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UNMANNED AERIAL VEHICLES IN AGRICULTURAL RISK INSURANCE

This study analyzes the need for the use of drones in agricultural production and the use of information for agricultural risk insurance. It is proven that drones in agriculture can be used to carry out the necessary range of activities to reduce the load on the soil, spray agricultural plants, and collect information for further use in farms. It is substantiated that insurance of agricultural risks requires information support for concluding an insurance contract and determining the amount of losses upon occurrence of an insured event. Drones in agriculture can perform the following operations: aerial photography, video recording, 3D modeling, thermal imaging, laser scanning, spraying, planting seeds, scaring away animals, etc. Drones can be used in analyzing soil quality for land quality insurance. The article presents a classification of insurance risks of agricultural production, which helps to determine the insurance risks and the possibility of their insurance. We propose a mechanism for insuring the risks of agricultural plants and the possibility of determining the amount of damage compensation using information from drones. The use of drones and associated analytics has great potential to support and enable operational decision-making despite external factors and weather conditions.
Keywords: risk, insurance, agriculture, drones, insured event.

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БЕЗПІЛОТНІ ЛІТАЛЬНІ АПАРАТИ У СТРАХУВАННІ СІЛЬСЬКОГОСПОДАРСЬКИХ РИЗИКІВ

У статті аналізується необхідність використання дронів у сільськогосподарському виробництві та використання інформації для страхування сільськогосподарських ризиків. Доведено, що дрони в сільському господарстві можуть бути використані для проведення необхідного комплексу заходів щодо зниження навантаження на ґрунт, обприскування сільськогосподарських рослин, збору інформації для подальшого використання в господарствах. Обґрунтовано, що страхування сільськогосподарських ризиків вимагає інформаційного забезпечення укладення договору страхування та визначення розміру збитків при настанні страхового випадку. Одним із застосувань дронів у сільському господарстві є спостереження за посівами без необхідності постійного контролю з боку особи, відповідальної за нагляд за полями. Роботу спростять дрони, оснащені камерами, якими фермер може керувати сам або використовувати спеціалізоване програмне забезпечення, що дозволяє збирати дані без втручання людини. Доведено переваги використання дронів при контролю врожаю на кількох гектарах. При цьому перевагами є: економлення ресурсів, пов'язаних з роботою інших сільськогосподарських машин; обмеження участі працівника та витрати, пов'язаних з наймом працівників; ідеальне рішення для непередбачених надзвичайних ситуацій, спричинених повенью або пожежею, іншими стихійними лихами. Це дозволяє страховим компаніям, які

займаються страхуванням сільськогосподарських культур, швидко з'ясувати де відбулося їх пошкодження, у якому вони стані на момент настання страхового випадку, який розмір збитку був завданий страхувальнику. Дрони в сільському господарстві можуть виконувати такі операції: аерофотозйомка, відеозйомка, 3D моделювання, тепловізійна зйомка, лазерне сканування, обприскування, посів насіння, відлякування тварин тощо. Дрони можна використовувати для аналізу якості ґрунту для страхування якості землі. У статті наведено класифікацію страхових ризиків сільськогосподарського виробництва, яка дозволяє визначити страхові ризики та можливість їх страхування. Пропонуємо механізм страхування ризиків сільськогосподарських рослин та можливість визначення розміру відшкодування збитків за інформацією з дронів. Використання дронів і пов'язаної з ними аналітики має великий потенціал для підтримки та забезпечення оперативного прийняття рішень, незважаючи на зовнішні фактори та погодні умови.
Ключові слова: ризик, страхування, сільське господарство, дрони, страховий випадок.

Statement of the problem. In recent years, the use of unmanned aerial vehicles, also known as drones, for both personal and professional purposes has become increasingly common. Drones are known to be used as professional equipment used by the military, photographers, filmmakers, archaeologists, and surveyors. However, they can be equally useful in agriculture.

Agriculture is one of the fastest growing sectors of the economy in terms of the introduction of new technological solutions. The use of satellite imagery has already become commonplace in crop planning. Modern irrigation systems ensure a constant level of moisture in crop fields. Today, we can see an increasing use of drones in agriculture – they are used in many aspects of crop cultivation, livestock breeding, and field monitoring.

One of the applications of drones in agriculture is to monitor crops without the need for constant supervision by a person responsible for field supervision. The work will be simplified by drones equipped with cameras that the farmer can control him-/herself or use specialized software that allows collecting data without human intervention [1-3]. This way, one can properly control the harvest on several hectares. There are many advantages:

- resources associated with the operation of other agricultural machines are saved;
- employee involvement and costs associated with hiring employees are limited;
- this is an ideal solution for unforeseen emergencies caused by floods or fires, and other natural disasters. This allows insurance companies that insure crops to quickly find out where the damage occurred, what condition they were in at the time of the insured event, and how much damage was caused to the insured.

In agriculture, drones are also used for:

- spraying fertilizers and plant and soil protection products;
- obtaining up-to-date and accurate information on the area, relief, soil specifics of fields, plant and soil conditions;
- inventory of agricultural land;
- assessment of crop germination;
- forecasting crop yields;
- use instead of dogs when grazing livestock.

Drones can be useful for spraying crops. Spraying is an important branch of agriculture where drones can also find their application. Small drones will not replace machines designed for spraying large areas, but they can be successfully used for small areas. Thanks to the accuracy of the drone, spraying can be performed with high precision [4-5]. An additional advantage of using drones for this purpose is the scaring away of wild animals that feed on crops. The sound of the device can keep them from approaching the fields. This allows to reduce losses for the agricultural producer (insured) in case of loss or damage to crops in the case of an insured event.

These are not all the benefits of drones for agricultural purposes. Agriculture, as an industry that depends on weather and random factors, changes frequently. A drone can easily help to prepare detailed documentation in case of crop damage due to, for example, heavy rain or hail. It can be used to collect the documents required by the insurance company (or to receive financial assistance from the state). In addition to preparing documentation to optimize various processes, a drone can be used to monitor work efficiency.

Analysis of recent research and publications. The issue of agricultural risk prevention has been considered by scientists for a long time. The peculiarities of involving innovative technologies in the development of agricultural production and insurance protection of agricultural producers have been studied: Baliyants K.M. [15], Dokholyan S.V. [15], Hidirova S.Z. [15], Zhamolatova Z.N. [15], Skryl T.V. [16], Osipov V.S. [16], Vorozheikina T.M. [16], Shumkova O. [16], Ma X. [19], Gryshova I. [19], Khaustova V. [19], Bobrovnyk D. [19], Khaustov M. [19], Petrunenko Ia. [21], Pohrishcuk B. [21], Abramova M. [21], Vlasenko Yu. [21], Cao W. [22], Zhang Y. [22], Peng Qian P [22] and others. Features of artificial intelligence involvement have been studied: Takehiro K. [1], Hideaki S. [1], Yoshihide S. [1], Stutsel B. [6], Johansen K. [6], Malbéteau J.M. [6], McCabe M.F. [6] and others.

Formation of the objectives of the article (task statement). The purpose of the article is to analyze the activities of insurance companies when insuring agricultural risks with the use of unmanned aerial vehicles; to clarify the specific features of the use of drones in agricultural production.

Summary of the main research material. Drones in agriculture take aerial photographs, monitor fields, create 3D maps, sow seeds, apply fertilizers and chemicals, control crops, help with irrigation, and monitor animals [6-7]. They can perform a variety of operations:

- Aerial photography – to detect bald spots, crop damage caused by natural factors, and other defects that need to be eliminated in a timely manner. Aerial photography from a drone is much better than satellite photography in terms of its detail, due to the low flight altitude.

- Video recording – the performance of the aircraft during video recording reaches 30 km in 1 hour, which significantly reduces time and financial costs compared to the use of ground-based equipment.

- 3D modeling – allows one to identify waterlogged or arid areas, excavation, and competently create plans and maps for soil moisture or drainage, site reclamation or land reclamation.

- Thermal imaging is carried out using the entire spectrum of infrared radiation: near, middle and far ranges. The study makes it possible to determine the timing of differentiation of growth points, which directly affects the yield and preservation of productive properties of plants while maintaining the hereditary capabilities of the variety.

- Laser scanning – used for terrain analysis in hard-to-reach or inaccessible areas. This method provides an accurate high-density model with a detailed display of the terrain, even when working in conditions of strong plantation density.

- Spraying – due to the possibility of retrofitting, drones are used for spot spraying of plants and fruit trees. This approach allows farmers to treat only diseased plants, preventing chemicals from getting on the rest of the crop.

- Seed planting has started practicing relatively recently and has not yet become widespread, but some companies are experimenting with planting seeds using drones. Essentially, producers are experimenting with specific systems that are programmed to scatter seeds into prepared soil. This technology helps to minimize the need for personal presence to plant plants in a selected area, which can sometimes become an expensive and energy-consuming task. The same drone technology can be adapted and applied to many types of farms, reducing planting time and labor costs.

Modern unmanned systems in agriculture solve the following tasks:

- assessing the quality of crops and detecting damage or death of crops;
- determining the exact area of dead crops;
- audit and inventory of land;
- identification of crop defects and problem areas;
- analysis of the effectiveness of measures aimed at plant protection;
- monitoring compliance with the structure and crop rotation plans;
- detection of deviations and violations committed in the process of agrotechnical works;
- relief analysis and mapping of vegetation indices PVI, NDVI;
- collection of information for the security service, including the detection of illegal grazing in the fields;
- support for the construction of land reclamation systems;
- monitoring the storage of root crops in piles;
- application of trichogramma;
- creation of maps for differentiated fertilization and spraying of fields.
- counting seedlings and biological yield.

Modern drones in agriculture allow insurance companies to use the information to take preventive measures when insuring crops and to determine the damage in the event of an insured event. Agricultural risk insurance helps to reduce financial losses, provides agricultural producers with a stable income and promotes sustainable agricultural development in the face of unpredictability [8-9].

Clarifying the essence of agricultural risk insurance and the manifestation of various risks in the agricultural sector necessitate improving their classification. We propose a classification of agricultural insurance risks based on the object criterion, which is shown in Fig. 1. The risks of property resources cover the possibility of causing damage to material resources and intangible assets of agricultural enterprises and property of rural residents. We do not consider the risks of damage to intangible assets (goodwill, brand, patents, know-how, technical, scientific and practical, instructional, design, and other documentation), as they are not insured because it is impossible to accurately determine the amount of damage.

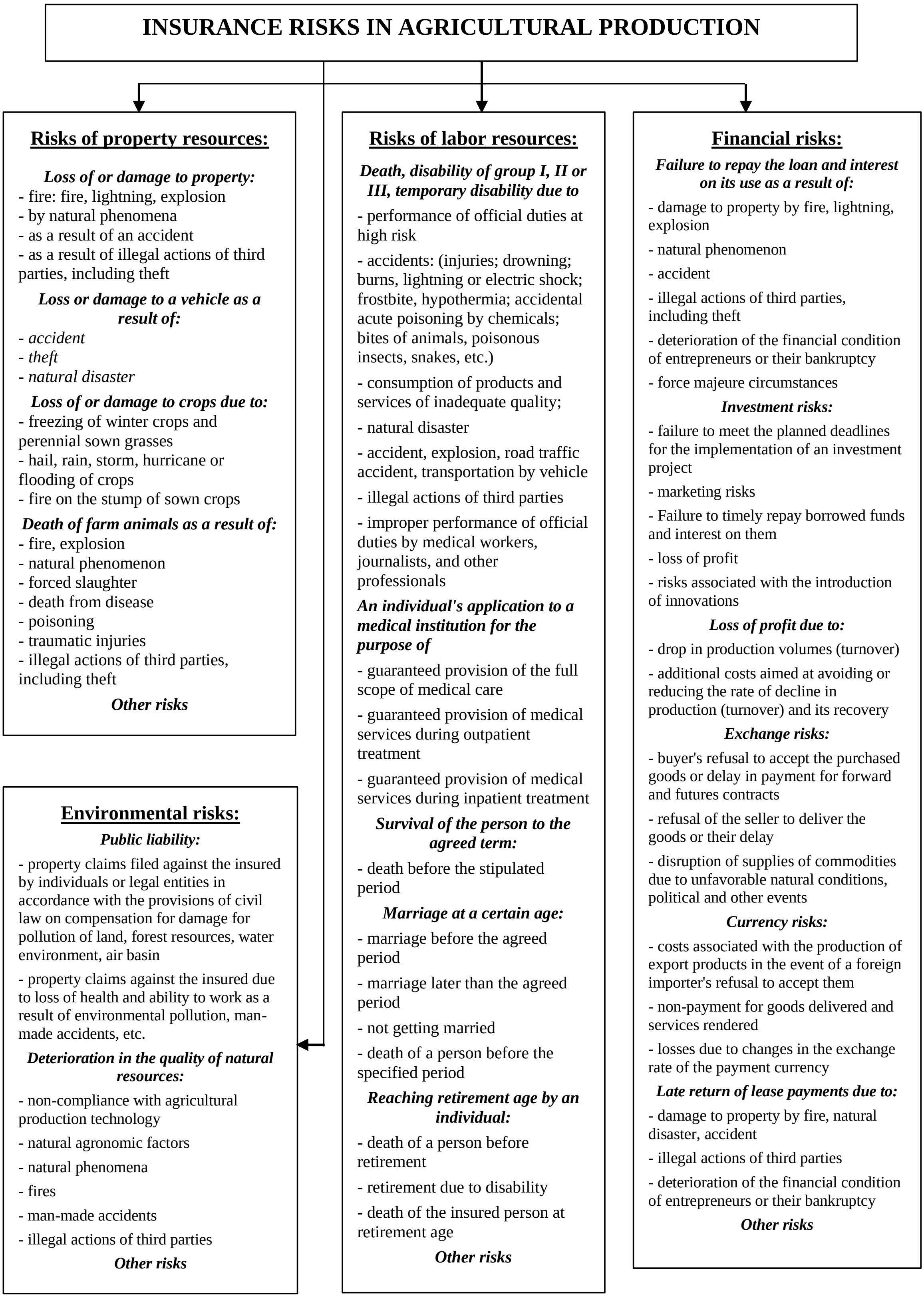

Fig. 1. Classification of insurance risks in agricultural production

Source: authors' presentation

It should be emphasized that agricultural risks are significantly influenced by unfavorable objective, human-independent, natural and other factors. Since the resumption of compulsory insurance of property of farm households, tenants, joint-stock and other non-state-owned enterprises in Ukraine is currently being carried out slowly, and they do not have sufficient funds for voluntary insurance, since insurance premiums are paid only from the profit remaining after taxes, a significant part of the property of these enterprises is not insured [10, 11].

Crop insurers can be: agricultural enterprises, tenants, farm households located in Ukraine. The insurance covers all types of agricultural crops and plantations: winter and spring cereals, legumes, industrial, vegetable, melons, fodder, orchards, berry gardens, vineyards, greenhouse crops, etc. The object of insurance is the insured's property interest related to indemnification of actual costs of sowing and growing crops as a result of complete loss of plants on all or part of the sowing (planting) area, regardless of the phase of their development, due to: freezing of winter crops and perennial grasses sown in previous years (the term of use of which has not expired according to agrotechnical standards); hail, rain, storm, hurricane or flooding of crops, if the latter is a result of a natural disaster; fire on the stump of spiked and other sown crops.

The sum insured under the insurance contract, within which crops (groups of crops) are insured, shall be determined in the amount of planned or actual costs of sowing (planting) and growing the crop, based on the data of the economic and social development plan of the farm (business plan) and relevant accounting documents. The sum insured may not exceed the total planned or actual costs stipulated by the technology of growing a crop, nor be less than the actual costs incurred at the time of entering into the insurance agreement. Depending on the zone and conditions in which the crop is grown, the sum insured shall be determined with due regard for the impact of climatic and other factors (agrotechnical requirements for growing), which also directly affect the condition of crops at different stages of plant development and harvest formation. In this case, the amount of the sum insured is set within a certain percentage of the total cost of the identified expenses. It may be limited by an unconditional deductible of up to 20%.

When drawing up an act for the complete or partial loss of crops, special attention should be paid to establishing the actual cause of crop loss, which is well assisted by agricultural drones. If the crops were lost due to reasons for which the insurer is not responsible, an act of any form is drawn up, which indicates the actual cause of the crop loss, the size of the area of its sowing and loss, and the location (field number, team, etc.). In case of complete destruction of crops on the entire sown area or part of it as a result of insured events stipulated in the insurance contract, the amount of loss is determined for each crop separately, based on a duly drawn up act and the availability of the necessary documents. The amount of loss is determined based on the costs actually incurred by the insured at the time of the insured event on average per 1 hectare, which is taken into account by dividing the total amount of costs by the area of crops planted under the insurance contract and the area of the crop that actually died. The insurer shall not be liable for crops where the plants are partially damaged (falling out) and it is necessary to reseed the crop. Such areas shall not be included in the calculation of the loss and the amount of insurance indemnity. An insurance contract under which an insurance indemnity has been paid shall remain in force until the end of the term specified therein in the amount of the difference between the insurance amount stipulated in the contract and the amount of the insurance indemnity paid.

The direct losses indemnified by the insurer shall not exceed the amount of costs actually incurred by the insured and stipulated in the insurance contract. If any crop is sown (planted) on an area larger than the area accepted for insurance, the amount of loss in case of its destruction shall be determined on the basis of the entire actual area of sowing of the crop. The amount of insurance indemnity shall be paid in proportion to the percentage of the area of the crop under the insurance contract to the actual area sown. The amount of insurance indemnity shall be deducted from the unconditional deductible, the next payment, and the overpaid insurance indemnity. Upon payment of the insurance indemnity, the insurer shall be entitled to the right of claim that the insured has against the person whose fault caused the loss.

Let's take a closer look at the capabilities of drones:

1. An orthophotomap allows one to accurately measure the geometric dimensions of a field and determine its geometric area in projection. This will be the area for which the farmer pays land tax and rent. In addition, the orthophoto plan obtained with the help of a drone will provide a lot of additional information for an attentive agronomist. It shows sifting, reseeding, areas where plants have died, and traces of trampling by people and machinery. Moreover, they are not just visible, but can be counted on the orthophotomap, measured and the area can be measured, and vector contours of interesting and problematic areas can be obtained for further work with them. For example, to create tasks for ground-based unmanned vehicles, which also work using vector contours and GPS coordinates.

2. Multispectral imaging. Any farmer will confirm that all his fields are different and heterogeneous. Even within the same field, there are areas where the yield is always different from the average. In some areas, it is noticeably higher, in others, it is lower. Moreover, for different crops, these differences can be diametrically opposed. What does it depend on? There are many factors. The relief of the field – some hillsides are more exposed to the sun, others are shaded. Mineral composition. Different soil moisture. Different weed infestation, susceptibility to pests, and this is an incomplete list. There are so many factors that even an experienced agronomist is not always able to predict their impact on a particular crop at a certain stage of the growing season, and even take into account the influence of the weather. Even knowing about this mosaic, agronomists still have questions about field management. There are also different approaches here. One can, for example, ignore the mosaicism and hope for an average harvest. One can additionally feed the plants in weak areas to a greater extent [12-14].

On the contrary, one can spend less expensive fertilizers and seeds on potentially weak and unpromising areas and, at the same time, increase their dosage on potentially strong areas to reduce overall financial costs across the field and increase overall yields. And finally, one can simply reseed the field in whole or in part if the views on the future harvest do not cover the expected investments. The decisions are ambiguous, difficult, and responsible. In these conditions, an objective decision support system will be very useful for agronomists and farmers. Such a system will provide quantitative indicators on the basis of which an informed and least risky decision can be made for a given situation.

The initial data for the system can be information obtained as a result of processing multispectral imagery from a drone.

Creating tasks for parallel driving systems. By obtaining information about the field's zoning based on various indicators, such as plant stress level, vegetative mass, distribution of specific chlorophyll content across the field, weed infestation and their localization, a farmer or agronomist can develop the right strategies for managing this field. And so, using the materials obtained from the drone, the agronomist decides to treat the field with herbicides. One can fill the field with a wheeled sprayer evenly, which is expensive in terms of the cost of the product and the cost of application.

One can use a more expensive but "smart" wheeled sprayer to apply the herbicide differentially, which is cheaper in terms of drug consumption but more expensive in terms of application costs. Or one can use an unmanned agrodron, which not only was originally designed for differential application of liquids, but also does not trample the field, does not add stress to plants from mechanical contact with parts of the sprayer and heat from its engine.

3. Application of substances by drone. Liquids, granules, trichogram, fumigation. In the case of tall crops, such as sunflower and corn, it is not always possible to drive a sprayer into the field. Unlike wheeled sprayers, a sprayer on an agricultural drone can apply substances to the leaf with jewelry-like precision, and with a consumption of only a few liters per hectare. Given the fact that a drone literally blows agrochemicals down to the ground with its propellers, the application of liquids by drones is becoming perhaps the most effective today. In addition to liquids, the drone is capable of dispersing granular preparations on the

field. And, of course, a drone can also apply trichogramma as a means of safe biological plant protection [15-16].

Fumigation is another unusual type of active ingredient application. During fumigation, a special installation on the drone creates a powerful stream of hot air. The hot air is fed with a mixture of a liquid and biologically neutral steam generator and the active ingredient. Microdroplets of the active ingredient are attached to the steam particles, then the biologically active steam is forcefully blasted out of the fumigator nozzle.

The active ingredient can be used to fumigate orchards and vineyards, effectively kill pests in open warehouses, streams and forest belts, and kill mosquitoes in reeds. The fumigation method is especially effective when combined with a drone, which brings a cloud of vapor to the destination in places that cannot be reached in any other way.

An important activity of drones in agriculture is field monitoring, observing the condition of crops. Thanks to cameras installed on drones, the farmer does not need to do this personally. Of course, he or she can control the drone him-/herself or, thanks to special software, the equipment will collect the necessary data without involving a person in the whole process. This feature is especially useful for multi-hectare crops – by using drones, one can save the costs associated with operating other agricultural machinery. It also works perfectly in case of emergencies – random natural phenomena such as fires, flooding of crops, and also helps in solving issues related to the distribution of agricultural land plots, obtaining information by insurance companies if necessary to take preventive measures in the case of crop insurance or land quality insurance; determining the damage in the event of an insured event.

Methodical bases of the insurance of quality of land resources of agricultural producers. One of the ways of the corresponding mechanism can be the compulsory insurance of land resource quality. In this case, insurers are the enterprises-users of agricultural land resources of all forms of ownership. The object of insurance is land resources owned or leased by agricultural enterprises.

Insurance risk involves a reduction in soil fertility in accordance with the standards specified in a land plot certificate, for which relevant authorities should examine the quality of land resources within their certification. An insured event is the deterioration of the key certificate indicators of land resource quality through geo-climatic processes, natural phenomena, accidents, illegal actions of third parties, etc. The fact of occurrence of an insured event is determined by the annual comparison of existing indicators with the certificate ones [17-19].

Formation of the insurance reserve fund for the conservation and recovery of soil fertility on the example of Sumy Region, Ukraine. Environmental risk insurance is carried out both on a voluntary basis and in a mandatory manner. The source of formation of insurance funds are insurance premiums of enterprises with environmentally hazardous production facilities. The seed capital of the insurer may be created at the expense of regional environmental funds, financial resources of state and commercial insurance systems, contributions of the founders. The payment of insurance indemnities will first depend on the number of insured persons, the amount of seed capital and the relevant payments, the possibility of reinsurance.

The results of the calculations carried out according to the statistical reporting on the formation of the insurance fund for the conservation and recovery of soil fertility for agricultural purposes, where the main types of crop production are grown in accordance with formula 5 on the example of the Sumy Region in 2022, are shown in Table 1.

Table 1. Formation of the insurance fund for the conservation and recovery of soil fertility in Sumy Region in the cultivation of grain and industrial crops*

Name of districts	Grain crops				Industrial crops			
	Area, thousand hectares	Monetary value of 1 ha of land, thousand US dollars	Insurance payment amount from 1 ha, US dollars	Size of insurance fund, thousand US dollars	Area, thousand hectares	Monetary value of 1 ha of land, thousand US dollars	Insurance payment amount from 1 ha, US dollars	Size of insurance fund, thousand US dollars
Total for region	**594.5**	**38.5**	**192.5**	**114,441**	**94.2**	**36.0**	**180.0**	**16,956**
Sumy	1.5	40.0	200.0	300	0.1	41.0	205.0	21
Bilopilskyi	51.9	39.5	197.5	10,250	8.2	35.5	177.5	1,456
Burynskyi	38.8	39.0	195.0	7,566	7.0	35.0	175.0	1,225

Velykopysarivskyi	24.8	40.0	200.0	4,960	5.7	6.8	170.0	969
Hlukhivskyi	35.5	38.5	192.5	6,835	5.1	36.0	180.0	918
Konotopskyi	49.4	39.0	195.0	9,635	8.2	36.0	180.0	1,476
Krasnopilskyi	32.5	39.5	197.5	6,420	5.7	35.5	177.5	1,012
Krolevetskyi	20.4	30.0	150.0	3,060	1.6	33.0	165.0	264
Lebedynskyi	44.7	40.0	200.0	8,940	7.1	36.5	182.5	1,296
Lypovodolynskyi	31.5	39.5	197.5	6,220	5.4	35.5	177.5	959
Nedryhailivskyi	33.0	40.0	200.0	6,600	3.9	36.0	180.0	702
Okhtyrskyi	37.8	40.0	200.0	7,560	7.9	35.5	177.5	1,402
Putyvlskyi	17.0	38.5	192.5	3,275	2.2	34.0	170.0	374
Romenskyi	58.1	39.0	195.0	11,330	9.5	35.0	175.0	1,663
Seredyno-Budskyi	12.1	29.5	149.5	1,785	0.8	31.5	157.5	126
Sumskyi	51.4	40.5	202.5	10,410	10.0	40.5	202.5	2,025
Trostianetskyi	22.9	40.5	202.5	4,635	4.0	36.0	180.0	720
Shostkynskyi	19.0	29.5	149.5	2,805	1.0	30.5	152.5	153
Yampilskyi	12.2	29.0	145.0	1,770	0.8	26.0	130.0	104

Continued Table 1. Formation of the insurance fund for the conservation and recovery of soil fertility in Sumy region in the cultivation of potatoes and vegetables*

Name of districts	Potato and vegetables			
	Area, thousand hectares	Monetary value of 1 ha of land, thousand US dollars	Insurance payment amount from 1 ha, US dollars	Size of insurance fund, thousand US dollars
Total for region	**87.4**	**35.5**	**177.5**	**15,514**
Sumy	1.1	40.0	200.0	220
Bilopilskyi	6.1	38.0	190.0	1,159
Burynskyi	3.0	37.0	185.0	555
Velykopysarivskyi	3.0	28.0	140.0	420
Hlukhivskyi	6.5	38.0	190.0	1,235
Konotopskyi	8.7	37.0	185.0	1,610
Krasnopilskyi	3.5	29.0	145.0	508
Krolevetskyi	5.0	32.0	160.0	800
Lebedynskyi	6.2	37.5	187.5	1,163
Lypovodolynskyi	1.6	30.5	152.5	244
Nedryhailivskyi	3.6	31.0	155.0	558
Okhtyrskyi	6.0	36.0	180.0	1,080
Putyvlskyi	3.6	35.5	177.5	639
Romenskyi	6.7	37.5	187.5	1,256
Seredyno-Budskyi	2.5	34.0	170.0	425
Sumskyi	9.3	39.0	195.0	1,814
Trostianetskyi	3.2	29.5	147.5	472
Shostkynskyi	4.3	37.0	185.0	796
Yampilskyi	3.5	30.5	152.5	534

* Calculated by the authors according to the data of the State Statistics Service of Ukraine: http://www.ukrstat.gov.ua/

In the calculations made, the amount of insurance rate is equal to 1% of the monetary value of agricultural land resources, but it varies for each farm depending on the quality of land resources in accordance with the certificate indicators in connection with the use of increasing (from 1.0 to 2.5) and decreasing (from 0.9 to 0.2) coefficients.

The insurance reserve fund should be used to recover the quality of land resources, paying insurance compensation to their owners upon occurrence of an insured event subject to their compliance with the agrotechnical requirements for growing crops; to reproduce land resources unsuitable for agricultural use; to prevent the deterioration of the ecological state of agricultural land; to carry out measures to reproduce degraded and contaminated soil, to increase fertility, etc. The relations between the insurer and the insured are based on the principles of mutual benefit and economic interest of the insured in improving the level of its own environmental safety.

Conclusions. The use of drones and associated analytics has great potential to support and solve some of the most pressing challenges facing agriculture in terms of access to valid real-time data and the ability to make operational decisions despite external factors and weather conditions.

One of the main advantages of using agricultural drones is a significant increase in the efficiency and productivity of agricultural operations. Modern drones are equipped with advanced sensors, imaging technology, and GPS capabilities that allow for precise and targeted application of fertilizers, pesticides, and herbicides. This targeted approach minimizes wastage of resources and reduces chemical exposure, contributing to sustainable agricultural practices. In addition, agricultural drones can cover large areas of farmland in a shorter amount of time, reducing labor and time. They can access hard-to-reach places and provide real-time data and statistics for better decision-making. In general, agricultural drones optimize agricultural processes, help reduce resource use, and contribute to higher yields and increased profitability for farmers. In today's world, drones are widely used in agriculture to improve production efficiency.

Comparing drones to satellites, we can say that unlike drones, satellites are sensitive to cloud cover. At the same time, the radar sensors of SAR satellites penetrate the clouds, so they can receive images even on cloudy days. An agricultural drone, on the other hand, is not suitable for use in the dark, during heavy rain or strong winds. Cloud cover with gaps also degrades the quality of drone images, so it is better to use them when the sky is completely clear or overcast.

Thus, despite certain drawbacks of drones, the market is developing steadily. According to Global Market Insights, the global market for agricultural unmanned aerial vehicles is expected to exceed USD 4.4 billion by 2024 [20-22].

Agricultural risk insurance is aimed at creating conditions for reimbursement, first of all, of extraordinary expenses incurred as a result of as a result of destructive insured events. The risky nature of production is increasing nature of production is increasing due to the growth of man-made the environment, and the contradictions between human activity and the ecological potential, which is increasingly losing the ability of natural of natural recovery. Therefore, the use of artificial intelligence in the insurance of agricultural risks by insurance companies is extremely important for determining the causes and amount of damage in the event of an insured event, and makes it possible to quickly pay insurance compensation to the insured.

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