WEATHER HAZARD CHALLENGES FOR FLYING AGRICULTURAL DRONES IN IRAQ

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ABSTRACT

Deploying drones in agriculture improves resource management and crop monitoring by providing real-time data on insect infestations, plant growth, soil conditions, and irrigation requirements. This study highlights the weather hazards for launching and flying agricultural drones in Iraq. The ten most popular drones for agriculture were chosen, and the weather limitations were determined. Hourly climate data (wind speed, temperature, precipitation, and visibility) in file format NetCDF were used for the period 2004–2023. The Python programming language was used to perform analyses on climate data and calculate the percentage of flight ban frequency due to weather hazards during the study period. Using ArcGIS v.10.8, maps were created of the percentage frequencies of weather hazards for each climate element, as well as for the total elements in Iraq annually and seasonally. The results showed that the worst area for launching and flying agricultural drones in Iraq is the northern region, especially in the winter, spring, and autumn seasons, as the highest percentage of preventing drone flying during the year reached 54.8%, and the percentage was 64.2% in winter, 46.7% in spring, and 51.2% in the autumn. The worst area for launching and flying Don during the summer was in the southern region and reached 40.3%.

Keyword: weather risks; agricultural problems; python; ArcGIS; flyability.

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تحديات مخاطر الطقس التي تواجه الطائرات الزراعية بدون طيار في العراق

سيف علي الجحيشي ياسين كاظم التميمي باسم إبراهيم وهاب التميمي
الباحث استاذ أستاذ
قسم علوم الجو – كلية العلوم – الجامعة المستنصرية

المستخلص

يؤدي نشر الطائرات بدون طيار في الزراعة إلى تحسين إدارة الموارد ومراقبة المحاصيل من خلال توفير بيانات في الوقت الفعلي عن تفشي الحشرات، ونمو النباتات، وظروف التربة، ومتطلبات الري. تسلط هذه الدراسة الضوء على المخاطر المناخية لإطلاق وتحليق الطائرات الزراعية بدون طيار في العراق. تم اختيار الطائرات بدون طيار العشرة الأكثر استخدامًا في الزراعة، وتم تحديد قيود الطقس. تم استخدام بيانات المناخ كل ساعة (سرعة الرياح ودرجة الحرارة وهطول الأمطار والرؤية) بتنسيق NetCDF للفترة 2004–2023. تم استخدام لغة البرمجة Python لإجراء معادلات على البيانات المناخية وحساب نسبة تكرار حظر الطيران بسبب المخاطر الجوية خلال فترة الدراسة. وباستخدام نظام ArcGIS 10.8 تم إنشاء خرائط لنسب تكرارات المخاطر الجوية لكل عنصر مناخي، وكذلك لمجموع العناصر في العراق سنويا وموسما. وأظهرت النتائج أن أسوأ منطقة لإطلاق وتحليق الطائرات بدون طيار الزراعية في العراق هي المنطقة الشمالية، وخاصة في فصول الشتاء والربيع والخريف، حيث بلغت أعلى نسبة منع تحليق الطائرات بدون طيار خلال العام 54.8%، وكانت النسبة 64.2% في الشتاء، 46.7% في الربيع، و51.2% في الخريف. أسوأ منطقة للانطلاق والطيران بالدون خلال فصل الصيف كانت في المنطقة الجنوبية وبلغت 40.3%.

الكلمات المفتاحية: مخاطر الطقس، المشاكل الزراعية، لغة بايثون، نظم المعلومات الجغرافية، القدرة على الطيران.

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INTRODUCTION

Drones, In the agricultural sector, have emerged as a useful tool with a wide range of uses that improve farming methods. These uses include mapping the characteristics of the soil, evaluating the health of the crops, applying targeted treatments, keeping an eye on the livestock, and issuing early warnings of agricultural problems (27). It has been used to estimate production, monitor crops, detect diseases, and apply precise pest control, all of which have improved agricultural productivity and resource allocation (15, 26). Drones are also essential for monitoring and evaluating plant challenges like water, diseases, poor nutrition, and pests, which helps with agricultural management (9). Additionally, farmers may monitor their fields from above thanks to drones fitted with cutting-edge technology like artificial intelligence, which makes it possible to conduct accurate assessments and intelligent farming practices (33). Drone adoption in agriculture is impacted by a number of aspects, including farmers' knowledge of drone applications, their comfort level when operating drones, and their educational background in agriculture (8,23). Furthermore, new agricultural organizations welcome drones because of their flexibility and efficiency in applying pesticides; drones can cover large regions for disease and pest prevention (28). In the literature, Dutta et al. studied precision farming tasks using agriculture drones, including weed density targeting, crop biomass monitoring, growth assessment, and food quality assessment (14). Singh highlighted the use of drones in sustainable agricultural methods by utilizing machine learning and image processing techniques to improve crop health monitoring and optimize pesticide application (32). Gao et al. discuss how farmland photos can be analyzed in-depth using drones and Internet-of-things technologies to monitor agricultural pests and illnesses (17). Hunt et al.'s research on precision agriculture using drones found that remote sensing technologies improve nitrogen levels in potato crops, leading to increased yields, lower costs, and positive environmental impacts (21). Deng et al. used a Sequoia multispectral camera on a UAV and a Mini-MCA6 camera for maize imagery and SPAD values. The Sequoia produced more accurate reNDVI, which was more effective for SPAD prediction (12). Stamatopoulos et al. explore UAV use in Australian forestry, focusing on remote region replanting, seed dispersal, and regeneration monitoring, discussing advantages, challenges, and potential applications (34). Quebrajo et al. studied sugar beet plant water status in soil-variable plots using infrared imaging. No correlation was found, but lower root mass and sugar content increased crop water stress (29). Barbedo et al.'s research on drones for livestock surveillance found that advanced imaging technology can monitor movement patterns, herd health, and detect illness, reducing labor costs and improving animal welfare (10). Tsouros et al. found that drone use in agriculture saves money, reduces labor, and supports sustainable methods by reducing chemical use and environmental contamination (37). Ayamga et al. conducted a study on drone laws in Sub-Saharan Africa, identifying challenges in agriculture and emphasizing the need for informed authorities, sustainability, and participatory regulation (7). Tsouros et al. discuss data collection techniques, processing methods, results, and potential applications of UAV-based precision agriculture, highlighting their advantages and disadvantages (36). Khayoon and Al-Taai's study revealed that fog significantly impacts Baghdad International Airport, while dust storms, thrusters, and snow significantly affect Najaf, Basra, Erbil, and Sulaymaniyah airports (22). This study analyzed the weather hazards associated with deploying and operating agricultural drones in Iraq. Ten most widely used agricultural drones were selected. For the years 2004–2023, hourly climate data (temperature, wind speed, precipitation, and visibility) were used. Using climate data, the Python programming language was utilized to compute percentages of flight ban frequency caused by weather hazards across the study period. The percentage frequencies of weather hazard for each climatic element, as well as for all elements in Iraq annually and seasonally, were mapped using ArcGIS 10.8.

MATERIALS AND METHODS

Study area: Iraq is located in the northern hemisphere of the earth, between 29° 05 and

37° 23 north and 38° 45 and 48° 45 south (1). It’s bordered to the north by Turkey, to the east by Iran, to the south by Kuwait and Saudi Arabia, and to the west by Saudi Arabia, Syria, and Jordan (30). Iraq is a country with a total area of 438,320 km^2. There are mountains all around to the north, northeast, and east, some of which rise to heights of 35.50 meters above sea level. Iraq's eastern region is a plateau, with a sedimentary plain separating it from the mountains . Figure (1) shows the study area. The climate of Iraq lies between the continental and subtropical zones. Typically, winters are cool to cold, with daily highs of up to 16 °C and lows of 2 °C at night. The summers are scorching and dry, with highs of over 43 °C in July and August and lows of 26 °C at night (3). Iraq's continental climate is characterized by hot, dry summers and cool, rainy winters, with a predominance of northwesterly winds. Most of the rainfall occurs due to the fluctuation of storm weather in the Mediterranean region during the winter as it moves towards the east and across northern Iraq (6,25). Rainfall in Iraq is considered seasonal, as most of the rain occurs in the winter from December through February in all area of the country except in the north and northeast, where the rainy season is from November to April. The annual precipitation ranges between 700 and 1,000 millimeters in the northeastern part of Iraq, occupied by the mountains of Iraqi Kurdistan (Zagros and Taurus), while in the rest of Iraq, which is occupied by plains or hills, the climate is arid. The annual rainfall in the lowlands range between (100 -180 mm) (2,4). The total average rainfall over all regions of Iraq is 192.03 mm/year (5). The dust storms that occur in springtime in Iraq are caused by two different types of wind: first, by North wind, which has long caused dust storms in this region, and second, by Al-Khamsian (19).

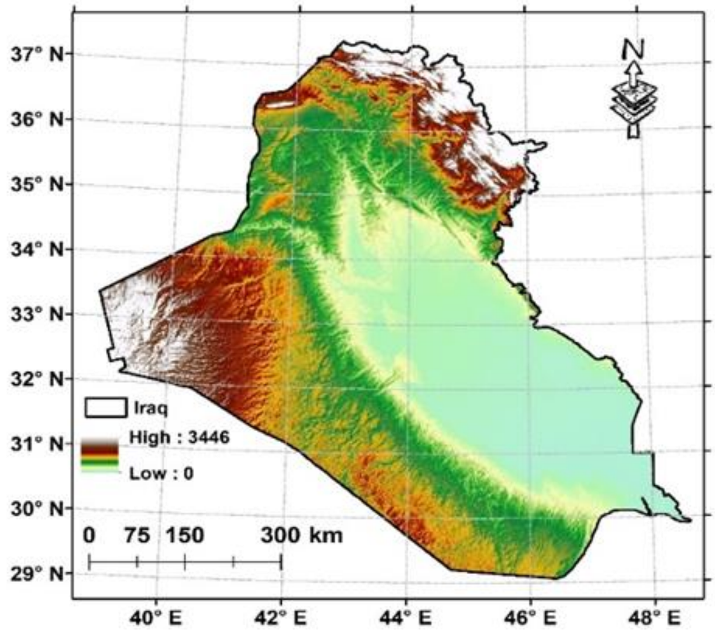

Figure 1. Study area

Data: The hourly climate data for the study period (2004-2023) temperature, precipitation, and wind speed, obtained in NetCDF format from ECMWF Reana Analysis v5 (ERA5) (31), the fifth generation ECMWF reanalysis of global climate and weather over eight decades. the past (24). Visibility data were obtained from ECMWF. The Copernicus Atmosphere Monitoring Service (CAMS), is an analysis of the atmosphere that focuses on the chemical species, aerosols, and greenhouse gases that make up the atmosphere (11). Compared with standard meteorological fields, CAMS is more suitable for investigating aerosol concentrations and chemical species (16). The cell size for the ERA5 data was 0.25 and for the CAMS data 0.4; All data were in NetCDF format with a pixel depth of 64 bits (20). Observations were taken every 24 hours each day throughout the study period.

Drones and weather conditions limitations: When launching the drone, weather conditions limitation must be taken into account; otherwise, the drone will be exposed to damage and loss in some cases. This limitation differs according to the type of aircraft and its characteristics (size, weight, design, Thrust power source and aerodynamics of the aircraft). In this study, ten types of drones were selected, which are used in the agricultural sector, differing in terms of design, weight, endurance, speed, and maximum flight height, as shown in Table (1). They also differ in the weather determinants of flight, as shown in Table (2).

Table 1. Technical Specifications for drones (13, 18, 35)

Drone	Type	Weight (kg)	Max speed (m/s)	Altitude (m)	Endurance (min)
DJI AGRAS T50	Quadcopter	39.9	10	2000	20.5
Autel EVO II 640T Series	Quadcopter	1.25	20	6000	36
Perimeter 8	Quadcopter	10	16	2700	180
DJI Agras MG-1s	Quadcopter	10	12	2000	22
Matrice 200 Series	Quadcopter	3.8	22.7	3000	27
Phantom 4 Pro Plus	Quadcopter	1.388	16	6000	30
DJI Matrice 100	Quadcopter	2.431	17	3000	17
CW 15	Fixed wing	17	16.9	6500	180
AgEagle RX-47	Fixed wing	2	16	3000	50
eBee X	Fixed wing	0.8	30.5	5500	90

Table 2. Drones weather limitations (13, 18, 35).

Drone	Wind (m/s)	T_Min (°C)	T_Max (°C)	Precipitation (mm)	Visibility (m)
DJI AGRAS T50	6	0	45	> 0	< 500
Autel EVO II 640T Series	18.5	-10	40	> 0	< 500
Perimeter 8	9.7	-10	45	> 0	< 500
DJI Agras MG-1s	8	0	40	> 0	< 500
Matrice 200 Series	10	-20	45	> 0	< 500
Phantom 4 Pro Plus	10	0	40	> 0	< 500
DJI Matrice 100	10	-10	40	> 0	< 500
CW 15	13.8	-20	50	> 0	< 500
AgEagle RX-47	13.4	0	38	> 0	< 500
eBee X	12.8	-15	40	> 0	< 500
Average	11.22	-8.5	42.3	> 0	< 500

Methodology: The average weather limitations for the ten drones selected in this study were wind speed 11.22m/s, T_Max 42.3°C, T_Min -8.5°C, precipitation >0mm and visibility <500m to calculate the percentage of their hourly frequencies in Iraq for the period from January 1, 2004 to December 31, 2023. The Python programming language was used to analyses the climate data. Figure (2) showed the research methodology flow chart. The NetCDF files were converted into zero matrices for the climate component after comparing hourly climate data for the study area with weather limitations for flying agricultural drones. Then the number of times that drones were prohibited from flying due to weather hazards was collected every hour, and for each pixel during the study period, the percentage frequency of preventing flights on agricultural drones in the study area was calculated. These procedures were repeated for each climate component separately. Finally, it produces a NetCDF file that contains a single-layer matrix that contains the percentage of flight ban frequency due to weather hazards for each pixel during the study period. Using ArcGIS 10.8, NetCDF, resulting from data processing using Python, was converted to a raster using the Make Raster from NetCDF tool within the Multidimension toolbox. Using the Cell Statistics tool within the Raster Analysis toolbox, the frequencies to prevent flight due to weather hazards were summed for each pixel in the rasters for the five elements resulting from the first step. Using the Contour tool, contour lines were created. The maps were reclassified for the hazards of each element over the area of the study area according to a unified and pre-defined Legend. Finally, the final layout of the maps was prepared, and map elements were added. The above procedures were implemented for all months during the study period 2004 - 2023 to produce maps of the percentage of flight prevention due to the hazards of weather elements, as well as the total weather hazards for all elements. The above procedures were repeated to produce no_fly maps due to weather hazards for each season. The data was divided into four seasons, each season having three months. For the winter season, data for December, January, and February were used. For the spring season, data for the months of March, April, and May were used. For the summer season, data for June, July, and August was used. For the autumn season, data for September, October, and November was used. This is to analyze the impact of weather hazards on agricultural drone flying in each season.

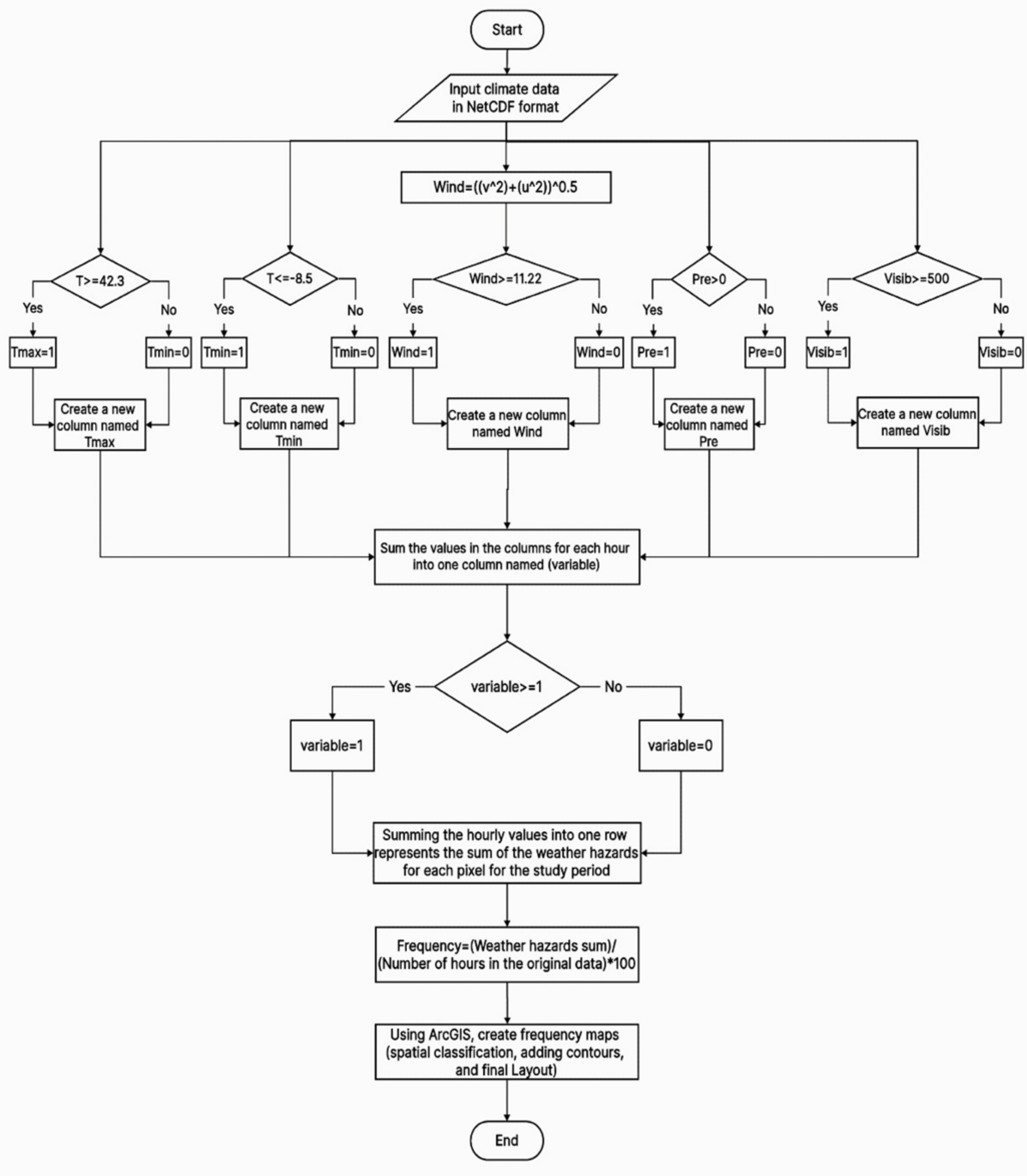

Figure 2. The research methodology

RESULTS AND DISCUSSION

Figure (3) shows the percentage of flight ban frequencies due to the hazards of each climate element on agricultural drones for the period 2004–2023 and for all months. It is noted that the climatic element that poses the greatest danger to drone flight is precipitation, due to its high frequency during the year, followed by the maximum temperature. The percentage of precipitation hazards in aviation ranges from 10.6% - 51.3%. The value is greatest in the mountainous region of northern Iraq and gradually decreases as we head south. It is noted that the class 10.6%–20% affects the entire central region. The southern region of Iraq is the least affected and has the lowest hazards due to precipitation during the year compared to the northern region. T_max comes in second place in terms of the highest frequency of weather hazards after precipitation, ranging from 0% to 10.6% during the year, and its frequency is highest in the alluvial plain area in the south and gradually decreases as we head north. The third place in terms of frequencies is T_Min, ranging from 0% to 2.8% during the year. Its frequency is highest in the northern region and gradually decreases as we head south. The effect of visibility was very small compared to the effect of the above elements. The frequency of visibility hazards ranged from 0.02% to 1.16%. Finally, the effect of wind is very small and almost non-existent. The frequency of wind hazards ranges from 0% to 0.42%, which is the least influential compared to the rest of the weather elements.

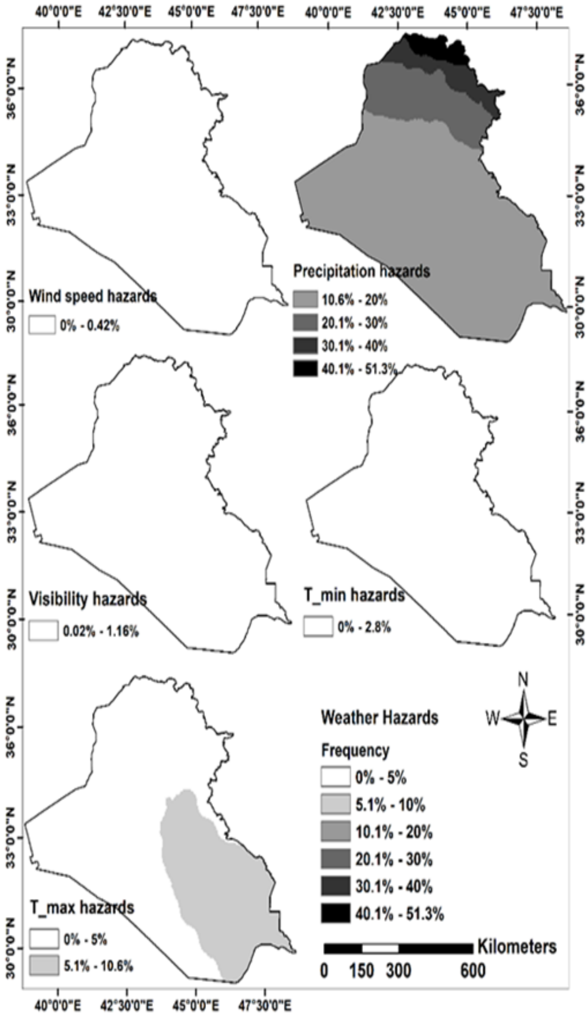

Figure 3. Percentage frequency of weather hazards for agricultural drone flight

Figure (4) shows the percentage of agricultural drone flight prevention due to weather hazards for the total weather components. It was observed that large frequencies occurred in the mountainous region in the north, with frequencies ranging from 43.6% to 54.8% due to heavy rains in this region, as well as the presence of frequencies for hazards due to visibility and T_ Min in this region, followed by the frequency of frequencies in the northern region. And the eastern part of Iraq, due to the sum of the frequencies of weather hazards due to rain with T_Max and wind speed in this region, the frequencies of weather hazards in it range from 22.6% to 43.5%. Finally, the region with the lowest frequency of weather hazards in Iraq is the western and southern region, where the frequency of frequencies ranged between 12.2% to 22.5% during the year because it is the least frequent of weather hazards due to the totality of the weather elements.

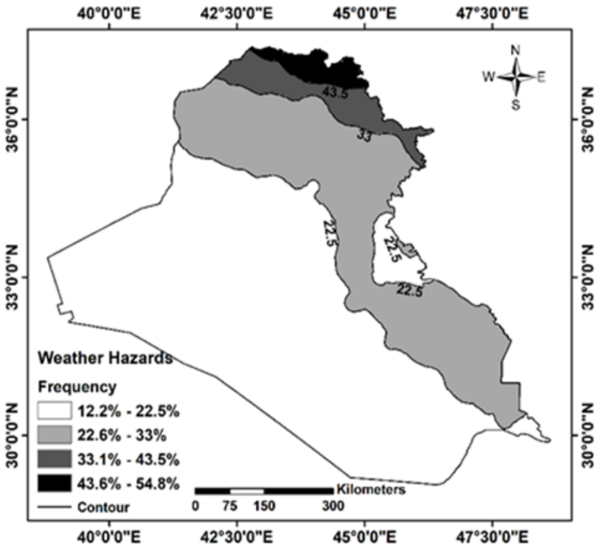

Figure 4. Percentage Frequency of weather hazards for all components during the period (2004-2023).

Figure (5) shows the percentage of frequency of weather hazards over Iraq in the winter season for the period (2004-2023). It is noted that the highest percentage of weather hazards in the winter months was in the mountainous region in the far north of Iraq and amounted to 53.1% to 64.2% due to the increase in the concentration of precipitation in This region, followed by the northern region, with frequencies of 23.1% to 53%. The region least affected by weather hazards to agricultural drones is the central and southern region of Iraq, where frequencies ranged from 8.2% to 23%.

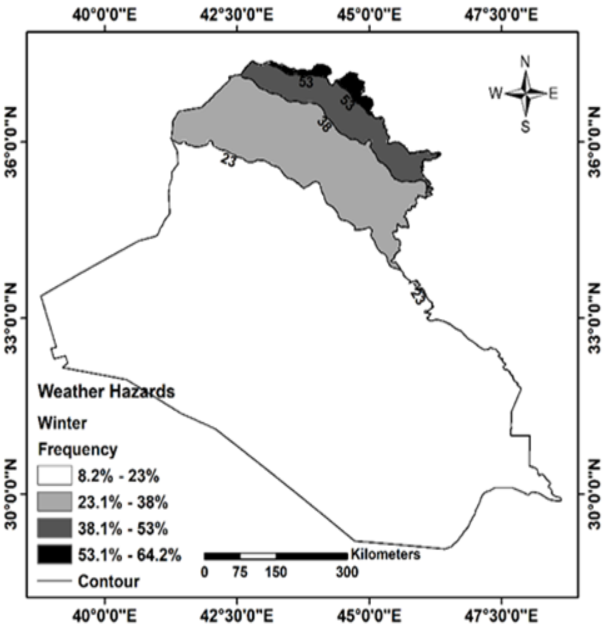

Figure 5. Percentage frequency of weather hazards for agricultural drone in Iraq for winter

Figure (6) shows the percentage of frequency of weather hazards over Iraq in the spring season for the period (2004-2023). It is noted that the highest percentage of weather hazards in the spring months was in the mountainous region in the far north of Iraq and amounted to 38.6% to 46.7% due to the increase in the concentration of precipitation in this region. These are lower than the frequencies in the winter season, followed by the northern region with frequencies of 16.6% to 38.5%. The region least affected by weather hazards to agricultural drones is the central and southern region of Iraq, where frequencies reached 5.5% to 16.5%.

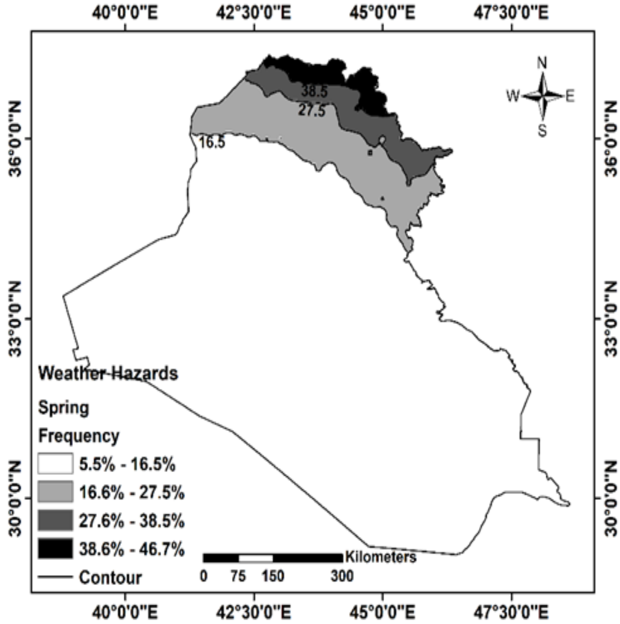

Figure 6. Percentage frequency of weather hazards for agricultural drone in Iraq for spring

Figure (7) shows the frequency of weather hazards on Iraq in the summer season for the period (2004-2023). It is noted that the significant impact of T_Max, especially in the southern region of Iraq due to the country's influence on the warm weather accompanying the low monsoon, reached 33.1% to 40.3%, followed by the central region. And the eastern part of Iraq, with frequencies of 11.1% to 22%. Frequencies for weather hazards decrease as we head north, reaching 40.3% in the western and northern region of Iraq.

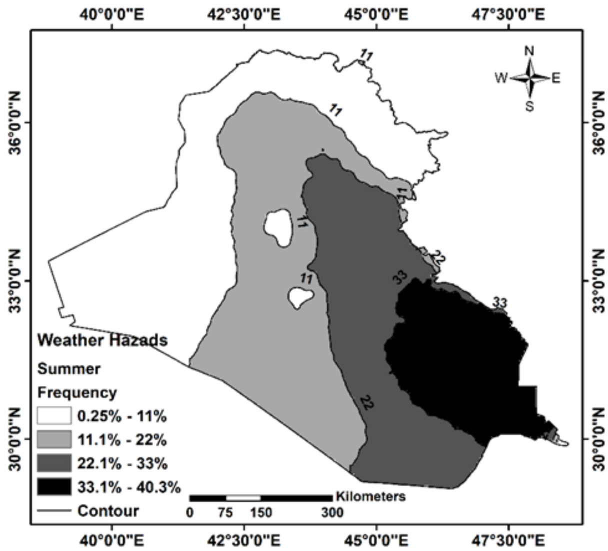

Figure 7. Percentage frequency of weather hazards for agricultural drone in Iraq for summer

Figure (8) shows the frequency of weather hazards over Iraq in the autumn season for the period (2004-2023). It is noted that the highest percentage of weather hazards in the autumn months was in the mountainous region in the far north of Iraq and amounted to 48.1% to 51.2% due to the increased concentration of precipitation in this region, followed by the northern region with frequencies ranging from 24.1% to 36%. The region least affected by aerial hazards to agricultural drones is the central and southern region and part of the northern region of Iraq, where frequencies ranged from 12% to 24%. It is noted that there has been an increase in the frequencies of weather hazards in the southeastern region, ranging from 24.1% to 36%. This is due to this region being affected by low monsoon extensions, which increases the effect of T_Max.

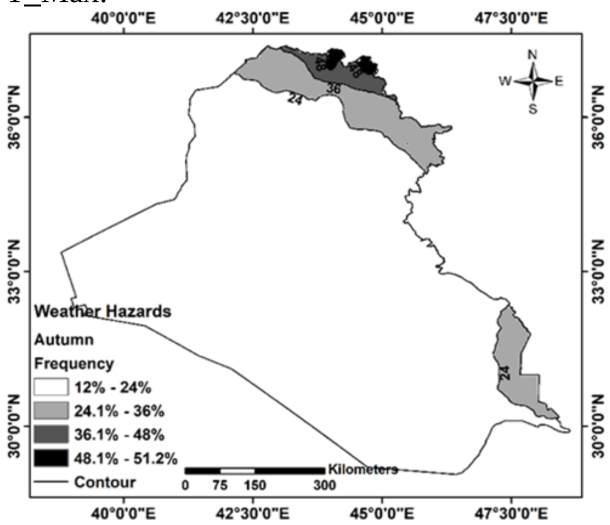

Figure 8. Percentage frequency of weather hazards for agricultural drone in Iraq for autumn

CONCLUSIONS

Agricultural drones in Iraq are affected by weather hazards, which limit their use to perform their tasks. In general, the most influential element is precipitation, especially in the northern region in winter, followed by T_Max, which has the greatest impact in the central and southern regions in summer, and the effect of T_Min in the north is less, as is the effect of visibility. Wind speed is the least influential among the weather elements. The worst area for launching agricultural drones in winter is in the mountainous region in the far north of Iraq, with a rate of up to 64.2% throughout the year, followed by the northern region, with a rate ranging from 23.1% to 53%. In the summer, the southern region is the worst area for launching agricultural drones in Iraq, with a rate of up to 40.3%, followed by the central and eastern region, with a rate ranging from 11.1% to 22%. The worst area in spring and autumn is the far north of Iraq, where the rate of weather hazards reaches 46.7% in spring and 51.2% in autumn, followed by the northern region with a rate ranging from 16.6% to 38.5% in spring and 24.1% to 48% in the autumn. Therefore, it is necessary to choose agricultural drones suitable for the climate of Iraq, and to take into account the weather conditions of the region and the season in which they are intended to be used in the planning stage before purchasing.

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