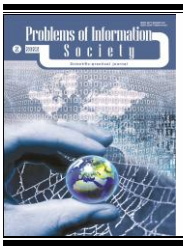

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Utilization of drones for innovative development of infrastructure and agriculture in Azerbaijan

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ABSTRACT

Today, the market for civil and commercial use of drones is actively developing, while the risks associated with their use are also increasing. At the same time, according to market research data from leading foreign companies, the rapidly developing market for civil and commercial use of drones has the greatest growth potential. Therefore, drone legislation is developing rapidly and is being improved every year. However, now it has come to a state of relative stability, allowing us to assert those general rules that will apply for a long time. The proper implementation of laws on the usage of unmanned aerial vehicles (UAVs), commonly known as drones, is proposed for the successful innovation and development of infrastructure and agriculture in the Republic of Azerbaijan. Through the clear enforcement of laws and guidelines of UAVs, involving registration, certification, and regular surveillance of UAVs by the National Aviation Academy, the implementation of drones will be systemized, paving the way for further innovative development of Azerbaijan.

1. Introduction

The development of UAVs in Azerbaijan allows for the addressing of several key issues in the sectors of infrastructure and agriculture. For instance, in infrastructure, these issues include the verification of site conditions for risks often carried out by inefficient land surveying, the secure monitoring of materials, the production of accurate cartographic materials, reports of work status, and collection of analyzable data. These issues are most pertinent in infrastructure, such as in the construction and maintenance of transport and logistics, water service, electric systems, communication networks, etc. In agriculture, issues include preliminary analysis of soil conditions, constant assessment of crop health, gathering of complex data through various scanning systems, and the chemical spraying of crops.

In the development of rural and newly liberated regions of Azerbaijan, with terrain that may be difficult to access, these issues are at the forefront of their respective sectors. However, with the utilization of UAVs, a new paradigm of drone-powered solutions can be established. As will be shown, the UAV industry is growing more popular in its application across multiple sectors worldwide. This is due to the ease with which it allows for the optimization of the aforementioned processes. Drone-powered solutions allow for autonomous and long-distance reach, efficient monitoring and scanning of terrain, and complex data gathering and analysis. This lends itself to the creation of advanced cartographic models and the automation of tasks previously carried out routinely, both with more precision and efficiency. Thus, the question of how drones can be utilized becomes the focal point of the development of infrastructure and agriculture in Azerbaijan. This

question will be tackled and analyzed in the following sections.

Alongside this question, the consideration of how UAVs can be regulated likewise becomes crucial. Security in the implementation of drone-powered solution requires clear guidelines which standardize usage of UAVs. As will be shown, we have created a model that allows for the secure monitoring and tracking of UAVs, including the categorizing of UAVs in accordance with their utility, which allows for coherent organization of all UAVs utilized across all sectors and industries in Azerbaijan, and for surveillance of undue activities and improper conducts.

2. Application of UAVs Across Multiple Sectors Worldwide

The relevance of innovative progress of infrastructure and agriculture in the development of all regions of Azerbaijan is crucial, considering that infrastructure and agriculture act as foundational gateways to further development. In 2017, the accounting firm PwC, one of the 'Big Four' accounting firms worldwide, placed the potential value of the market for four types of drone-powered solutions, with infrastructure placed as valuing $45.2 billion, and agriculture placed as valuing $32.4 billion [1] (see Fig. 1). These quantities comprise 36% and 25% of the $127.3 billion total valuation, placing infrastructure as the highest valued category in relation to other implementations, with agriculture in second place.

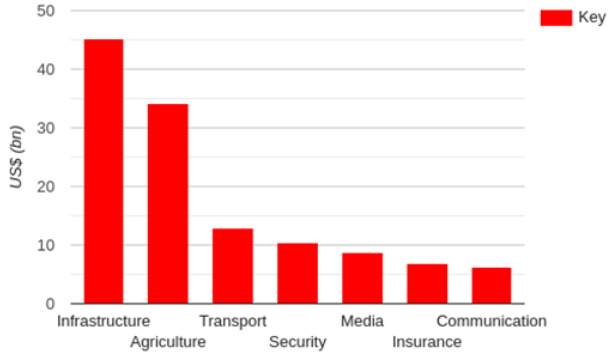

Fig. 1. Potential Global Value of Drone-Powered Solutions, PwC [1]

With the accelerating progress in the innovation of UAVs and the increasing appearance of new and unaccounted uses of UAVs, security and systematization are of key importance if the power of UAV solutions is to be harnessed.

3. Utilization of Drone-powered Solutions for the Innovative Development of Infrastructure in Azerbaijan

Subsequent reports from PwC demonstrate the extensive applications of UAVs in the infrastructural sector, many of which have existing applications in nations around the world. As there is a great importance in laying foundations of infrastructural development in the Republic of Azerbaijan, the proposal of systematic implementation of UAV guidelines and rules additionally suggests placing UAVs as the central point in this development. As a highly influential industry that is accelerating in development and will only continue to gain exponential relevance in the coming years, the adoption of UAVs considers both existing and concrete applications, as well as further innovations that will appear increasingly in the coming years. The continued utilization of UAVs is also effective in the Karabakh regions of Azerbaijan likewise, as it leads both to highly innovative developments in areas of increasing importance, such as the need to implement green energy and considering environmental factors, as well as being highly relevant to the needs and issues faced in the development of infrastructure in these regions. The incentives offered from the utilization of UAVs will hopefully serve to cement the importance of drone-powered solutions in the developing regions of Azerbaijan, promoting continued development and promoting the progression of these regions as a global example of innovative development and utilization of budding industries for the benefit of developing regions.

The aforementioned utilization of drones with consideration to green energy and environmental factors is of particular interest in relation to the UN's 2030 Agenda for Sustainable Development, formed on the basis of 17 Sustainable Development Goals (SDGs), which are considered by the United Nations to be 'urgent calls for action from all countries – developed and developing - in a global partnership'. The 9th SDG ('build resilient infrastructure, promote inclusive & sustainable industrialization, and foster innovation') [2] is of particular importance to the proposal. Of the specific categories in the SDG, the most relevant to the utilization of environmentally friendly technology as the main innovative force in the development of Azerbaijan is Target 9.4 ('increased resource-use efficiency and greater adoption of clean and environmentally sound

technologies and industrial processes'), due to the intensive development of infrastructure in these regions. The utilization of drone-powered solutions reaps positive externalities across a wide variety of fields, including in the critical reduction of carbon emissions that would otherwise be generated without the usage of UAVs [3], thus positioning the implementation of UAVs as a form of alternative environmentally friendly energy use.

In the subsequent reports from PwC, several key implementations of UAVs in infrastructure are outlined [4]. In the each of these applications, drone-powered solutions can be utilized at every step of the process to reduce issues and generate positive externalities:

- Investment Monitoring:
  - Tender (terrain conditions, risks, verifications, etc.),
  - Design (visual data, cartography, photogrammetry; relevant in the possibility of further applications both in and out of infrastructural development),
  - Construction (analyses of quantifiable data (e.g., potential risks and safety issues), adherence to design, aid in dangerous construction),
  - Post-Construction (documentation, reports on safety and operational issues);
- Maintenance;
- Asset Monitoring.

Due to the possibility of multiple implementations of UAVs in each stage of the process, the contributions of drone-powered solutions in relation to the specific requirements of regions in Azerbaijan is outlined in Table 1, as per the benefit of the consequences of the successful application on infrastructural development [5].

Due to the rapid acceleration of the application of drone technology, specifically in the infrastructural sector, it is additionally proposed to capitalize on the innovation of such solutions and apply them for the development of Azerbaijan. One such proposal involves the construction of drone-friendly platforms around the certain territories. The platforms are constructed to allow drones to land and charge themselves, readying for further trips, allowing for long-distance delivery and infrastructural development beyond line-of-sight. With the construction of such platforms in each village, drones can navigate around multiple regions of Azerbaijan. Innovations of UAVs in fields such as medical delivery has become increasingly relevant in the past years, as well as in deliveries of groceries and general supplies, with the total market value of UAV implementations in Transport being around $13 billion [1].

Such implementations would cement the development of relevant regions in Azerbaijan as examples of environmentally friendly innovations. In addition, the concept can integrate further innovations, such as the possibility of human transport via UAVs, which is actively developing around the world. These UAV stations are to be utilized alongside and in the benefit of preexisting projects in certain regions of Azerbaijan, such as the construction of airports in Lachin and Kalbajar, as well as the successful construction of the Fuzuli airport. However, for the standardized implementation of drones in the active innovation of these regions, specifically in long-distance and beyond line-of-sight trips, it is required to enforce systemized surveillance and guidelines for the insurance of safe and stable development.

In addition, drone-based innovations in fields such as Building Information Modeling (BIM), machine learning, as well as augmented and virtual reality for the development of infrastructure have been predicted [4].

Outside of such innovations, uses and externalities in agriculture are present with the aforementioned utilization of drone-based solutions.

Drone technology offers a large variety of crop monitoring possibilities at a lower cost, with the possibility of implementation at every stage, ranging from preemptive assessments of the soil and seed planting to the analysis of the optimal points of harvesting, thus allowing for continuous implementation of drone-based solutions in agriculture. Due to the importance of agriculture in many regions of Azerbaijan, such solutions could be integrated with the infrastructural applications of UAVs, as well as with the innovative use of automatic drone-friendly platforms across the regions, allowing for synergistic development in the region.

Table 1. Relevance of drone solutions to development of infrastructure in Azerbaijan

Category of application	Specific use in investment monitoring	Effects and consequences of successful application	Relevance to innovative development of infrastructure in Azerbaijan
Tender	Identifying terrain conditions and assessing the risks of investment. Pre-verifying the conditions of the site.	UAVs can provide scans of construction sites up to 20 times faster by drones than ground-based land surveying teams. Monitoring of construction sites by UAV helps check whether site borders have been crossed and confirm that materials are being stored and handled correctly.	Security of investments in this phase allows for long-distance verification of site conditions in rural areas, as well as areas which are difficult to reach, which includes those in the newly liberated regions of Azerbaijan.
Design	Gathering data of a high quality. Processing the data into accurate photogrammetry materials, such as Digital Surface Models, Ortophotomaps, and 3D models.	Data collected by UAVs can also enable the creation of 3D-elevated Digital Terrain Models, which ensure better contract valuation. By providing better field data, measuring up to 1cm of discrepancy, UAVs can significantly improve design quality.	3D-elevated Digital Terrain Models can be used for further cartographic purposes even after construction. Considering the recency of liberation of certain regions in the Republic of Azerbaijan, such data is invaluable in the facilitation of further development.
Construction	Regular and continuous reporting, which covers the status of ongoing work. Describing and analyzing gathered data for potential risks and issues with safety.	On the construction site, contractors can use accurate data gathered by UAV to perform precise work such as positioning steel slabs in concrete or measuring the depth of pipelines, preventing costly and dangerous construction errors. UAVs further increase safety by performing hazardous work. PwC has calculated that the number of life-threatening accidents on an average construction site monitored by drones has been decreased by 91%.	For the development of less developed regions in Azerbaijan, both the construction of roads and towns is necessary to establish a foundation for future innovation and development. UAV solutions can be used to minimize costs and maximize security in the extensive and intensive construction required for the restoration of the Karabakh region.
Post-Construction	Generating a post-construction report, which contains a synopsis of the inspections performed and reports outlined and describes issues. Assembling data which provides verifiable documentation, which can further be utilized in events such as legal proceedings.	UAVs can be used to precisely assess the effect of work performed in relation to the initial design, and to detect any potential deviations. Additionally, drone solutions can be used to assess a project's impact on both the environment and other parties. The data collected can be further used for maintenance and marketing purposes.	It is crucial to facilitate stable and environmentally friendly development in all regions of Azerbaijan, as per Target 9.4 of the United Nations' Sustainable Development Goals: «increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes». Impacts on third parties and maximization of externalities are additionally important, as several other sectors are to be considered for the development of Azerbaijan, including the agricultural and financial sectors.

4. Utilization of Drone-powered Solutions for the Innovative Development of Agriculture in Azerbaijan

One of the most important issues in the field of agriculture worldwide is the need to increase agricultural production to meet the demands of an increasing population. As stated by the United Nations Food and Agriculture Organization in 2015, the production of food must be increased by 60% from that point by 2050 [6]. As a result, innovations in the methods of encouraging agricultural production were developed across the world, with the UAV industry quickly developing in this sector. It is likewise pertinent for Azerbaijan to increase agriculture production in the coming years to populate more rural areas.

In the previous section focused on infrastructure, the advantages of UAVs over ground-based land surveying were shown. In the field of agriculture, satellite imagery is often used instead. However, UAVs also offer advantages over satellite imagery in multiple key areas. Operating at a lower altitude than satellites, they can capture more detailed and accurate data, while also operating autonomously and with ease even in areas ground-based surveying cannot reach. PwC likewise outlines several areas in agriculture in which UAVs can be utilized [4]. Drone-powered solutions have several key advantages in each step of the agricultural process:

- Preliminary Analysis (soil and field analyses, gathering data crucial for crop health);
- Supervision (assessment of crops, monitoring risk);
- Health Assessment (constant field monitoring, multi-spectral images, documenting losses, crop spraying).

The relevance of drone-based solutions in the development of agriculture in Azerbaijan is outlined below in Table 2.

Solutions involving the application of innovative drone-based solutions in agriculture are additionally proposed. NDVI, or Normalized Difference Vegetation Index, is a form of measurement categorizing differences between near-infrared light (NIR), which is strongly reflected by vegetation, and red light, which is absorbed by vegetation. Healthier crops reflect more NIR light and absorb more red light than unhealthy crops [8]. As such, we propose utilizing UAVs equipped with NDVI sensors to the rural areas of Azerbaijan in agricultural means. Such UAVs would be distributed to governmental bodies for use in management, coordination, and surveillance. With the implementation of proper UAV guidelines, agricultural workers will additionally be able to access such technology. This allows for several important innovations in agriculture. NDVI allows to identify diseased or stressed crops before the human eye can do this. It also allows for the identification of invasive plants and fungi that may be damaging the crop, and identification of areas that are more in need of attention. In addition, the use of such solutions allows for strict monitoring of crops, discouraging misreported planting of crops. As varying plants may be liable to different subsidies, the misreporting of planted crops can result in farmers benefiting from higher monetary support than they may be entitled to. Governmental surveillance using UVAs allows for clear management by organizational bodies, as UAVs equipped with NDVI sensors can detect all crops and their varieties in a given area.

This methodology allows for specific data-driven approaches to agriculture, wherein farmers will be able to assess specifically which areas of crops need attention. As there are areas in Azerbaijan where agriculture is planned to be developed, this offers an opportunity to establish drone-powered foundations that will allow agriculture to transition into a high-technology sector with aggregation of mass data. UAVs also allow for much higher precision than satellite imagery, and can be utilized more frequently, which allows for the collection of more precise data, and thus, more specific analysis [4].

The application of drones in the agricultural industry additionally supports drone-powered solutions in infrastructure, since the establishment of a common structure for using drones in all areas of Azerbaijan will be beneficial for all drone-related ventures. As UAVs can be be used for multiple purposes, the investment into UAVs can be used across many sectors. However, for the full integration of UAVs in these fields and their transitioning into high-technology data-driven fields, clear guidelines on the regulation of UAVs are to be required in preventing misuse and maintaining order.

Table 2. Relevance of Drone Solutions to Development of Agriculture in Azerbaijan

Category	Specific use in crop monitoring	Effects and consequences of successful application	Relevance to innovative development of agriculture in Azerbaijan
Preliminary Analysis	Producing 3D maps for soil analysis. Spreading nutrients into soil. Assessing which parts of field require water or other improvements.	UAVs are shown to be highly efficient in this area, with certain ventures succeeding in achieving decreased planting costs by 85% specifically through use of ex-military drones [7]. Drones, which may be equipped with hyperspectral and thermal sensors, can provide specific and precise data for which parts of the field require improvements, leading to more accurate preliminary analysis.	UAVs can produce precise imagery that can be used to plan seed planting patterns in a more accurate way as compared to satellites, while also covering areas that are difficult to reach in the rural areas of Azerbaijan, unlike ground-based land surveying.
Supervision	Monitoring the development of crops. Gathering precise data revealing inefficiencies in management.	Satellite imagery, which is often ordered in advance, suffers from only showing infrequent intervals of development with little guarantee of quality in the face of weather conditions. UAVs can offer crop monitoring with lower cost relative to existing alternatives.	Unpredictable weather conditions across multiple areas of Azerbaijan would become less problematic with the implementation of drone-based solutions. With the precision of data collected by UAVs, animations showing development of crops could be produced in the future, which would lead to higher efficiency by revealing issues in crop management.
Health Assessment	Producing multi-spectral imaging which displays changes in plants and indicates health. Spotting bacterial and fungal infections. Documenting losses for insurance claims. Spraying crops using accurate distance and pathway coordination.	Through UAVs equipped with NDVI (Normalized Difference Vegetation Index) scanning systems, crop health can be accurately assessed. UAVs may also generate multi-spectral images through VIS (Visible Light) and NIR (Near Infra-red) scanning systems, which allows for high-precision images showing changes in crops. Efficiency of aerial spraying can also be increased with reduced waste of chemicals through usage of UAVs.	Efficient decisions can be taken with quick identification of illness in planned agricultural areas in Azerbaijan. Through usage of systems such as NDVI, crop identification can be carried out regardless of conditions or angles of photography, which also aids in spotting discrepancies in misreported planting of certain crops. Such misdemeanors would go unseen with less precise data-gathering systems.

5. Implementation of UAV Guidelines to Support Development in Infrastructure and Agriculture

We propose a group of guidelines consisting of multiple key aspects, which include, but are not limited to:

- Installation of an "electronic tracking module", relaying geographical coordinates and the unique identifier of the UAV.
- The creation of a "UAV registration portal", with the State Civil Aviation Agency as its operator, requiring all drones to be signed up via e-services.
- Pilot certification of Category B drones, which are all drones heavier than 2.5kg. Drones under 2.5kg are Category A drones, which will not require certification.

As such, the creation of specific certifications about the different categories of UAVs are required. The guidelines we proposed above are constructed in accordance with the global standard of UAV guidelines, paving the way for secure and efficient implementations of drone-based solutions. With recent innovations in the applications of drones, leading nations in the utilization of drones have begun to introduce similar guidelines:

- In the United Kingdom, certification is required for individuals flying drones above 250g, consisting of a theoretical test [9].
- In April of 2021, the United States Federal Aviation Administration (FAA) implemented a "remote ID" system for identification of UAVs. The installed module can broadcast the unique drone identifier, the drone location and altitude, drone velocity, control station location and elevation, time mark, and the emergency status [10].
- In the United States, both commercial and recreational UAVs must be electronically registered on the "FAADroneZone portal" [11].
- Likewise, in Israel, registration for both commercial and recreational uses is required for drones weighing above 300g [12].

For the creation of the proposed UAV guidelines, the National Aviation Academy is proposed as an intermediary body for the implementation of the 'electronic tracking modules', and crucially, for the certification and training of Category B UAV pilots. Due to the focus of the National Aviation Academy on UAV technology, it can be considered the most capable agent for the enforcement of the proposed guidelines. The planned process of implementation is outlined in Fig. 2.

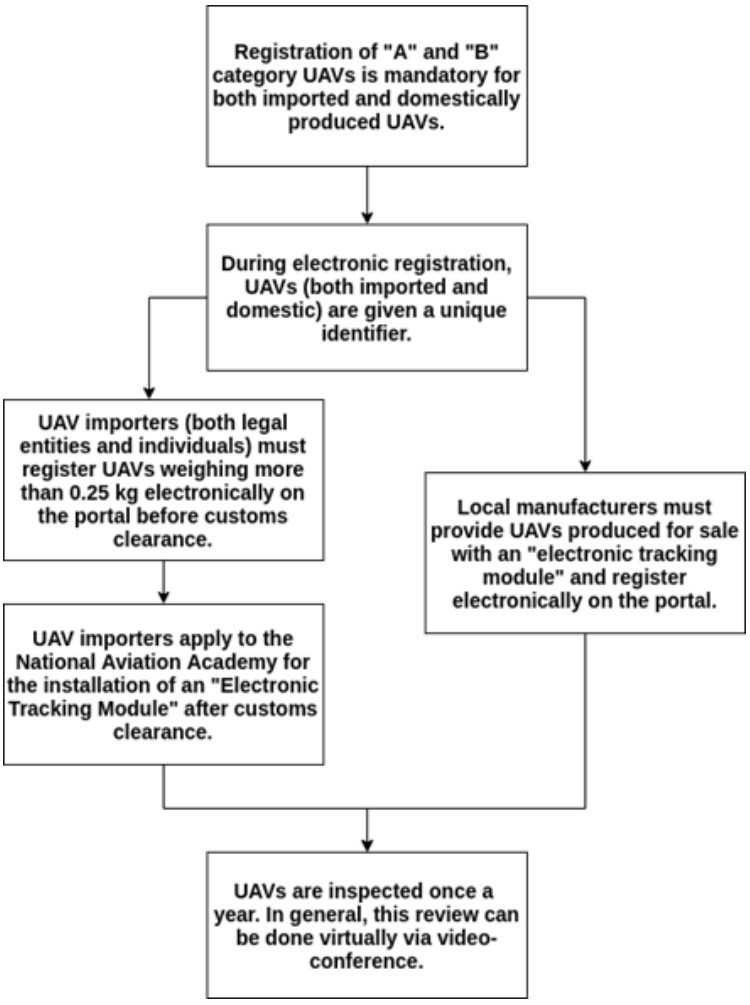

Fig 2. The Flow diagram of planned drone guidelines

6. Conclusion

This paper addressed the problems in the innovation of infrastructure and agriculture through the application of drone-powered solutions. In infrastructure, existing means for data-gathering and monitoring of the full construction process are not precise enough to allow for high-technological data analysis to take place in the industry. Likewise, in a field as crucial to the development of Azerbaijan as agriculture, reliance on intuition and imprecise data for directing agriculture planning hinders from capitalizing on the full potential of the land used. From this, it is clear that the utilization of drones in the innovative development of infrastructure and agriculture in the Republic of Azerbaijan results in an accelerated rate of development, allowing for

both the utilization of environmentally friendly energy, as well as the efficient implementation of drones as the central point of the territories, allowing for integration of further innovations from the rapidly growing UAV industry. In the development of these sectors in Azerbaijan, the application of drone-powered solutions allows for the transition to data-driven forms of analysis, focused on efficiency, certainty, and optimization.

Nevertheless, the full utilization of drone-powered solutions for the innovative development of these regions cannot be achieved without the creation of proper guidelines for the safety and regulation of UAVs. As evidenced by major powers worldwide, harnessing drone-based solutions for rapid development can only be achieved with proper regulation, including identification of drones, certification, and regular surveillance. As shown by PwC's comprehensive report on drone-based solutions, the main issues facing usage of drones worldwide are aviation risk and privacy. These factors should be considered in the utilization of UAVs – however, the two aforementioned obstacles are able to be resolved with the introduction of proper systemized guidelines for UAV use.

Air control systems and management using 'electronic tracking modules' allows for the minimization of air risk, while proper surveillance and guidelines of proper drone conduct eliminate the possibility of using UAVs to breach the privacy of any individuals or bodies. With the creation of the guidelines and their subsequent enforcement by the National Aviation Academy, any issues of risk or security are solved before they can arise to begin with, allowing for the stable and continued progression of development in the infrastructural and agricultural sectors, as well as providing positive externalities for the development of transport and further innovations.

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