Application of UAV and ArcGIS in Soil and Water Conservation Monitoring of slag area—Taking a slag area of hydroelectric power station in Dadu River as an example

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Abstract. In the process of slag area in hydropower projects, the ground will be disturbed strongly, and a large amount of spoil slag will be generated, resulting in serious soil erosion. Therefore, the monitoring of soil and water conservation in the slag area of hydropower projects is particularly important. Traditional ground monitoring cannot fully meet the needs of current monitoring work. UAV technology is more efficient than traditional technology. Through periodic aerial photography and post-modeling, combining with ArcGIS, provides enhanced data analysis support for UAV data analysis. Taking the 1# slag yard of a hydropower station in Dadu River as an example, this paper discusses the applicability of UAV and ArcGIS technology in soil and water conservation monitoring of large hydropower project slag area. The effective way of maintaining information, while improving the monitoring efficiency of soil and water conservation, can ensure that the monitoring data and the Soil erosion error control are within 10%, making up for the traditional technical ways that is insufficient in the monitoring of soil and water conservation in the large-scale hydropower project slag yard.

In recent years, the state has paid more and more attention to the construction of ecological civilization. As an important part of ecological civilization construction, soil and water conservation work has become more and more important. As an important part of soil and water conservation work, soil and water conservation monitoring is the basis for ecological restoration and comprehensive management of soil and water conservation, and is a powerful guarantee for national ecological construction decision-making [1]. In recent years, the application of remote sensing technology for UAVs is for production and construction. The project of soil and water conservation monitoring work provides a new technical way [2-4]. UAV operation has high automation and precision, and it is targeted. Some models have reached the application-level standards, and with the rapid progress of software and hardware technology, it is greatly improving the post-processing applicability of aerial image data, making drones widely used in aerial photography, agriculture, plant protection and monitoring. Torres-Sánchez et al [5], Francisco et al [6] use low-altitude high-resolution drone remote sensing imagery to carry out on precision agriculture and agricultural pest control. Mitch Bryson et al. [7] used low-altitude visible drone images to study vegetation type classification based on vegetation color and texture characteristics. Sebastian d'Oleire—Oltmanns et al. [8] used high-altitude drone aerial imagery to complete the monitoring of soil erosion in Morocco, providing a reference for soil and water
conservation. UAV and post-space data processing technology have gradually entered a mature stage, and its application in the water and soil maintenance supervision industry of hydropower projects is still in its starting stage. Based on this, this study is aimed at solving the problems in the monitoring of soil and water conservation. Taking the monitoring of soil and water conservation of 1# slag yard of a hydropower station in Dadu River as an example, the application of UAV and ArcGIS technology in soil and water conservation monitoring is discussed.

1. Introduction
The hydropower project dam site is located in Maerkang city and Jinchuan city of state, Sichuan Province. The project yard is located in the mountain and alpine valleys of the southern foot of the Qinghai-Tibet Plateau. It belongs to the monsoon climate zone of the western Sichuan Plateau. The annual average precipitation is 768.8mm, and the average annual temperature is 8.6°C, the extreme maximum temperature is 34.8°C, and the extreme minimum temperature is -17.5°C. The area where the project is located belongs to the key prevention and protection zone for soil erosion in Sichuan Province. The regional soil erosion allowable value is 500 t/km².a, and the soil erosion type is dominated by hydraulic erosion, followed by gravity erosion and freeze-thaw erosion. The 1# slag yard of the hydropower station belongs to the Linhe type slag yard, which mainly accommodates the dam standard and the flood discharge standard slag. The slag yard capacity is 1.95 million m³, the slag height range is 2270~2320m, the land occupation is 18.6hm², and the final pile slag volume is 1.8 million m³. The soil and water conservation monitoring work of the slag yard has the following characteristics:

1.1. Large amount of slag
1# slag yard is an important source of soil erosion during the construction of the hydropower station. With the excavation of dams and flood discharge tunnels, the final slag volume will reach 1.8 million m³, according to the “Code for Design of Slag Fields for Hydropower Projects” (NB) /T 35111-2018), 1# slag yard is a secondary slag yard.

1.2. Difficult to manage
The design, construction or acceptance stage of soil and water conservation work is the attention of focus and difficulty: high proportion of soil erosion (accounting for 40% or more), high strength (expected strong and above), and the hazard caused by soil erosion is serious (the Linhe type slag yard), the water and soil conservation project has a high proportion of investment.

1.3. Long slag cycle
The construction period of the project is 8 to 9 years, and the corresponding slag stacking time is also longer. The slag process of this project is constantly changing, and the amount of slag is increased first and then decreased: during the construction period, the amount of slag increases with the excavation of foundation pit, flood discharge and other projects. With the end of the excavation project, the filling project begins. During the construction, part of the slag is used, and the amount of slag is gradually reduced; when the large-scale construction is nearing the end, the amount of slag tends to be stable.

2. Material and Methods
1# The slag yard is long and narrow, the area is smaller than that of the linear project. Therefore, the multi-rotor UAV is used for aerial photography. The aerial monitoring period is from March 2018 to March 2019, for a total of four quarters.

2.1. Drone parameters
This project monitors the selection of DJI phatom 4pro series UAV as the main model for soil and water conservation monitoring. It equipped with 1 inch, 20 megapixel sensor, 5742×3648 (resolution × resolution), lens equivalent focal length 24mm, single battery The endurance time is about 23 minutes.
The take-off mode is vertical take-off. The aerial photography uses DJI GS Pro software to automatically plan the route to achieve automatic flight point flight operation. The flight height of the drone is set to 70m, and the heading overlap rate is over 60%. The plan is shown in Figure 1, and the ground mark is set as the control point to improve the accuracy. The final aerial coverage space is about 1.4 km².

![Figure 1. Route planning.](image)

2.2. Data processing interpretation
The aerial film processing and 3D reconstruction work adopts Pix4D software, which automatically reconstructs the 3D model and the orthoimage based on the coincidence degree of dense point clouds in the aerial film, and the high quality 3D point cloud can give the accurate location of reconstruction object. Using the point cloud editor to manually select and delete point clouds, the software workflow is highly automated, significantly improving the efficiency of drone aerial processing.

After the UAV aerial film processing, the average ground resolution of the slag area image is up to 0.2m, and the geographic information data included in the orthoimage is edited and analyzed by ArcGIS10.3.

2.3. Monitoring factor
The monitoring indicators of soil and water conservation in the slag yard of hydropower project mainly include the basic characteristics of the slag yard, the composition of the slag yard, the soil and water conservation measures and the dynamic changes. The details of each index are shown in Table 1.

| NO | Monitoring indicators                        | detailed content                                                                 |
|----|---------------------------------------------|----------------------------------------------------------------------------------|
| 1  | Basic characteristics of the slag yard      | Location, boundary, length, width, stack height, grade of side slope, and horse path settings |
| 2  | Soil and water conservation measures        | Construction measures and quantity of engineering measures and plant measures such as blocking, drainage and slope protection |
| 3  | dynamic indicators changes of soil erosion  | Disturbed yard range, quarterly pile slag, etc., dynamic change monitoring of prevention and control responsibility scope, etc. |

Table 1. Monitoring indicators of soil and water conservation in the slag yard.
3. Results

3.1. Basic characteristics monitoring of slag yard

The Pix4D Mapper and smart 3d kits are used to construct the orthoimage and 3D model of the project yard. The aerial photographs have information such as shooting position and elevation. The DOM and DEM results established in the later stage also have information such as position and elevation. Based on DOM and DEM, taking 1# Basic soil and water conservation monitoring information (position, boundary, elevation) of the slag yard.

3.2. Soil and water conservation measures monitoring

The soil and water conservation measures of the 1# slag yard are small in size. For example, the width of the masonry retaining wall is less than 2m, and the resolution of commercial satellites is difficult to meet the needs of soil and water conservation measures. Through the drone, the three-dimensional modeling of the soil and water conservation facilities of the slag yard is carried out, the engineering type is interpreted in real time, and the data, area and volume data of various soil and water conservation engineering quantities are measured (based on DEM results, calculated by differential method). UAV aerial photography and post-three-dimensional modeling can not only reflect the current situation of soil erosion and the type, quantity and control effect of soil and water conservation measures. The powerful visual and immediate feedback characteristics of the data can strengthen the water and soil conservation control during the construction of the project and standardize soil and water conservation management work.

Figure 2. 3D model of 1# slag yard.

Figure 3. measures the amount of soil and water conservation.
3.3. Monitoring of dynamic indicators of soil erosion
Through the use of UAV low-altitude remote sensing and post-production software every quarter, the orthoimages of the slag yard are periodically produced, and the powerful spatial data analysis and processing capabilities of GIS are fully utilized, and dynamic indicators changes of various soil erosion conditions in the slag yard is fully grasped by comparing the front and back orthoimages. The orthoimages before and after the dumping of the 1# slag yard are shown in Figure 4 and Figure 5.
During the construction period, the dam foundation excavation, construction road construction, material area soil removal, slope cutting leveling, and slag dumping and other engineering activities will cause a large number of earth and stone excavation and backfilling. It is often difficult to do the side station record in soil and water conservation monitoring. Statistics on slag can only consult the owner or construction unit. Through the on-site aerial photography every quarter, the digital elevation model of the project area is established, and the amount of slag is calculated by using the project area and elevation changes (as shown in Figure 6).

**Figure 5.** Comparison of orthoimages before and after stacking slag.

**Figure 6.** Digital elevation model for the first to third quarters of the slag yard.

### 4. Discussion

In the one-year monitoring, the conventional technical means mainly use hand-held GPS, tape measure and other tools for field measurement, and the volume data is mainly measured by GPS and ranging altimeter. From the analysis of Table 2, it can be seen that compared with the traditional technical means, the scope of responsibility of drone control for slag yard, the length of masonry retaining wall, the area of dry masonry slope protection, the area of temporary sluice cover, the first quarter of dam standard 2019 The measurement errors of the amount of slag and the amount of slag in the first quarter of the flood discharge standard were -1.84%, 4.62%, 3.91%, 4.46%, -7.03% and -7.78%, respectively. The deviation of drones in the scope of prevention and control and soil and water conservation engineering
measures is less than 5% compared with the traditional monitoring methods, and the average error in the monitoring of slag accumulation is 7.41%, which is due to the assumption of disposal before slag disposal. The assumption the location of the area is flat, and in practice there is a certain elevation change at the bottom, resulting in a small drone monitoring data. However, the relevant results meet the requirements of self-inspection error of not more than 10% in remote sensing monitoring in the Technical Regulations for Soil and Water Conservation Monitoring. At the same time, in terms of measurement efficiency and cost, the monitoring efficiency of UAVs is greatly improved compared with the traditional monitoring methods and greatly reduced manual monitoring costs.

Table 2. Comparison of UAV technology and traditional methods.

| NO. | Monitoring object                        | UAV monitoring results | Traditional method monitoring results | Difference | error  |
|-----|------------------------------------------|------------------------|---------------------------------------|------------|--------|
| 1   | Slag yard control responsibility         | 88678.84               | 90341.32                              | -1662.48   | -1.84% |
| 2   | Stone masonry wall length                | 515.15                 | 492.37                                | 22.78      | 4.62%  |
| 3   | Dry masonry slope protection yard        | 18903.31               | 18191.00                              | 712.31     | 3.91%  |
| 4   | Temporary cover yard                     | 1399.96                | 1465.23                               | -65.27     | 4.46%  |
| 5   | Dam 2019 first quarter slag volume (m³)  | 19935.08               | 21442.00                              | -1506.92   | -7.03% |
| 6   | Flood discharge standard 2019 first quarter pile slag volume (m³) | 12655.37               | 13722.00                              | -1066.63   | -7.78% |

Note: The difference is the difference between the monitored value of the drone and the traditional method; the error is the difference divided by the traditional method monitoring value.

5. Conclusions
Taking the soil and water conservation monitoring of the 1# slag yard of a hydropower station in Dadu River as an example, it can be seen that the aerial photography of the UAV combined with ArcGIS technology can realize the high-efficiency and accurate realization of monitoring of the factors that include the large-scale hydropower project slag yard disturbing land yard, soil and water conservation measures, slag volume, etc. Relying on the design stage data of the slag yard and the three-dimensional model of the construction stage, it can be used as an important auxiliary means for the management of the slag yard construction stage.

At the same time, there are still some constraints in this technical means: (1) Aerial image is greatly affected by weather and time. If the air temperature and exposure of the aerial film are different every quarter, the data of orthoimage data will also be affected. (2) At present, the Dajiang Elf series drones are still standard for digital cameras in terms of camera sensor size and pixels, while drones equipped with high-pixel cameras are difficult to carry, and it takes half an hour to take off and land. It is difficult to adapt to the actual needs of water conservation monitoring work; (3) The post-processing accuracy needs to be improved, and the basic knowledge of aerial survey is highly required. Due to the large land occupation and complex terrain, the accuracy is greatly affected by factors such as altitude and terrain. If the control point is not placed on the ground, it will cause a certain offset of the DEM image in the
later stage. If no later correction is performed, it is difficult to accurately calculate the amount of excavation and filling in the project area by means of the overlay.

With the comprehensive roll-out of water and soil conservation self-acceptance, the importance of the supervision and management responsibility of the soil and water conservation monitoring agency during the project construction process and the authenticity of the monitoring data during the completion phase have become more prominent. At present, the UAV technology has gradually matured and can be used for project monitoring. Following the development of UAV aerial survey accuracy and post-software development, UAVs will bring more exploring the space in water and soil conservation monitoring work for construction projects.

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