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AGRICULTURAL SECTOR OF KAZAKHSTAN: FOCUS ON INNOVATIVE DEVELOPMENT

ҚАЗАҚСТАННЫҢ АГРАРЛЫҚ СЕКТОРЫ: ИННОВАЦИЯЛЫҚ ДАМУҒА БАҒДАРЛАНУ

АГРАРНЫЙ СЕКТОР КАЗАХСТАНА: ОРИЕНТАЦИЯ НА ИННОВАЦИОННОЕ РАЗВИТИЕ

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Abstract. *The goal* is to show the importance of innovative technologies that contribute to the development of agricultural sector of Kazakhstan. *Methods* – objectivism, logical-methodological approach, phenomenalism. *Results* – as the authors note, today it is obvious that creation of new and modernization of existing industries requires the use of the latest technology and equipment. On this basis, it is possible not only to ensure food security of the republic, but also to fully realize export potential of agricultural sector of economy. Large innovative projects are being intensively developed and implemented to increase the potential of agro-industrial complex. The main constraining factors for increasing innovative activity at present are as follows: the lack of sufficient volumes of production of domestic competitive agricultural products and products of their processing on the world market; low level of the effective demand from agribusiness; underdevelopment of the innovation-conducting infrastructure "from science to producer"; non–compliance of the material and technical base of Kazakhstani agro-industrial production with new economic and production requirements; high cost of innovation. The article discusses the Fitbit technology; various devices, platforms and remote sensing based on artificial intelligence; vertical farming. *Conclusions* – the authors state that modernization of the country's AIC in the future is robotization. It is substantiated that the State should legally and economically motivate the introduction of autonomous robots. For example, the programs for the development of agriculture in the Republic of Kazakhstan can be based on robotization concepts through the use of technologies such as the Verdant Robotics weeding device. Particular attention should be paid to the formation of regulatory and legal mechanisms that facilitate the flow of innovations into agricul-

tural sector, as well as public support for them, organization of an effective system capable of concentrating investment resources in priority areas, and the creation of conditions for training of qualified personnel. This proves the relevance and timeliness of scientific developments in the proposed direction.

Аңдатпа. *Мақсаты* – Қазақстанның аграрлық секторының дамуына ықпал ететін инновациялық технологиялардың маңыздылығын көрсету. *Әдістері* – объективизм, логикалық-әдістемелік тәсіл, феноменализм. *Нәтижелері* – авторлар атап өткендей, бүгінде жаңа өндірістерді құру және қолданыстағы өндірістерді жаңғырту жаңа техника мен жабдықты пайдалануды талап ететіні анық. Осы негізде республиканың азық-түлік қауіпсіздігін қамтамасыз етіп қана қоймай, экономиканың аграрлық саласының экспорттық әлеуетін толық көлемде іске асыруға болады. Агроөнеркәсіптік кешеннің әлеуетін арттыру үшін ірі инновациялық жобалар қарқынды әзірленуде және енгізілуде. Қазіргі уақытта инновациялық белсенділікті арттырудың негізгі тежеуші факторлары: әлемдік нарықта бәсекеге қабілетті отандық ауыл шаруашылығы өнімі мен оны қайта өңдеу өнімдері өндірісінің жеткілікті көлемінің болмауы; агробизнес тарапынан төлемге қабілетті сұраныстың төмен деңгейі; «ғылымнан өндірушіге» инновациялық-өткізгіш инфрақұрылымның дамымауы; Қазақстандық агроөнеркәсіптік өндірістің материалдық-техникалық базасының жаңа экономикалық және өндірістік талаптарға сәйкес келмеуі; инновациялардың жоғары құны болып табылады. Мақалада фитбит технологиясы қарастырылады; әртүрлі құрылғылар, платформалар және жасанды интеллектке негізделген қашықтықтан зондтау; тік егіншілік. *Қортындылар* – авторлар еліміздің АӨК-ін жаңғырту болашақта роботтандырылатынын айтады. Мемлекет автономды роботтарды енгізуді заңнамалық және экономикалық тұрғыдан ынталандыруы керек. Мысалы, Қазақстан Республикасының Ауыл шаруашылығын дамыту бағдарламаларының негізінде verdant Robotics арамшөп машинасы сияқты технологияларды қолдану арқылы роботтандыру тұжырымдамалары болуы мүмкін. Аграрлық секторға инновациялардың түсуіне ықпал ететін нормативтік-құқықтық тетіктерді қалыптастыруға, сондай-ақ оларды мемлекеттік қолдауға, инвестициялық ресурстарды басым бағыттарға шоғырландыруға қабілетті тиімді жүйені ұйымдастыруға, білікті кадрларды даярлау үшін жағдайлар жасауға ерекше назар аудару қажет. Бұл ұсынылған бағытта ғылыми әзірлемелерді жүргізудің өзектілігі мен уақтылығын дәлелдейді.

Аннотация. *Цель* – показать значимость инновационных технологий, способствующих развитию аграрного сектора Казахстана. *Методы* – объективизма, логико-методологического подхода, феноменализма. *Результаты* – как отмечают авторы, сегодня очевидно, что создание новых и модернизация существующих производств требует использования новейшей техники и оборудования. На этой основе возможно не только обеспечить продовольственную безопасность республики, но и в полой мере реализовать экспортный потенциал аграрной сферы экономики. Интенсивно разрабатываются и внедряются крупные инновационные проекты для наращивания потенциала агропромышленного комплекса. Главными сдерживающими факторами повышения инновационной активности в настоящее время являются: отсутствие достаточных объемов производства отечественной конкурентоспособной на мировом рынке сельскохозяйственной продукции и продуктов ее переработки; низкий уровень платежеспособного спроса со стороны агробизнеса; неразвитость инновационно-проводящей инфраструктуры «от науки к производителю»; несоответствие материально-технической базы казахстанского агропромышленного производства новым экономическим и производственным требованиям; высокая стоимость нововведений. В статье рассматриваются технология фитбит; различные устройства, платформы и дистанционное зондирование на базе искусственного интеллекта; вертикальное земледелие. *Выводы* – авторы констатируют, что модернизация АПК страны в перспективе за роботизацией. Обосновано, что государство должно законодательно и экономически мотивировать внедрение автономных роботов. Например, в основе программ развития сельского хозяйства Республики Казахстан могут быть концепции роботизации путем применения таких технологий, как прополочная машина Verdant Robotics. Особое внимание необходимо уделить формированию нормативно-правовых механизмов, способствующих притоку инноваций в аграрный сектор, а также государственной поддержке их, организации эффективной системы, способной концентрировать инвестиционные ресурсы на приоритетных направлениях, созданию условий для подготовки квалифицированных кадров. Это доказывает актуальность и своевременность проведения научных разработок в предлагаемом направлении.

Keywords: agricultural sector, production, product processing, innovation, agricultural automation, robotization, competitiveness, food security.

Түйінді сөздер: аграрлық сектор, өндіріс, өнімді қайта өңдеу, инновациялық қызмет, ауыл шаруашылығын автоматтандыру, роботтандыру, бәсекеге қабілеттілік, азық-түлік қауіпсіздігі.

Ключевые слова: аграрный сектор, производство, переработка продукции, инновационная деятельность, автоматизация сельского хозяйства, роботизация, конкурентоспособность, продовольственная безопасность.

Introduction. The agricultural development in the Republic of Kazakhstan has huge significance for the future economic development leading to the rise in the quality of life within the republic. Therefore, the rationale behind trying to generate new innovative ways of agricultural development has economic value, e.g. food safety, internal stability, economic growth. However, the establishment of the agricultural programme could be impossible without establishing the programme which at least give suggestions on how to develop the agriculture.

The initial establishing of Kazakhstani agricultural programme based on the experience of developed nations could encounter the number of challenges. For instance, ensuring that government scheme design encounters inconsistencies between proposed measures and state agrarian policy principles. Moreover, state agrarian measures should include inspiring efficient and financially justified programmes aiding family–owned and small household farmers.

Steering wheels of environmentalism of the government programme could be payment to small farming enterprises to protect land and water landscape features, qualities and services as goods for the common public. For instance, a private farmer could be paid for keeping small part of his/her land intact to preserve biodiversity of pastureland otherwise dedicated to grow cash crops on it. In the longer term this kind of environmental protection subsidies are intended to provide financial safety net to small farming enterprises instead of focusing on reduction of negative environmental externalities [1].

Moreover, this type of financial stimulus could decrease human capital flight intensity from the countryside towards urban centres, especially among young men and women.

On the other hand, motivating smaller and middle range farming enterprises to maintain landscape qualities and values through financial means could have two positive bonus effects.

Firstly, the beautiful countryside landscape's biodiversity is the public commodity which cannot be maintained through government non-interventionist policy towards how private markets run.

Secondly, these types of environmental payments would not only decrease the rate of soil degradation but help to save extra scenic "countryside" for tourism sector. However, it is worth noting that overall rationalisation of the agricultural sector of the Republic of Kazakhstan could bring higher profitability and efficiency.

There are three types of agricultural rationalisation policies that could be applied in Kazakhstan. Firstly, enhancing specialisation and cooperation could decrease overall count of private farms while increase how much livestock would remain in those farms. Motivating private farmers to cooperate and establish larger enterprises through means of accessible loans, financial stimulus and other types of legal and economic aid could overall improve efficiency of the agricultural sector. Secondly, the government policies on agricultural rationalisation should be geographically conscious. For instance, more government grants for grain producers should be allocated to grain producers in the areas where soil quality and climate favour that kind of agrarian activity.

Finally, smaller and medium farming enterprises should be financially and otherwise economically motivated to embrace mechanisation and big data analysis technologies. The future of the agro-industrial sector in the Republic of Kazakhstan relies on shift from the labour-intensive farming practices towards reliance on less hazardous chemical fertilizers, remote sensing, mechanisation and internet of things. However, evolution of the agricultural practices in the Republic of Kazakhstan may require the creation of the platform allowing access to any farmer about the current state of the agriculture.

Moreover, there is no database which shows full and consistent information about how agricultural practices impact the rural environment at the lowest-tier level of government administrative division. For instance, full access to the big data related but not limited to the following factors could improve agriculture related decisions at the

local level of administration: chemical fertilizer and pesticide usage impact, wastage of water and from intensive animal farming effect, biodiversity decline and soil degradation consequences, how destructive on environment were forest fires and other natural disasters. Blind incentives for enlarging livestock numbers and intensifying use of natural pastures without paying attention towards environmental limitations could do more harm for the local community in the long run. It is important to keep the gentle balance between cash crop and herding based on the soil and climatic constraints.

On the other hand, the government incentives towards heavy mechanisation and intensive irrigation could be beneficial in the underdeveloped rural areas despite natural handicaps. The government subsidies are often pre-requisite not just for the development but for the survival of the entire rural clusters and communities [2]. In addition, initial support for the farming communities is often the pre-requisite for the future intensification and further specialisation of the agro-industrial sector.

However, intensification of agricultural activity should not come at the expense of wildlife habitat destruction. For instance, increase in arable land area, rise in pesticide and fertiliser application, change in agricultural management and production administration practices should be monitored to avoid significant damage to the natural habitat [3]. Hence, the Republic of Ka-zakhstan needs to set up the scheme of compensation. This scheme should be locally focused and allocated to private and medium farming enterprises for not following agricultural practices that bring significant environmental damage. For instance, regulating and overcoming nitrate pollution consequences of the agrarian sector.

The reformation of Kazakhstani agro-industrial sector could require development of vertically designed compensation schemes with the legal power only within the specific geographic areas focused on the certain types of agricultural activity. For instance, co-financing or government backed schemes helping rural population to change farming practices from the labour towards data and technology intensive. However, it is important that this scheme should intensify abandonment of agricultural practices in the least favourable regions to avoid escalating farm abandonment tendencies [4]. Farm abandonment not only marginalises already underdeveloped communities but also escalates environmental issues as soil degradation and fire hazard.

Material and methods of research. The scientific research methods are case specific and not always based on experiments that can be repeated or controlled. For instance, those type of practical experimentation played small significance for the birth of evolutionary biology. Moreover, advanced techniques from the mathematical field may have varying degree of applicability as the research methodology. For instance, early innovations and discoveries in the science of genetics did not rely on the sophisticated mathematical analysis tools.

Therefore, there is no ultimate directive on procedures for assessing theories taking into consideration the collected evidence by the researcher. On the other hand, tedious performance of time consuming and often costly observations by itself does not guarantee the adoption of the scientific research methods. The classical civilization became the cradle of the human experience. The ancient Romans and Greeks elevated their nature through expressing their civilizational values with theatre, music, politics and etc. However, these civilizations were too reliant on rationality and logic. In contrast practicing the scientific research methods requires rejection of the human nature itself through questioning rationality.

Hence, the following research methodologies were chosen: objectivism, inductivism and phenomenalism. Therefore, any knowledge presented by this paper should be acknowledgeable by the human senses. Moreover, the research methodology emphasizes that any new generated knowledge should come from the factual sources. In addition, the research methodology focuses on trying to be as free as possible form subjective assumptions.

Results and their discussion. The gross output for products and services in the agricultural sector of the Republic of Kazakhstan was equal to 7 346 672.6 million tenge in 2021 [5].

The Ukrainian conflict proved again that the strengthening the superpowers. The adoption of advanced agricultural techniques and technologies could be possible through analysing the experience of the developed nations. These kinds of technologies would not only increase productivity of the agroindustrial sector but also would also provide more safety to employees and have lower negative environmental impact through being more eco-friendly. There are several

agrarian and farming techniques that could worth considering to implement in the Republic of Kazakhstan:

1. The fitbit technology is spreading within the fitness industry of the developed countries. This technology helps to keep its users healthy through wide range of tracking services. For instance, the fitbit may help a customer to make sure that he/she walks the desired 8 km walking daily quota. However, the fitbit technology could be taken further through adapting to the application in the animal husbandry of the Republic of Kazakhstan [6].

For instance, companies as Vence offer service of equipping fitbit devices to cows allowing but not limited to the following set of functions [7]: monitoring the health of the observed cow through range of data collection techniques such as analysing the heart rate; containing the cow within the virtual fence by designating the territory allowed for its grazing; tracking the precise location of the observed cow through GPS tracking system; directing the cow through the electric stimuli to the desired location.

The ability to impact the movement direction of the observed cow not only forces it to come back to its owner but also helps to avoid overgrazing (through keeping track and planning when and how many cows are going to graze on the specific plot of the land). Therefore, fitbit technology has the huge potential in the animal husbandry of Kazakhstan through not only providing higher productivity but also being more ecologically friendly. The spread of the fitbit technology though the economies of scales will reduce the cost of this technology making it more affordable to Kazakhstani farmers.

2. The pests are considered as one of the major hazards for the small agrarian entities in the Republic of Kazakhstan. The private farming enterprises and even medium agrarian entities often cannot or struggle with affording the cost of pesticides. Moreover, it is not always obvious which pests are going to threaten your harvest in the future. Therefore, farmers are not confident in what type of pesticide to invest in. As a result, combining the insect trapping with visual observation systems are gaining the momentum.

For instance, Trapview offers the trapping device which would not only monitor the insect and other pest activity but also would use the research findings to change the pest lure product [8]. Therefore, farmers may save money on fertilizers by purchasing only the necessary types of pest control products. Moreover, creating the national network for the data generated by devices as Trapview may help to create the foundation for the machine learning system. This Kazakhstani machine learning system once created would become one of the integral sources for the developing the ecological protection framework.

3. The experience of the developed countries shows that the automatization of the tractor exploitation could be the next step of the agrarian revolution [9]. Hence, the concept of self-driving at least should be considered at the government level of the Republic of Kazakhstan. It is true that the agrarian advances of the pre-independence period of Kazakhstan were achieved through training an operator who drove a tractor. The idea of human operated use of the heavy machinery for agricultural purposes were at the centre of the twentieth century “Green” revolution worldwide. However, the development of the artificial intellect and the big data through application of the machine learning techniques allows to create fully automated self-driving tractors.

4. The application of the satellite imagery for collecting the agricultural data is not uncommon trend in the developed countries [10]. Hence, the Republic of Kazakhstan could use its satellite resources to create the centralised and subsidized service allowing farmers to gain round-the-clock access form the aerial perspective to their crop related data. Kazakhstani satellites could chart the plough lands to determine the qualitative metrics regarding the crop health.

5. The process of managing the large farming estate has always been considered as the difficult task [11]. The farming entities by having vast fields at their disposal often simply physically do not have the opportunity to track all the changes that occur with their farmland which may negatively affect the future yields. However, integrating the application of unmanned aerial vehicles into the crop production process could solve the mentioned problem. The cost-benefit ratio for applying drones to collect data in the agricultural sector is falling short to become affordable by Kazakhstani farmers [12]. However, the affordable drones on the cheaper edge of the market supply may have accuracy limitations. It does not mean that drones should not be used for the agrarian practices.

On the other hand, gaining accuracy to the extent of knowing the data up to every single entity of the grown crop could be the next level of the evolutionary development in the agricultural sector of the Republic of

Kazakhstan. For instance, robots on the TerraSentia platform could roll through the rows of crops and apply its visual cameras, sensors and GPS tracker to fulfil the following sets of functions [13]: count the crop number; collect the data on the health of every single unit of crop, e.g. stem width, height and etc.; map the specific location of every single crop while mentioning qualitative data related to each of them. As a result, the TerraSentia platform would summarise the data collected by all robots and provide data driven suggestions to a farmer.

6. Starting an agricultural enterprise in the Republic of Kazakhstan could become easier if the profit expectation guessing element could be reduced from the decision-making process. Hence, the government of the Republic of Kazakhstan could set up the centralised platform which would allow the scientific institutes and universities to analyse the soil quality at the demand of the business sector.

For instance, the research institutions could be subsidized for determining whether the chosen for the potential use the plot of land is too degraded or eroded for agrarian activity. This could be achieved through applying DNA sequencing techniques by determining what type and how many microbes would be present in soil [14]. Moreover, the creation of the centralised server for collecting the data from every single soil test could create machine learning potentials. Moreover, this type of institutional tests through comparing chemical with biological soil data could define what type of agricultural activity could be more profitable (e.g. growing crops or grazing) or what type of plants at which plot of field to grow [15].

As a result, the centralised approach to institutional soil quality testing for agricultural lands could take away the guessing element from the initial decision-making on the nature of the agricultural activity, therefore, could save many farmers from financial losses and bankruptcy.

7. The concept of the vertical farming is spreading throughout the developed world in the recent years.

The vertical farming is becoming economically viable in or near the urban environment where the space is limited.

The concept of the vertical farming is involved building the agricultural space upwards instead of extending the plough fields horizontally. Hence, the vertical farming could encourage throughout the densely populated areas of Almaty or Astana (major cities) to practice the agricultural activity. For instance, even individual households despite the space limitations could rely on growing shelves to grow certain agrarian cultures to satisfy nutritional needs of growing population within Almaty and Astana. Moreover, the growing shelves offer more versatility compared to the traditional agricultural practices of the rural Kazakhstan. In addition, the vertical farming allows the application of more advanced agricultural techniques, including but not limited to [16]:

- creating the controlled vegetable growing environment which not only reduces the weather dependence but also reduces pest risk. Moreover, the presence of the controlled environment makes easier to automate the agricultural practices as it becomes easier to track the state of the agricultural produce. In addition, ability to control water and nutrient supply, quantity and quality of the light exposure and temperature provides more power to impact the cultivated crop quality. Hence, the vertical faming [17] could not only provide the qualitative advantage but also higher crop rate per unit of resource spent on its agricultural produce compared to the traditional agrarian practices;
- allowing hydronponic (when the crop cultivation takes place in the water bowl dense in nutries) or aeroponic (when the crop roots, which are freely flying, are sprayed with necessary amounts of nutrients or water in the systematic manner) agriculture;
- enabling internet-of-things because providing good quality Wi-Fi connection within the indoor vertical farming facility in the urban centre is more achievable task than doing the same things for the massive fields of plough lands in the middle of nowhere.

On the other hand, the vertical farming has the following significant disadvantages which could prevent it from being adopted by Kazakhstani farmers in the near future:

- there are only limited number of crops which could be grown in the vertical farms at this moment of the current technologic development;
- tall field crops could not be grown in the vertical farms at the mass scale because they would physically not fit;
- the high reliance on technology makes the vertical farms vulnerable to technocratic accidents as power cuts. Hence, the development of the vertical farming in the rural Kazakhstan, where vast majority of agricultural lands are located, may become economically not beneficial at this stage of technologic development. Moreover, the Republic of Kazakhstan has no issues with

availability of vast territories of land which eliminates the need for the space efficiency of the vertical farming;

■ the high energy reliance of the vertical farming means that the majority of small and even middle agricultural entities could struggle running them.

To sum up, all the mentioned above experiences of the developed nations could help to strengthen the development of the agricultural sector in Kazakhstan. However, there is the need to take into consideration the economic losses caused by the COVID-19 pandemic to the global economy [18]. Hence, the government support funds to the agricultural sector should be spent cautiously. As a result, allowing farmers to implement whatever innovations they seem visible while focusing the government support into one type of innovation may seem to be the policy of change.

Conclusion.

1. The analytical research results showed that the global trends in the agricultural practices were moving towards adopting the autonomous robots which could make strategic decisions. Therefore, the government of the Republic of Kazakhstan should prioritise economically and legally integrating the autonomous robotisation of the agricultural sector. Moreover, Kazakhstani government could enter the partnership with enterprises as Verdant Robotics.

For instance, Verdant Robotics offers an organic weeding machine which self-targets and then kills weeds [19]. This sniper machine could also fertilize with high precision. This device relies on the machine learning algorithms and computer vision first to locate, see and then carry out precise set of the programmed actions on the objects of its interest with its sharp shooting. The potential of using this kind of machines opens big potentials for the agricultural sector of Kazakhstan.

2. Hence, the Kazakhstani government should either partner or fund universities and institutions for developing a robotic sniper machine which could identify every single plant it would hover over to decide whether to water, fertilize, treat with medicine or to kill it. Then, as Verdant Robotics machine it should also be able with sub-centimetre precision degree to deliver the necessary product to every single plant. Therefore, less chemicals would be used making agricultural not only cost efficient but also ecologically friendly. Moreover, Verdant Robotics machine would remember every single crop unit it dealt with.

3. This type of equipment through scanning with high resolution camera is capable of creating 3D mapping of the entire field with centimetre-level precision degree showing the location of every single unit of plant. Moreover, using the geolocation technologies a farmer could find every single plant growing in his/her field and track their state.

4. The modern data collection techniques with drones and satellites could provide more data than the human mind is capable of comprehending. However, these types of technology are only the early steps in the automatization process of the agriculture. Therefore, the programme of agricultural development of the Republic of Kazakhstan should be based around the concept of robotisation through enforcing adoption of technologies as Verdant Robotics weeding machine.

5. Hence, the state should fund the creation, cooperate with the private enter-prises or use any other means that could be necessary in order to achieve one goal: spreading the use of a weeding machine would not only create a computer-aided design (CAD) of the entire field with centimetre-level decision, but also deliver automatic solutions (kill, fertilize, water, treat with medicine and etc.) at the single unit plant level. More-over, using this kind of machinery would allow tracking the health progress of every single unit of crops instead of tracking plots of land.

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