, most of the roofing is made of asbestos slate, which is recommended to be replaced with sandwich panels. The minimum thickness of the panels is proposed to be 80 mm (ideally 100 mm). Similarly, thermal insulation of exterior walls should be performed using mineral wool or sandwich panels. Thermal insulation should comply with NCM E.04.01-2006 Thermal Protection of Buildings, with a calculated resistance to heat transfer (R-value) not less than 2. Furthermore, the use of new materials for thermal insulation, such as sheep wool, is proposed. Currently, the cost of one m2 of sandwich panel is about 40 euros. About 2000 m2 is needed for the rehabilitation of one roof. Respectively, a minimum of EUR 80,000 is required for a roof. For complete insulation of the hall is required about 150 thousand EURO. In the Republic of Moldova, it is necessary to modernize at least 200 farms on average of 3 halls each, a total of 600 halls.	

Project #25	Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept.
Problem and description of the project	
Drought, as a consequence of climate change, has a major impact on ensuring animal feed, subsequently affecting food security for the population. Similarly, animals are directly affected by climate change, particularly by high temperatures experienced during the summer, when temperatures exceed 30°C, surpassing the animals' comfort threshold and directly affecting their well-being. High-producing animals, typically imported from other countries with different ambient temperatures than those in the Republic of Moldova, are especially affected. As a technological solution, the installation of fully automated maintenance and microclimate monitoring systems in animal shelters is proposed. Additionally, the installation of cooling systems and comprehensive thermal insulation of the halls is suggested. The system will consist of a central computer that controls the microclimate within the facility, automated cooling systems (air conditioning), and thermal insulation of the halls. The equipment will be compatible with the breeding and maintenance system of all types of animals (birds, pigs, cattle) and all types of productivity (meat, eggs, milk, reproductive stock). The price of a high-performance computer is about 10 thousand euros. The cooling system varies between 3-4 thousand euros. The thermal insulation of the hall varies between 80 -150 thousand EURO. Respectively, for a modernized hall, about 164 thousand euros are needed In Moldova, it is necessary to modernize at least 200 farms. On average of 3 halls, a total of 600 halls.	

Project #26	Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production.

Problem and description of the project

Biogas technology involves the process of converting organic matter, especially animal manure, into combustible gases such as methane and carbon dioxide through the anaerobic decomposition of organic matter by bacteria. The zootechnical sector generates a significant amount of organic waste, such as manure and food residues. Biogas technology allows for the transformation of these wastes into a valuable resource instead of simply being disposed of. The produced biogas can be used for the generation of both electricity and heat, reducing dependence on fossil energy sources and contributing to the reduction of greenhouse gas emissions.

Utilizing biogas as an energy source can reduce the costs associated with heating and electricity supply for zootechnical farms. The anaerobic digestion process also generates liquid and solid digestate, which can be used as natural fertilizer for agricultural crops, thereby enhancing soil fertility and reducing the need for chemical fertilizers.

The anaerobic digestion process reduces the amount of organic waste, thus contributing to maintaining a cleaner environment and reducing the risk of soil and groundwater pollution. As a technological solution, the construction and equipment provision for biogas production and its conversion into electricity are proposed for zootechnical farms.

In Moldova, it is planned to equip 50 farms with biogas stations. The cost of a biogas plant varies between EUR 1-2 million.

Project #27	Ensuring access to water for animals

Problem and description of the project

Supplying animals with quality water is crucial for their health and well-being, as well as for the overall performance of livestock operations. Water is essential for hydrating animals. Quality water ensures an optimal level of hydration, contributing to the proper functioning of their cardiovascular system, body temperature regulation, and maintaining an adequate level of milk or meat production. Contaminated water may contain harmful microbes, bacteria, parasites, or chemicals that can cause diseases or health problems in animals. Providing clean and potable water supply contributes to maintaining animal health and reducing the risk of illness. Quality water directly influences animal performance and production. Animals that have access to clean and fresh water experience better growth, improved feed efficiency, and higher milk or meat production. Constant access to clean and fresh water helps reduce stress among animals. Stress can negatively affect their health and performance, so ensuring adequate water supply is crucial for maintaining a comfortable and stress-free environment in livestock operations. Supplying quality water is essential for the health, well-being, and performance of animals in livestock operations. It is important for farmers to pay special attention to providing a clean and safe water source for their animals.

As a technological solution, the rehabilitation of water supply systems at livestock farms is proposed. Currently, many water supply systems at livestock farms are outdated, and modernizing them would contribute to reducing water losses and ensuring reliable water supply. By efficiently managing water and increasing storage capacity, water wastage can be reduced. This is essential considering that water is a limited and valuable resource, and reducing water consumption can have a positive impact on local aquatic ecosystems.

It is proposed to replace old probes with newer, more energy-efficient ones and to modernize water pipes by replacing old metal pipes with plastic ones. Plastic pipes are less permeable than metal ones and reduce the risk of leaks and water losses. Modernizing water tanks by replacing them is also proposed. Currently, there are external tanks of 20 - 25 m3, with two underground tanks of 50 m3 each, and the installation of a pumping station. Additionally, the installation of water metering systems for consumption monitoring is proposed. In the pump area, the establishment of a protection zone according to current environmental legislation is suggested. After modernizing the systems, a special water use permit must be obtained.

The modernization of a water supply system costs about EUR 100 thousand. In Moldova, it is necessary to modernize at least 200 farms.

Project #28	Cleaning of water basins
Problem and description of the project	

Supplying animals with quality water is crucial for their health and well-being, as well as for the overall performance of livestock operations. Water is essential for hydrating animals. Quality water ensures an optimal level of hydration, contributing to the proper functioning of their cardiovascular system, body temperature regulation, and maintaining an adequate level of milk or meat production. Contaminated water may contain harmful microbes, bacteria, parasites, or chemicals that can cause diseases or health problems in animals. Providing clean and potable water supply contributes to maintaining animal health and reducing the risk of illness. Quality water directly influences animal performance and production. Animals that have access to clean and fresh water experience better growth, improved feed efficiency, and higher milk or meat production. Constant access to clean and fresh water helps reduce stress among animals. Stress can negatively affect their health and performance, so ensuring adequate water supply is crucial for maintaining a comfortable and stress-free environment in livestock operations. Supplying quality water is essential for the health, well-being, and performance of animals in livestock operations. It is important for farmers to pay special attention to providing a clean and safe water source for their animals.

Currently, the water surface area of the country, totaling 96,000 hectares, consists of 4,220 artificial water basins (covering 51,710 hectares). Most of these basins were constructed before the 1990s and were primarily used for irrigation. Over the past 30 years, many of them have been leased to economic agents who use them for fish farming or recreational purposes. However, these ponds have not been periodically cleaned, as required by current legislation, due to the high costs involved, which can amount to around 25,000-50,000 Euros per water basin and cannot be borne by economic agents.

As a technological solution, the rehabilitation of 1,000 water basins is proposed. This technology ensures the cleaning of existing water basins. To carry out this work in the first stage, the following steps are necessary:

Inventory of water basins and cartography.

Assessment of hydrological, hydrochemical, and biopotential indicators to determine the vulnerability of water resources to climate change for each hydrographic basin.

Construction of new infrastructures, refurbishment, modernization, and arrangement of complex-use ponds and lakes to ensure reserves during periods of low flow.

The modernization of a water pool reaches around 25-50 thousand Euro / pool. In the Republic of Moldova, it is necessary to modernize at least 1000 basins.

Project #29	Establishing protection belts (this technology is also common of the cereals sub-sector)
Problem and Project Description	

A network of shelter belts and ponds is one of the best solutions for landscape organization in order to prevent and reduce the negative impact of wind and water erosions, as well as droughts. Shelter belts together with ponds in the bottom parts of the relief are increasing the humidity of the air.

In the context of climate change, tree protection zones act as crucial refuges for animals by providing shelter, food sources, and a stable habitat amidst changing environmental conditions.

Shelter belts are „dressing" each field in the crop rotation in accordance with the protective capacities of trees. In such a way it is becoming possible to establish also the optimal size of fields and to avoid discrepancy between agronomic requirements and tendency of modern industrialized agriculture (big fields under the influence of powerful tractors and other agricultural equipment together with pesticides for higher level of infestation of the fields in narrow specialized crop rotations).

It is considered that the optimal share of shelter belts in the total area of arable land is 4-6%. If to take in average 5% for the total area of arable land in Moldova — 1,7 mln. ha, the area under shelter belts should be 85 000 ha. For half of the area of arable land the area under shelter belts should be 42,5 thousand ha.

The expenses for the plantation of one hectare of trees in the shelter belts from seedlings consist from 1300 up to 2400 Euro. For the area of 42500 ha of arable land total expenses will consist 55,2 - 102,0 mln. Euro or 59,6 - 110,2 mln. am.doll.

At the moment the main obstacles in promoting building of the entire network of shelter belts in Moldova is the lack of legislation regarding using of arable land for the plantation of shelter belts. The same is for water reservoirs in the bottom parts of the relief.

Project #30	High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency
Problem and Project Description	

The construction of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency will be implemented in 25 farms. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce tomatoes, cucumber, cabbage, bell peppers, eggplants and until the 1990s they produced about 40 t/ha for tomato, 50 t/ha for cucumbers, 55 t/ha of cabbage, bell peppers yield some 25 t/ha, eggplants 40 t/ha. Current yields are decreasing as a consequence of increased climate-induced stresses, such as extreme temperature variations, heatwaves and late frost events. The ambition of this TAP at demonstration level is to deploy 25 high-tech greenhouses for tomatoes, cucumber, cabbage, broccoli, cauliflower, strawberry, raspberry, grape, asparagus. This goal will be achieved through the construction of greenhouse shells made of galvanized metal and equipped with best in class double glass and PCM walls for maximum climate control. In addition, high-tech greenhouses are equipped with shade cloth, anti-insect nets, irrigation and fertilization system, ventilation system, complete climate control systems, renewable energy powered, equipped with biomass burners for CO2 supply in greenhouses, computerized control system of all systems, artificial intelligence, Internet of Things and home automation controls, for greenhouses with an area of approximately 1,000 m2 for each farm, and the development of programmes to train personnel to operate and maintain the high-tech greenhouses in the case study farms.

Well-designed and operated high-tech greenhouses are spreading in several countries in the EU and in the United States as they are capable of providing year round production of vegetables with unparalleled efficiency and total resilience to the impacts of climate change. Planning attentively where to locate these structures is however a key determinant of success. Several limitations currently exist in Moldova for authorizing the building of these structures on agricultural land, and these procedures are often complex, costly and time consuming. Policymaking is necessary to remove these barriers and a dedicated action (Action 1.) is foreseen to this end. An important component of the TAP involves the planning and execution of the procurement of high-tech greenhouse (glasshouses and PCM-RA structures) and their ancillary equipment, including renewable energy sources like agrivoltaics and biomass burners to produce heat and renewable CO2 for injection into the greenhouses. Currently, greenhouse employed in Moldova are for the most part (95%) based on galvanized metal and plastic film cover. Activity 2.3 will substitute up to 25 plastic film greenhouses and recycle agricultural plastics used for greenhouse covers and crop mulching. Capacity building of farmers enrolled in this program is crucial to train them on the sound management of the high-tech greenhouses built and to maximise their output for a resilient horticultural sector in Moldova. The Capacity Building Action (Action 3.) will train greenhouse operators in hardware and software management, problem solving and long-term maintenance of the greenhouses and their systems. Capacity building will also be provided to extension agents and future entrepreneurs as well as scientists through the provision of PhD courses for 10 students (at least 50% of them females) to develop the capacity of high-tech greenhouse managers of tomorrow through classes, study tours and study abroad exchange programs with the main European and American Universities working in this field. Lastly, Action 4. will develop solid market opportunities for the uptake of domestic horticulture products through a full value chain approach, to inform and include retailers and consumers as key players for the success of this TAP.

Project #31	Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer

Problem and Project Description

Agroforestry systems in comparison with monoculture systems, have better use of water, soil and light, can help reduce the application of herbicides, fungicides, pesticides, fertilizers, increasing food security, biodiversity protection and adaptation to climatic change. The multilayered structures of agroforestry can maintain the stability of internal microclimates which are strong assets for extreme weather adaptions, trees cause important changes in microclimate (immediately under and adjacent to trees), mesoclimate (tens to hundreds of square meters away from the trees) and macroclimate (at a landscape scale of tens to hundreds of square meters).

All the different components of agroforestry systems are continuously interacting. Their interactions are determined by the

management of the system, including the selection of species and their functional characteristics, planting density, stratification and fertilization regime. The recommendation is therefore to use well-adapted tree-crop combinations, thereby limiting competition for resources and maximizing synergies between the plants. Three types of agroforestry and intercropping systems are recommended to adapt the Moldovan horticulture sector to climate change:

1) **Agri-horticulture:** Agroforestry system where fruit trees and annual crops are intercropped
2) **Horti-olericulture**: Agroforestry system where fruit trees and annual vegetables are intercropped
3) **Horti-silviculture:** Agroforestry system where leguminous plants, timber, oleaginous trees and fruit trees are intercropped

Agro-silvopastoral systems introduce also various livestock in the intercropping system.

A central hypothesis in agroforestry is that productivity is higher in agroforestry systems compared to monoculture systems due to complementarity in resource-capture i.e. trees acquire resources that the crops alone would not. This is based on the ecological theory of niche differentiation; different species obtain resources from different parts of the environment. Tree roots generally extend deeper than crop roots and are therefore able to access soil nutrients and water unavailable to crops, as well as absorbing nutrients leached from the crop rhizosphere. These nutrients are then recycled via leaf fall onto the soil surface or fine root turnover. This will lead to greater nutrient capture and higher yields by the integrated tree-crop system compared to tree or crop monocultures.

Trees modify microclimatic conditions including temperature, water vapour content and wind speed, which can have beneficial effects on crop growth and animal welfare. Wind speed reductions can extend to 30 times the height of tree belts on the leeward side. The resultant decline in wind erosion effects can have multiple benefits for crops including increased growth rate and quality, protection from windblown soil, moisture management and soil protection. Furthermore, higher air and soil temperatures in the lee of a shelterbelt can extend the growing season, with earlier germination and improved growth at the start of the season.

Project #32	Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation

Problem and Project Description

Photovoltaics (PV) are the most common form of renewable electricity worldwide. However, being PV panels a surface-based generation option, the of ground-mounted PV facilities has led to conflicts in some regions and increasing concerns about the loss of arable land for more profitable PV energy production. In view of this conflict, the development of agri-photovoltaic (APV) systems can be seen as a way of combining PV and food production on the same land area.
Studying the effects of Agri-PV installations, authors have begun to understand the effects for adaptation to climate change that these systems, originally imagined only as a mitigation option, can have on agricultural production.
A study from the Fraunhofer Institute, shows the effective positive impact of APV on crop yields due to its shading effect and contribution to the formation of a more favorable microclimate in the context of raising temperatures.
APV are structures that suspend photovoltaic panels (commonly referred to as “solar panels”) above agricultural plantations in open field environments. This allows for a double simultaneous use of the land, thus increasing the overall production efficiency and crucially the yield of crops prone to climate change impacts such as increased temperatures and even extreme events such as hailstorms. The protection from the scorcing sun during summer, as well as from hail impacts on vegetables can return higher yields and adapt these crops to live under unfavorable conditions due to the changing climate.
An experimental report on the use of APV on potato cultivations returns increased yields when compared to control parcels due to the shading effect of the plants. The overall land use efficiency with APV installations raises to 186% when compared to traditional agriculture or PV installations on agricultural land.
Soil moisture is higher in soils shaded by APV systems, average air temperature on the surface of the leaf is much lower with resulting lower evapotranspiration and stress for the crops. Research on APV shows that in arid conditions these systems deliver higher yields by up to 40% in tomato production, while also generating renewable electricity to be used on or off-farm, with potentially even higher adaptation benefits. Combining APV with other technologies in fact (e.g. high tech greenhouses) part of the energy required for the integrated system can be generated by the panels, thus increasing crop productivity and processing capacity of raw materials into final products for the food or feed industry.

Project #33	Set up next-generation national horticulture breeding systems

Problem and Project Description

Approximately 10,000 years ago, plant breeding emerged as a central approach for plant domestication by exploiting wild relatives to select the desired traits through a continuous selection process over several generations for crop improvement. Many important crops that are cultivated extensively in Moldova have been developed through various breeding processes. Generally, in classical breeding, elite crop varieties have been selected via hybridization and a continuous screening process. The limitations of this techniques reside in the pace of mutations through hybridization and the *trial and error* type of approach to highlight new features during the breeding program.
Next-generation breeding tools can be used to increase crop production by developing climate-resilient superior genotypes to cope with the challenges of crop production and food security. Recent innovations in genomic-assisted breeding (GAB) strategies allow the construction of highly annotated crop pan-genomes to give a snapshot of the full landscape of genetic diversity (GD) starting from native breeds collected locally, and recapture the lost gene repertoire of a species. Pan-genomes provide new platforms to exploit these unique genes or genetic variation for optimizing breeding programs.
These systems support breeders to identify the genetic traits of relevance for climate-related vulnerabilities and consequently, speed up the solution to such problems by flagging those varieties that have intrinsic genetic resistance to a certain disturbance. Once genetic mapping (not genetic engineering) is carried out, the genome can be used to select those individuals with best probability for traditional breeding to express those traits of interest in the fight against climate change. At this point, Speed breeding is used to shorten the time to express the useful traits identified earlier and express them into a new breed. Speed breeding mimics daily dawn and dusk, and plants are subjected to an extended photoperiod of about 22 h by using a combination of different light sources. It provides an extended day length with optimal light intensity coupled with controlled temperature to increase the photosynthesis activity, which results in quick flowering and early seed development to reduce generation time.
Traditional breeding techniques require 5 to 10 years to develop a line through crossing and generation advancements. With speed breeding these generations are shortened in a laboratory to 1-2 years, thus reducing drastically the time needed before field testing and variety release.
Speed breeding occurs in laboratory, greenhouses and other controlled environments and is a technology to speed-up traditional breeding.
By using genome-assisted breeding, characteristics of horticulture crop varieties of interest in adaptation to the impacts of climate change can be discovered, tested and validated within a few years, as opposed to traditional breeding which requires decades for the completion of an improved breed. In the context of climate change adaptation, response time is crucial and next-generation technologies like these have the potential to provide a quick and effective, nature-based solution to impacts on production due to climate change.

Project #34	Implementation of Climate-Smart Pest Management and biological control of macrothermal pests

Problem and Project Description

Climate change is affecting the biology, distribution and outbreak potential of pests in a vast range of crops and across all land uses and landscapes. Temperature changes are shaping the ranges of presence of a number of plant pests, with new species being found in agricultural fields that never hosted them in the past. Without effective monitoring and management systems in place, these invasive species have the potential to also become important pests in these new areas. Increases in temperature can increase the severity of diseases caused by pathogens of crops such as potatoes and other vegetables. Increases in temperature can also reduce the effectiveness of certain pesticides, for example, the toxicities of traditional insecticides were found to decrease as post-exposure temperature increased. Climate Smart Pest Management (CSPM) is a novel fully fledged approach to Integrated Pest Management in the context of Climate Smart Agriculture efforts. CSPM is characterized by an attentive monitoring of the landscape across seasons to predict conditions that foster pest outbreaks, specifically targeting increased temperatures and other climatic parameters that support the spread of specific pests. In addition, CSPM includes a set of measures to contain (also through biological control) such outbreaks. Early warning of annual invasive or outbreak pests is an important activity to support farmers in some areas and this is often carried out by different stakeholders. This requires effective interconnection and communication across at all management levels (central government, regions, provinces, townships, and farm level). Modern technologies support greatly this requirement by providing swift and easy to access, user friendly tools, such as smartphone apps, to communicated across management levels the results of remote sensing and modeling applied to potential pest outbreaks. The first step of any CSPM programme is to conduct a thorough appraisal of the local environment and perspectives. This serves as a basis for the second step, which is to identify the most locally appropriate CSPM approaches, taking into consideration the various contexts, including biodiversity and environmental conservation, socially differentiated groups and gender implications.
An increasing number of (new) pests are being seen, especially in the northern hemisphere due to poleward movement, and at higher altitudes due to upslope movement. For example, the southern green stink bug (Nezara viridula (Linnaeus), Hemiptera: Pentatomidae) has expanded its range northward in temperate regions of Europe (including Moldova) since the 1960s, most likely because of reduced mortality due to milder winter temperatures. More recently, the brown marmorated stinkbug, an alien species introduced from the far East, was officially found to be able to cope with milder winters and causes considerable damage to fruit production and vegetable farms in Moldova too.
CSPM encompasses (i) pest prevention, i.e. development and implementation of biosecurity action plans, raising awareness of threats at the local level and preventing arrival and spread; (ii) early detection and rapid response, i.e. development and implementation of surveillance and emergency action plans for detecting and eradicating listed species, and building capacity to implement these plans; and (iii) management, i.e. evaluating and scaling up existing management solutions, and developing and scaling up new solutions to ensure those living in rural communities have in place the best practice and locally adapted solutions.
One approach that is promoted by CSPM to increase resilience to climate impacts is the development of a more responsive national extension system and the promotion of

Project #34	Implementation of Climate-Smart Pest Management and biological control of macrothermal pests

functioning links between extension, research and farmers. A successful example of building the necessary institutional capacity of the extension service, and developing the required technology support system to contribute to early detection and provision of management advice for new pests, is the Plantwise approach, adopted by over 30 countries around the globe. Under this approach, national extension providers equip extension officers with handheld tablet devices, which are used to access pest-management information and can submit real-time GPS-tracked pest observation records directly from the field.

The figure above demonstrates how the presence of a viral disease of maize was documented by extension agents in Kenya in 2012, long before it was officially reported by the national authority responsible for pest reporting (in 2015), demonstrating the transformative power of information and communications technology (ICT) for information delivery, pest surveillance and resilience in the context of CSPM.

CSPM has the potential to provide early warning system targeting specifically those pests that are favored by increased mean temperatures and other climate change induced impacts in Moldova, and to put in place a coordinated set of measures to counteract and limit the damage to the horticulture sector by taking advantage of the most modern ICT technologies available.

Project #35	Pollinator's management, supporting and protecting natural bee colonies

Problem and Project Description

Two thirds of the food crops produced globally rely on pollinators for their production. Apples, zucchini, tomato and virtually all major horticulture crops grown in Moldova require the action of honeybees, bumblebees, butterflies, wasps, flies and other pollinators to bare their fruits and deliver products to the market. Several aspects though are severely impacting the health of pollinator's colonies, including climate change.
Best management practices to maintain pollinator populations healthy include integrated pest management, conservation of habitats and the creation of safe areas near orchards for pollinators to find shelter as well as food in different seasons. Roadside habitat for pollinators is one of the many practices consisting in adjusting roadside vegetation management techniques to accommodate pollinator resource needs, enhancing and restoring native roadside vegetation to include plant materials that improve pollinator habitat and incorporating native plants and pollinator habitat needs into roadside landscape design. Offering a variety of shelter and feeding options to pollinators is essential to obtaining more diverse and active colonies throughout the year.

Specifically in fruit production orchards, the distribution of pollinators is key. Apples require an adequate density of pollinating plants to be intercropped with flowering varieties, and pollinators such as honeybees should be favored by creating and installing improved beehives (see figure below) and placing them with the correct density on the side of the orchards Improved beehive designs use only natural materials and mimic the conditions found naturally by honeybees in nature but have superior thermal insulation characteristics and two-chamber design to help pollinators cope with the impacts of climate change.
Beehives are sometimes transferred from one location to another to "graze" on new pastures in order to optimize pollination efficiency by matching the flowering period with the presence of active colonies of pollinators. However, resident hives should always be preferred to nomadic ones to reduce stress on the colony. New, improved, beehive designs allow mimicking the natural conditions found inside wild beehives. These efficient hives have a two-chamber system – one honey chamber and one brood chamber – which are easily extractable. This makes it possible to harvest honey by minimizing stress for the bees. These hives are made of biodegradable natural materials such as wood and textile cotton fabric, and wool, no plastics are used. Conventional bee boxes neglect the needs of complex bee colonies, and these stresses are more severe due to climate change. Bees prefer a round shape and require good insulation which is naturally found in tree caves. Heat stress is a major cause of weakening of bee colonies, which in turn result in poor pollination and thus poor fruit and vegetable yields. In conventional beehive boxes, bees need to spend considerable energy on keeping the desired temperature during the seasons, warming themselves up during winter or creating an intense airflow with their wings during heat waves in summer. These issues are solved with pollinator management techniques and equipment.
By improving the living conditions of pollinator colonies the efficiency of pollination will increase proportionally. This translates into higher percentage of flower fertilization and thus higher yields. Also, increased agrobiodiversity has important beneficial effects on resilience of crops as cross-fertilization is more likely, especially for horticultural plants such as vegetables, to deliver increased genetic variability and therefore resilience options. In addition, adapting pollinator colonies to the current and future climate will provide not only a way to cope with increased pressure on crop production, but it will also provide additional income sources to

farmers who can diversify their production with the addition of honey, wax and other products from honeybees.

Project #36	Use of anti-hail, anti-frost film and anti-reflective material in horticultural plantations
Problem and Project Description	

Apples and grapes are the two most cultivated horticultural crops in Moldova. However, excessive summer temperatures and more frequent extreme events such as hailstorms are impacting the productivity of the sector and damaging the economics of Moldovan farms. Producers have been dealing with increasing temperatures in recent years during the grape ripening period, when the compounds that determine the wine's future quality are formed and balanced. In particular, the organoleptic characteristics of the wine are influenced greatly by the climate conditions during ripening stage, and final product quality is negatively affected by high ripening temperatures. Hailstorms, have also become more frequent in recent years and have affected both vineyards and apple orchards across the country.

Anti-hail, anti-frost and anti-high temperature materials and systems come in various solutions conceived and designed to adapt to any terrain and any latitude, depending on the winemaker's and apple producer's needs. Modern anti-hail nets are run-proof resistant nets with a double weave, lateral reinforcement, 7.1 x 6.2 mm hole size and dark green colour. The slight elasticity of this type of net makes it adaptable and suitable not only for protecting wine grapes, but also for tunnels and greenhouses. Companies also produces dense anti-hail nets with a 7.1 x 1.7 mm hole size and crystal colour. The small holes improve the microclimate and can protect fruits from wasp attacks during ripening. These systems have also a slight shading effect that contributes to reducing the temperature underneath the canopy.

Additional anti-hail systems also exist, such as shockwave cannons. These systems, use renewable energy to generate a shockwave that can dissipate hail in a radius of 1 km from the cannon and turn it into rain or wet snow. Every five seconds, the cannon fires ionizing (energy-rich) shock waves into the air. These quickly reach the higher atmosphere, up to 10,000 m, at -50°C, where the hails forms. Part of the waves is being bounced back by the clouds and the tropopause. These collide with the climbing waves. Hereby their speed and energy increase and they carry a large ionizing potential (ionizing is the process of knocking away electrons). By the continuous up and down movement of the waves, a mix of polarities is created inside the cloud. This leads to a chain reaction of micro explosions which makes the ice crystals unstable. They cannot absorb water drops or vapor anymore. They fall down and during their fall they cross the disturbance zone that is caused by the shock waves. Hereby the stones are fragmented. The hail finally reaches the ground as rain or wet snow. Shockwave cannons have sophisticated sensors to detect the occurrence of hailstorms and through the mechanical action of the shockwave, deviate the falling path of hail and protect the plantation underneath.

Anti-frost nets are also useful aids against late spring frost, another form of extreme events that are becoming increasingly common and causing increasing issues to the horticulture sector in Moldova

Physical protection of fruits and vegetables has a direct impact on the share of product reaching the market. For horticulture this is particularly important in terms of economic benefits and investments in protection systems like anti-hail systems are justified in areas where late spring hailstorms are frequent.

Project #37	Precision Agriculture including use of drones for pest and disease management

Problem and Project Description

Precision agriculture means making the process of crop or livestock farming more accurate and controlled by using information technology and high-tech equipment such as sensors, GPS, control systems and robots. The concept of precision ag was born around 1990 with tractor guidance as its primary application. Today precision ag and automation is becoming commonplace, from aerial crop monitoring to automated targeted spraying. Open fields are an ideal environment for GPS positioning where satellite visibility is seldomly obstructed. Many companies are introducing precision agriculture solutions, including those relying on high-tech drones. The role of drones in precision agriculture is primarily to monitor crop health, but thanks to recent development of drone technology, these aerial machineries can now carry considerable payloads that allow also for extremely accurate and efficient pest control, fertilization. Drones in fact can be coupled with top-quality GPS + INS (Inertial Navigation System) technology and industry leading multispectral cameras and AI to create cutting-edge precision farming sensors.

Drones can serve multiple purposes in precision agriculture, from crop health monitoring to response and pest control activities.

High-quality RGB and NDVI (Normalized Difference Vegetation Index) cameras are coupled with AI image recognition software. Many crop issues can be detected with NVDI cameras even before they can be recognized by the human eye. The imagery is then tagged with precise location information provided by multi-frequency multi-GNSS receivers (GNSS: Global Navigation Satellite System of which GPS is a part). On top of that, image location information is enhanced with 3D orientation (heading, pitch and roll) provided by the INS, which is coupled with the GPS receiver.

NDVI images can highlight areas of the field where difference in vegetation vigor are found. (Photo credit: DJI)

Below is a list of 5 advantages that high-precision GNSS+INS technology brings to mapping today's farms:

1. Precise weed and pest maps serve as an input for modern large-scale sprayers which are designed to spray with decimeter precision. Spraying only where needed saves cost and reduces the environmental impact of chemical and fertilizer use.
2. When two different plant species (i.e. intercropping) are grown in adjacent rows, precise positioning is needed to monitor each individual species.
3. Field surveying is completed faster and covers broader areas. Utilizing high-accuracy positioning and orientation information removes the need for image stitching software. Images are projected on a terrain model and their accurate positioning is used to create a single orthorectified image. This is referred to as "direct georeferencing". Unlike traditional image stitching processes based on feature matching between two or more adjacent overlapping photos, direct georeferencing is not sensitive to image overlap requirements. Less strict overlap requirements mean that drones can fly in lines which are further apart, enabling broader field coverage with one battery.
4. Since image stitching is not needed, the image-processing step is simplified and field statistics can be obtained in real-time on the sensor, without the need for cloud computing or post-processing.
5. High-quality positioning and camera sensors allow higher altitude flights, increasing the land surface area captured in each image and resulting in a larger total coverage area per

Project #37	Precision Agriculture including use of drones for pest and disease management

flight. Small errors in the camera orientation have a greater effect on the image projection accuracy at higher altitudes, but recent advances in sensor technology have enabled drones to fly higher while still collecting data with enough accuracy for precision agriculture applications.

After the most accurate mapping of fields has been carried out, other drones can use the direct georeferenced environment to accurately move towards the areas that require pest control actions, and deliver just the right amount of active principle to the specific area where an infection or a pathogen has been detected. In a scenario of lack of nutrients of specific areas of the field, these drones can also – automatically – deliver nutrients on demand.

Crucially, adopting drone technology in precision agriculture improves not only the productivity and the understanding of the conditions of the orchard, thus helping farmers to cope with the impacts of climate change, but it also mitigates the contribution of agriculture to climate change by reducing the use of inputs and fossil fuels.

Farmers can use data from drones recording fields to plan agronomic interventions and treatments to get the best yields possible. Drones collect an enormous amount of data that can be used by modern software and models to refine forecasts of impacts of climate change, therefore supporting adaptation actions in response. Instead of relying on satellite and public services for climatic data interpretation, farmers can use drones that collect much more accurate data specifically concerning their farm to present the most accurate picture of the conditions on the ground. Savings from tempestive action in treating disease outbreaks with efficient use of adequate quantities of chemicals is another important environmental and economic benefit of precision agriculture, particularly through the use of drone technology.

Limitations do exist however, since drone technologies require dedicated capacity building to farmers and drone operators to be successful.

Project #38 Rainwater harvesting systems

Problem and Project Description

Coping with drought and changing precipitation patters requires adaptation measures to capitalize and conserve available water resources. Rainwater harvesting systems are a powerful aid to increase water availability, for agricultural uses, including horticulture. Low precipitation coupled with high temperatures and winds, reduce water storage capacity of the soil and high runoff coefficients of the land lead to loss of water from the watershed. At sub-watershed level, rainwater harvesting systems are attentively mapped and planned to collect runoff water and divert it into storage basins and tanks. Water harvested during these events is then available for irrigation purposes in greenhouses and orchards. Rainwater harvesting systems are made of three main components: 1) rainwater ditches and runoff channels; 2) sedimentation tanks; 3) storage tanks. The first component is a system of channels that run along the impluvium of each sub-watershed to drive water towards a designated area. Runoff water often contains high loads of suspended solids (TSS) and sediments which can quickly buildup in a storage tank. Therefore, prior to the storage tank, these systems foresee the construction of an intermediate reservoir usually made of concrete, where water can slow down and sedimentation take place. Sedimentation tanks have a valve-release system that can be controlled manually or automatically to release excess water back into a nearby river or creek, or towards the actual rainwater storage tank/open reservoir. Once sedimentation has taken place, water with low TSS is released into the actual storage tank or an open reservoir. These structures are usually placed at a lower altitude (downhill) than the sedimentation tanks. Once emptied, the sedimentation tanks can be dredged and cleaned, sediments can be removed easily without standing water. The storage tanks instead will retain water until the orchards require irrigation. The system can use gravity as the driving force for the passage of water to each tank provided that a minimum slop exists.

Increasing the availability of water to fill up aquaculture ponds is an important action. Rainwater harvesting systems are a key technology to collect water available during rainfall events and limit the amount that reaches rivers and basins, often causing floods, and regulates water flow by releasing slowly and more constantly the necessary amount to the ponds. Constant water availability in aquaculture ponds, not only ensured the physical availability of space for fish to grow but it also concurs to maintaining acceptable water quality levels especially in terms of ammonia and nitrates as well as DO.

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Project #39	Soil moisture management through nature-based solutions including biochar, compost, green mulching
Problem and Project Description	
Water stress is one of several factors that can reduce crop yield and quality. Prolongued drought results in plant water stress, while over-irrigation leaches nutrients and other chemicals out of the root zone. Maintaining root zone water content is essential to any crop production operation and managing these fluctuations is even more complicated in the context of climate change. Nature-based solutions exist to maintain stable soil moisture even during drought events. Enriching the soils with organic matter in the form of biochar, composting and protecting soil surface from excessive transpiration through the use of green mulching, are effective technologies to manage soil moisture content in Moldova. Biochar is the product of carbonization (also known as *pyrolysis* of biomass). Biochar can be obtained from various biomass sources, from agricultural residues, both plant or animal wastes, to organic fraction of municipal solid wastes. Biochar is not recognized as an invaluable aid to fight climate change as it contributes strongly to both adaptation and mitigation. The European Commission whitelisted biochar to be used as a soil amendant and fertilizer due to its superior properties of interest against the impacts of climate change. Biochar is produced in kilns or pyrolysis plants, and depending upon the feedstock and the technology, it can even be a source of renewable energy (bio-oil and syngas). When applied to agricultural soils, biochar – especially if coupled with compost or manure – significantly decreases bulk density and increases total porosity when compared to regular soils. The pores of this natural amendant get filled with water and retain it well past the capacity of the original soil composition alone. Extensive literature on the matter confirms how biochar addition can result in up to 50% increase in easily available water content in the soil. Saturated hydraulic conductivity, however, remains unchanged which reflects a lack of influence on infiltration. Biochar, when mixed up with compost or manure can also enhance nutrient retention capacity of the soil. The application of biochar with and without additional compost and manure can enhance soil water retention in low-organic soils whilst maintaining or enhancing nutrient retention. Such finding supports the application of mixed organic amendments to low-organic (and therefore drought-prone) arable soils.	

Project #40	Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.)

Problem and Project Description

Reliable, efficient, and environmentally friendly irrigation systems are needed to support sustainable intensification of agriculture in the content of adaptation to climate impacts in Moldova. Water and energy are important resources for economic and social development as well as for environmental integrity, while both are essential to irrigation. One approach for improving water use efficiency is to replace surface irrigation systems with more efficient pressurized (sprinkler and drip) systems to significantly reduce water application on the farm scale, thereby increasing water and land productivity, but also increasing energy and investment requirements. The energy used by pumping stations generates significant greenhouse gas (GHG) emissions, which then contribute to accelerating climate change, therefore modern irrigation systems necessarily need to rely on technologies that maximise both water use efficiency (e.g. drip irrigation) as well as energy efficiency.

Maximizing water efficiency means finding the best combination of technologies and practices to return the highest water-use efficiency of crop production. This can happen both at national infrastructural level, as well as at farm level. At the national infrastructural level, monitoring and maintaining the hydraulic network is essential to avoid water leakages and losses before irrigation starts in the field. Technologies to update the national irrigation infrastructure include sensors and instrument to monitor pressures and identify potential losses, as well as improved valves and tubing junctions, made of flexible yet robust materials that have very long lifespans. Drip irrigation systems have higher capital costs than traditional systems, moreover, they require significant pumping power to operate. However, novel low-pressure drip irrigation systems can operate at 20 to 30 kPa.

This pressure can be obtained by placing the irrigation tank or reservoir 3 meters above the height of the drippers. Drippers can also be buried into the soil to deliver more efficiently water to the rootzone of the plants, this will increase the differential. At 25 kPa pressure an 8 liter per hour (lph) dripper will discharge about 3.4 lph. It is a good idea to use the 8 lph dripper as this will provide the maximum flow path size and be less resistant to clogging. Ideally the system should incorporate an inline filter, however this comes at a cost by creating a pressure drop as the filter traps contaminants. This is why it is advisable to use low-pressure drip irrigation systems always in conjunction with sedimentation tanks, so that particles will tend to settle in the bottom of the tank and if the outlet is above the sediment line filtering can be much less obstructive.

The only downside to using gravity (low pressure) for drippers is that they can be more susceptible to clogging as the turbulent flow path is more laminar in performance. This should always be considered when using gravity pressure systems.

When gravity pressure is not sufficient, or large filters are necessary, the low-pressure drippers can be hooked to a renewable energy powered pumping system. Small to large scale renewable energy plants can be deployed to sustain the irrigation facility. The electricity can be generated for instance by an Agri-photovoltaic systems as direct current (DC) and employed as such by DC pumps. When pumping power exceeds 10 kW, trifase pumps are needed, thus specific inverters are needed but these can still be operated by PV or other renewable energy systems.

At the field level, drip irrigation is a powerful technology that can reduce water consumption by 20-40% while increasing crop yield by 20-50% compared to surface irrigation or sprinklers, depending on the crop grown. Drip irrigation can enable farmers to grow crops under conditions where they otherwise could not and adapt to the impacts of climate change. Drip also allows farmers to grow a wider array of crops, increase crop yield, and save on labor and fertilizer costs.

Project #41	Sustainable soil management in horticulture and fruit production
Problem and Project Description	
There are several technologies and practices that can support the sustainable management of agricultural soils and a selection of these should be made based on specific site conditions. Soil erosion is one of the main factors affecting soil fertility in the Republic of Moldova. The eroded lands constitute 1.2 million ha or 80 percent of the arable land, while the surface of moderately and strongly eroded soils is 780 thousand ha. The area affected by erosion increases every year by 0.86 percent. The fertility of eroded soils is 40-60 percent lower than in the uneroded areas. Soil organic matter (SOM) content is another key soil quality indicator. The average SOM content of the soils of the country is 3.16 percent; on a surface of 270 thousand hectares it is under 2 percent. This value is considered to be the minimum admissible level. Technologies to reduce these impacts include a cover of growing plants or other organic and non-organic residues that protects the soil surface from erosion. Continuous cover crop should be maintained through implementation of appropriate measures such as mulching, minimum tillage, no-till by direct planting, reduced herbicide use, legumes intercropping. These agro-ecological approaches have numerous advantages and work in synergy with one another. Using manure, compost and biochar, in addition to green mulching and continuous cover crop in turn also contributes to the adapting agricultural soils in Moldova to climate change by increasing their SOM content. The concepts of sufficiency and utilization efficiency apply especially to nutrient dynamics in the soil-water-nutrients-plant root continuum. Plant nutrition should be based on crop needs, local soil characteristics and conditions, and weather patterns. Plant nutrition can be enhanced through nutrient recycling or additions including mineral (chemical) fertilizers, organic fertilizers and other soil amendments including biochar. It is crucial to select an appropriate plant nutrient management system and approach alongside assessing the suitability of the land for a given land use. The benefits of sustainable soil management are multiple and include increased long-term productivity, close to the optimum potential in the specific geographical context. Moreover, healthy soils have reduced need for pest control measures, external application of organic and inorganic amendments, and mineral fertilizers. This in turn will result in less pollution and enhanced soil carbon sequestration through biomass production and restitution to the soil.	

Project #42	Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.)
Problem and Project Description	
Popular vegetables grown in Moldova include tomato, sugarbeet, potatoes, pumpkins, watermelons, cucumbers, carrots, onions. All these summer vegetables require abundant irrigation during their growing period. Mapping attentively drought-prone areas is fundamental in order top plan a crop diversification strategy in these areas of the country. Once maps are available, drought-tolerant vegetables such as artichokes, beans, peas, sweet potatoes, eggplant (Ping Tung variety), peppers, Swiss chard, mustard greens, arugula, and others should be provided by local extension services and sown in Moldova, at least on some parcels on farm The lower water requirements of these plants will allow a higher unitary irrigation volume for more traditional and water-intense crops also grown on farm. Capacity to cultivate these less common crops might need to be provided to some farmers, always through the local extension services. Also, these vegetables need to find market access solutions in order to be appealing to the farmers, therefore activities to link these products to potential buyers are to be considered as an integral part of the practice. Crop diversification has many benefits including lower damages due to pathogens outbreak, diversification of income, and more. From an adaptation point of view, subsistence farmers will find an increased diversity of food available on the table as a result of the implementation of this practice. In case of extreme drought, food security of the household will still be provided by those drought-resistant plants, whereas in conditions of normal precipitations a more diverse production can be turned to local markets for increasing the revenue stream of the household. In the event of a pathogen outbreak, increasingly frequent as a consequence of higher temperatures in Moldova then, a monoculture could be dramatically impacted, whereas a diversified production will in general provide much higher chances to cope with extreme and systemic climatic adversities.	

Project #43	Hydroponics with recyclable solutions

Problem and Project Description

Hydroponics is a method of growing plants in water, or in an inert media, without soil and using mineral nutrient solutions in a water solvent to supply complete nutrition for plant growth. Hydroponics can give precise control over plant growth parameters which can lead to yield and quality improvement. In principle, nutrient solutions used in hydroponics can either be reused or discarded. Nowadays, the cultivation of leafy vegetables, medicinal herbs, and other plants with pharmaceutical value are commercially grown under recycled hydroponics with controlled environments. In recycled hydroponics, nutrient solutions passed through the growing medium are collected into a reservoir and reused repeatedly. In this system, both water and mineral nutrients are used efficiently and therefore minimizes the wastage of fertilizer and the environmental damage.

Hydroponic systems are commonly associated with high-tech greenhouses or other controlled environment agriculture (CEA) facilities. Additional control over growth parameters is ensured by using artificial grow lights, such as light-emitting diodes (LED), climate control and nutrient dosing with real-time measurements. Hydroponics may however be challenged by the accumulation of root exudates that affect plant growth and reduce crop yield and quality. Lower growth and yield performance of several crops including lettuce, strawberry, several leafy vegetables, and ornamentals have been reported in recycled hydroponics.

There are two main types of recycled hydroponics systems: the Nutrient Film Technique (NFT) and the Deep Flow Technique (DFT).

Hydroponics is put forward as a solution to combat climate change, to reduce the environmental damage and species extinction caused by overexploitation and intensive farming. It also allows for a more rational use of water, an ever-scarcer resource. Hydroponic crops are also more profitable and easier to control, which turns them into a weapon to fight against hunger and to enhance food safety, especially in developing countries.

Project #44	Promotion of biocontrol through the use of bacteria, fungi and oomycetes
Problem and Project Description	

Biological control is the use of living organisms to suppress pest populations, making them less damaging than they would otherwise be. Biological control can be used against all types of pests, including vertebrates, plant pathogens, and weeds as well as insects, but the methods and agents used are different each type of pest. The three categories of natural enemies of insect pests are: predators, parasitoids, and pathogens

Predators: Many different kinds of predators feed on insects. Insects are an important part of the diet of many vertebrates, including birds, amphibians, reptiles, fish, and mammals. These insectivorous vertebrates usually feed on many insect species, and rarely focus on pests unless they are very abundant

Parasitoids: Parasitoids are insects with an immature stage that develops on or in a single insect host, and ultimately kills the host.

Pathogens: Insects, like other animals and plants, are infected by bacteria, fungi, protozoans and viruses that cause disease. Using biological control in the field:

There are three primary methods of using biological control in the field: 1) conservation of existing natural enemies, 2) introducing new natural enemies and establishing a permanent population (called "classical biological control"), and 3) mass rearing and periodic release, either on a seasonal basis or inundatively.

Very cost-effective long term solutions like biocontrol have large scalability potential in Moldova, for horticulture as well as for other sub-sectors.

The deployment of biocontrol, by incorporating farmers' experiences in the implementation process, paves the way for widespread adoption of Integrated Pest Management techniques, organic agriculture and agro-ecological farming. In Moldova this practice has high scale-up potential and benefits for adaptation to climate change will be realized indirectly through a lower reliance on chemical pesticides, generalized treatments that do not target a specific pest but tend to impact a broader set of insects, or fungi, some of which might be beneficial to the agricultural system and have biodiversity value. Climate change exacerbates the vulnerability of many species and chemical pesticides contribute to biodiversity loss accelerating the already difficult conditions created by the changing climate, whereas targeted biocontrol measures can at least in part lift such pressure on biodiversity.

Project #45	Technologies for seed quality leading to higher germination rate and increased yield capacity

Problem and Project Description

Seeds of high physiological quality are defined by their superior germination capacity and uniform seedling establishment. Seed coating is one of the technologies available to increase seed quality. Application of materials onto the surface of seeds to make seeds' shape, size, weight and seed surface more uniform making planting easier and for application of products for plant protection and/or nourishment. Seed upgrading is another recent technology that offers great potential to increase yields since it allows to maximise the germination potential. There are various technologies for seed upgrading, but the most promising and effective ones are: Liquid density separation and X-ray upgrading.

Liquid density separation is an upgrading method used to increase the number of good plants in a seed lot. A seed sample is divided into six fractions that may vary in quality. By evaluating the germination results of each fraction, seed quality operators can calculate the effect of removing one or more fractions on the percentage of useable transplants of the remaining fractions. Using this information, the seed lot can be upgraded.

X-ray upgrading is a highly innovative automated seed sorting systems using X-ray imaging. With X-ray upgrading technology it is possible to look inside the seed to determine whether all the essential components are present and detect incompletely developed or damaged embryos. This fully automated sorting system is the most efficient seed upgrading to date. X-ray upgrading significantly increases the percentage of useable transplants in a seed lot for tomato and other vegetables.

Market scalability of these systems is very high as tomato production is strongly impacted by low germination and growth under impacts of climate change

Upgrading seeds leading to higher germination and increased yield capacity in a condition of climate change is crucial as the effect of drought or extreme climatic events can completely destroy production or lead to important losses. These technologies can offer much higher survival rates to the plants and therefore to the agricultural value chain linked to them.

Project #46	Grafting nurseries for improved tomato production

Problem and Project Description

Tomatoes are an important crop to backyard gardeners and commercial producers in Moldova. Ideal tomato plants have excellent foliage, robust production, marketable fruit characteristics and disease resistance. Thousands of tomato varieties are available for planting. Narrowing down which varieties to plant can be challenging. Even more challenging is finding a tomato variety that meets the needs of the local market and is resistant to disease. One way to meet that need is to graft the most desired fruiting variety onto a disease-resistant rootstock. The main reason to plant grafted tomato plants is to protect the plants from soil-borne diseases such as bacterial wilt, root knot nematode, and Fusarium wilt. Additional benefits of grafted plants may include increased yield and plant vigor, especially in conditions that favor the aforementioned infections as a consequence of climate change.

Grafting is done when the stem diameter of the seedlings is 1.5 to 2 millimeters at the point where the cut will be made, and the seedlings have two to three true leaves. This stage of development usually occurs seven to 10 days after the seeds germinate or 14 to 16 days after sowing. Seedlings should be watered 12 to 24 hours before grafting. Avoid watering the seedlings immediately prior to grafting. Graft early in the morning or just after dark. At these times the seedlings are typically transpiring slowly. Ideally, the grafting process should take place indoors. Therefore, building a grafting facility inside a greenhouse is a fundamental step of a grafting campaign.

The market potential for grafter tomato plants in Moldova is high, as imported plants are already present but domestic production does not suffice the demand

Grafting desired tomato varieties with resistant rootstocks is a key technology to obtain high yielding plants even in a context of climate change. These plants need to be adapted and grafted specifically to the conditions of the tomato production areas in Moldova and therefore investment in this technology domestically should be considered.

Project #47	Automation for crop production through digitalization and remote control via app
Problem and Project Description	
Automation of a variety of processes and actions taking place in agricultural production can deliver more coordinated and comprehensive information to manage food production. Several technologies can work in synergy to achieve this goal but their integration requires an increased level of automation. Internet of things and Artificial intelligence has already started capitalizing across all the industries including agriculture. Advancement in these digital technologies has made revolutionary changes in agriculture by providing smart systems that can monitor, control, and visualize various farm operations in real-time and with comparable intelligence of human experts. The potential applications of IoT and AI in the development of smart farm machinery, irrigation systems, weed and pest control, fertilizer application, greenhouse cultivation, storage structures, drones for plant protection, crop health monitoring, are a phenomenal instrument to tackle the impacts of climate change on agriculture and adapt the sector for better resilience. The application of the internet of things backed up with an efficient intelligent decision-making system can lead to a significant reduction in human intervention in various agricultural tasks, and crucially, a much more responsive action. Being connected to the internet, the main goal of the IoT deviceis togenerate real-time data andthese data are mostly unstructured. Duringthe early stages of IoT, when the device was simpler, the data generatedwere very few and used to trigger simple alert messages without much processing. There, the AI algorithms had no role to play. As the IoT systems got more complex and sophisticated, this huge dataset (Big Data) gave rise to the need for data analysis. AI algorithms have the capability to handle and derive meaningful insights from the data which can leadto high-quality decision-making. Problem solving and automation havebeen made quite simple by the introduction of new logic and methods. These systems can inform via app the farmers about the suggested action to take and when to take it with a responsiveness than in times of climate change are crucial. These systems can inform farmers about the immediate and even forecasted consequences of droughts or incoming storms, and suggest corrective or protective actions to be taken. Market scalability of these systems is very high as the technologies are constantly evolving and with them their possibilities. Despite the challenges due to climate change and other factors, the digital technology driven agriculture provides a plethora of methodologies for automating and enhancing agriculture production and productivity. Digitization in agriculture enables real-time analysis that helps in more effective spraying, land management, water management, and even land surveillance. The use of emerging digital technology will allow the agriculture industry to achieve several other benefits such as reducing input costs and wastage, achieving sustainable practices along with enhancing productivity to adapt agriculture to climate hazards and respond more effectively.	

Project #48	Climate-Smart rotations and using of predecessors capable to prevent problems
Problem and Project Description	
The dominant concept of agriculture intensification since 60-th years of the previous century is „green revolution”. It is based on applying nonrenewable sources of energy and their derivates (mineral fertilizers, pesticides, fuel for moldboard plow and irrigation etc). The industrial model of agriculture intensification led to many negative consequences on the environment and health of people, which have been externalized from the calculations of economic efficiency of their use. Simultaneously, the prices for industrial inputs and their derivates have increased dramatically. For farmers became impossible to compete at the local, regional and global markets. Farmers began to look for alternatives to the existing farming practices. Crop rotation is one of the main regularity of agriculture. It allows to prevent many negative consequences on the environment by preventing the wind and water erosion, the development of pests, diseases and weeds etc. It is cheaper to prevent many negative consequences on the environment and health of people instead of controlling them, especially with expensive and unsafe chemicals. By extending the areas of crop rotations in different pedoclimatic regions of Moldova it would be necessary to organize seminars with farmers in order to explain the advantages of respecting good predecessors and good alternation of crops. A monitoring system should be established in order to provide incentives for farmers in transition to a more sustainable and resilient agriculture. Simultaneously, the monitoring system is necessary for the evaluation of soil quality capable to provide social and ecosystem services.	

Project #49 Conservation Agriculture
Problem and Project Description
Conservation Agriculture System is mimicking the natural ecosystems through avoiding mechanical disturbance of the soil, permanent covering of the soil with cover crops and crop residues, alternation of a higher diversity of crops in the frame of crop rotation. CA makes farmers more competitive in the conditions of increased prices for industrial inputs and their derivates as well as reduces the negative impact of agriculture on the environment, including the reduction of green gases emissions. For a better restoration of soil fertility it is necessary to include perennial crops in the crop rotation and to integrate crop husbandry with animal husbandry. This will allow also to reduce considerably the application of mineral fertilizers, pesticides, moldboard plow and irrigation. By respecting the whole farming system it becomes possible to improve soil health and to provide better social and ecosystem services. We are suggesting to use Conservation Agriculture System (CAS) for half of the area under arable land in Moldova – 850 thousand hectares. This will allow to stop soil erosion in the conditions of extreme weather conditions and simultaneously to reduce the negative influence of droughts.

Project #50	Soil organic matter management and monitoring at farm and landscape levels

Problem and Project Description

The transition to a more sustainable agriculture is possible only if the farming system is respecting all the component parts which are oriented towards accumulation of soil organic matter. Unfortunately, modern farming systems are extracting more than they are returning back to the soil. The dominant approach doesn't work, because the amount of crop residues remaining in the soil can't compensate the mineralizational losses of soil organic matter.

Perrennial legumes and grasses in crop rotation is very beneficial in improving the regime of soil organic matter because of a higher amount of crop residues, including in the deeper soil layers. But only including perrennial herbaceous crops in crop rotation isn't enough for the compensation of the mineralization losses of soil organic matter. Integration of crops and animals can provide a nondeficit balance of soil organic matter. Each crop rotation should provide a nondeficit balance of soil organic matter which can be created by respecting a good crop rotation, with optimal ratio between compact drilled crops and row crops, minimum or No-till and optimal system of soil fertilization. Utilization of organic fertilizers and cover crops is very important for providing enough carbon as the main component of fertilization system, taking in consideration that soil is a living organism. Predominance of nitrogen from mineral fertilizers is dangerous for the soil because nitrogen is increasing the mineralization of soil organic matter and is leading to emission of nitrogen oxides, which are contributing to global warming.

Project #51	Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air

Problem and Project Description

A network of shelter belts and ponds is one of the best solution for landscape organization in order to prevent and reduce the negative impact of wind and water erosions, as well as droughts. Shelter belts together with ponds in the bottom parts of the relief are increasing the humidity of the air. They are beneficial for increasing the predators of agricultural pests and consequently allows to reduce the application of pesticides.

Shelter belts are „dressing" each field in the crop rotation in accordance with the protective capacities of trees. In such a way it is becoming possible to establish also the optimal size of fields and to avoid discrepancy between agronomic requirements and tendency of modern industrialized agriculture (big fields under the influence of powerful tractors and other agricultural equipment together with pesticides for higher level of infestation of the fields in narrow specialized crop rotations).

It is considered that the optimal share of shelter belts in the total area of arable land is 4-6%. If to take in average 5% for the total area of arable land in Moldova – 1,7 mln. ha, the area under shelter belts should be 85 000 ha. For half of the area of arable land the area under shelter belts should be 42,5 thousand ha.

The expenses for the plantation of one hectare of trees in the shelter belts from seedlings consist from 1300 up to 2400 Euro. For the area of 42500 ha of arable land total expenses will consist 55,2-102,0 mln. Euro or 59,6-110,2 mln. am.doll.

At the moment the main obstacles in promoting building of the entire network of shelter belts in Moldova is the lack of legislation regarding using of arable land for the plantation of shelter belts. The same is for water reservoirs in the bottom parts of the relief.

We should take in consideration also measures to be undertaken for cleaning of trees and the ponds.

Project #52	Including perennial legumes and grasses in crop rotations for farm mosaics

Problem and Project Description

The mixture of cereals and legumes as perennial crops are included in the crop rotations for three years. On the third year, in conventional agriculture, the mixture of crops is disced after the first cutting (end of May or beginning of June). Herbicides can be applied too for killing the vegetation of perennial crops in case of No-till technology.
The most difficult in this technology is to find seeds of perennial legumes (alfalfa) and grasses (reigras).
The amount of required seeds for alfalfa in mixture is 15-17 kg/ha and for reigras 8-10 kg/ha. The total cost for seeds pe 1 ha is equal to 83-94 am.dol./ha for alfalfa and 36-44 am.dol./ha for reigras. All together – 120-140 am.dol. per ha.
The area under mixture of perennial crops in crop rotations in Moldova should be at least 220 thousands hectares. The cost for seeds will be – 26,4-96,8 million USD. Perennial herbaceous crops can be used not only as forage for animals, but also as raw material for metanization and biogas production even on larger areas than in the previous period of time. Biogas production can be used as one of the alternative ways for returning legumes in the crop rotations in order to reduce the dependence from nitrogen from mineral fertilizers and for enriching soil in soil organic matter on the whole soil profile.

Project #53	Integration of crops and animals for recycling of nutrients in each crop rotation (farming system)

Problem and Project Description

Integration of crops and animals in the frame of agricultural farms in Moldova is one of the best solutions for improving the productivities of crops and for improving soil fertility without using chemicals for crop nutrition and crop protection. The experimental data from Selectia Research Institute of Field Crops are proving such objectives. It will allow also to make the transition to alternative farming systems such as: organic agriculture, regenerative agriculture etc.

Besides the plantation of perennial legumes and grasses investitions are required for the procurement of animals of high quality and building facilities for animals, equipment for processing and storaging forages for animals.

Total investment depends from the size of the farm and types of grown animals. For these purposes the total expenditures will consist – 500 mln. am.dol.

Operational costs will include the following:

- growing crops, including forage crops for animals in the crop rotation;
- keeping animals in buildings (providing water, forages, cleaning of manure, transportation on farmyard manure etc);
- buying insemnination material.

Project #54	Increased production and use of organic fertilizers and amendments (e.g. composts, biochar, green manure)

Problem and Project Description

Organic fertilizers are used in the crop rotation in order to provide at least a non-deficit balance of soil organic matter and to improve soil quality.

Farmyard manure must be composted in order to reduce the infestation of fields with weeds because when temperature in the compost pile is increasing the seeds of weeds are losing their germination.

Composts should be prepared from different organic residues. Cover crops should be used as organic fertilizers as well as measure of soil sanitation: species of cover crops should be different for different crops, but cocktails of different cover crops are preferable.

Biochar isn't practiced in Moldova, but initial trials proved a good perspective for this method. In order to be implemented we need training of trainers and farmers regarding the art of composting; we need to establish a system for seed production of cover crops.

In order to do these activities the production expenditures will consist: 100 million USD including the procurement of machines for the compost preparation.

Project #55	Improving soil structure by increasing the input of carbon in soil and reduced rates of soil organic matter mineralization

Problem and Project Description

Formation of structural soil aggregate as well as their stability is possible under the permanent application of fresh organic residues and organic fertilizers. They provide formation of glue from polymeric organic materials capable to maintain aggregate stability. The best results can be achieved by application of composted manure in the crop rotations with both perennial legumes and grasses together with cover crops. Moldboard plow should be avoided.

No capital cost is required. Principles of conservation agriculture system or regenerative agriculture should be used in order to guarantee a balance between the amount of mineralized and humified organic matter. The potential for this technology is very bright, but it requires modernization of the structure of sowing areas with the optimal ratio between compact drilled crops and row crops and their location in the fields according the particularities of the relief (landscape).

As incentives the state can use 60 million USD for stimulating farmers in Moldova to respect good crop rotations with perennial crops and composted farmyard manure.

Project #56	Real time wireless soil moisture monitoring system

Problem and Project Description

Sensors are established in soil up to the depth of 1 m, in each 10 or 20 cm soil layers. The validation of such data is done in comparation with classical method by using the stove at 105 ^{o}C and the difference of weight of the soil before and after drying.

The cost of sensors, equipment for taking soil samples and the laptop with the soft for processing of data is around 21 000 USD. We are proposing to begin with 50 farms in different regions of Moldova. The total cost will consist 1 Million USD.

Training of operators is needed regarding the manipulation of the obtained data directly in the field. Such equipment is very useful also for research institutions, especially which are practicing technologies of growing crops on irrigation.

Project #57	Irrigation by using the most efficient systems

Problem and Project Description

One of the most efficient system of irrigation is drip irrigation, but it requires high level of investment. It can be used for vegetables, orchards, vinyards – crops with a higher added value than field crops. The potential for upscaling the irrigation system can be high in case of the modernization of the whole cropping system by orienting it towards a better restoration of soil fertility. The source of water should be from rivers Prut and Dnister, where the content of salts per one liter of water is admissible for irrigation (less than 0,7 g per liter).

The system requires investment in building a water reservoir and equipment for pumping water and irrigation. At least 10 thousands USD should be invested per each hectare. Total investment for 100 thousands ha should be 10 mlrd. USD.

Project #58	Integrated Pest, Disease and Weed Management

Problem and Project Description

Preventing weed, pest and disease infestation is supposing respecting the whole farming systems and good management. It includes such component parts as:

1. Respecting crop rotation;
2. Avoiding using of easy soluble nutrients;
3. Selecting varieties and hybrids with high biological capacity to suppress weeds and high tolerance to pests and diseases;
4. Finding the best terms and rates of sowing crops;
5. Cleaning of seeds for preventing dissemination of pests, diseases and weeds together with prophylactic treatment of seeds;
6. Not allowing seeds of weeds to ripe etc.

Combination of biological and mechanical methods for weed, pest and disease control is cheaper than using chemical even from economic point of view without taking in consideration the environment and social consequences of their application. The fund for supporting farming as insentive in transition to a more sustainable and resilient agriculture should be used – 50 mln. USD. A service at the state level should be created for monitoring the transition.

Project #59	Integrated Nutrient Management

Problem and Project Description

Integrated nutrient management is supposing using of nutrients by crops from different sources: animal manure, crop residues, cover crops etc. The best agricultural practices oriented towards a higher carbon sequestration by the soil are the basis for the reduction of the dependence from mineral fertilizers.

Using of legumes in the crop rotation is crucial for the reduction of rates of nitrogen from mineral fertilizers. Using of miccorizhal preparation is essential for a more efficient utilization of phosphorus from deeper soil layers.

A sustainable farming system should provide an Integrated Nutrient Management without supplementary capital cost.

Operational costs are related to the rational management of soil organic matter in the frame of the sustainable and resilient farming (cropping) system.

As incentive for farmers to practice IPM a fund should be created of 50 million USD A state monitoring program should be established.

Project #60	Application of anthers culture „in vitro” isolated pollen method to obtain and use double haploid lines in plant breeding

Problem and Project Description

The current system of production of hybrid seed of the first generation (F1) is based on development of inbred lines, which, by using a conventional method, are obtained as a result of controlled self-pollination of the original form (variety population, hybrid) for 5-8 consecutive generations.

The genetic research carried out in early `60s of the last century have demonstrated the possibility of obtaining „pure” or double haploid inbred lines in a number of species, including maize, by androgenesis in „vitro” culture. Androgenesis is the transformation of a haploid cell of the male to phyte into a mature plant with a gametal number of chromosomes. Androgenesis may be induced through „in vitro” culture of anthers or pollen at a certain stage of development. In order to obtain normal plants, perfect homozygote, haploids diploidize. The fact that the double haploid lines, which are absolutely homozygotic, can be obtained during two generations, while using conventional methods inbred lines are obtained in at least 6-8 generations justify the increased interest of breeders to haploid method.

For the laboratory it necessary 110 000 USD.

For the staff and maintenance 5500 USD.

All together 115 500 USD.