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Comparative Study of Efficiency between Conventional and Photogrammetric Surveying Applied to Earthmoving Projects in Southern Mexico

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ABSTRACT
This study compares the technical and economic efficiency of two surveying methods applied to material banks in Yucatán, Mexico: the conventional total station and UAV photogrammetry. Measurements were conducted before and after material extraction to generate digital terrain models and volume estimates. A Data Envelopment Analysis (DEA–BCC) model evaluated technical efficiency, while a Multi-Criteria Decision Making (MCDM) approach integrated accuracy, cost, and time. Results indicate that both methods are technically efficient (φ=1), with photogrammetry achieving greater spatial detail and lower field costs but requiring longer processing times. Conventional surveying proved faster in the office stage and achieved slightly higher overall efficiency (0.95 vs. 0.87). These findings demonstrate that UAV photogrammetry is a viable method for large or hazardous terrains where field productivity is prioritized

***Keywords* -** Cost, DEA–BCC, Drones, Efficiency, Photogrammetry, Topographic Surveying

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I. INTRODUCTION

Topographic surveys are an essential tool in the development of any infrastructure project, as they are present from the planning stage and remain in place even after completion [1], providing useful data for feasibility assessments, design, construction, and even maintenance.

Currently, topographic work can be carried out conventionally using tools such as automatic levels and total stations, and using modern technologies that employ satellite technology, such as the Global Navigation Satellite System (GNSS), 3D scanners, drones, and other technological innovations [2].

A wide variety of construction projects require the use of stone materials, which are extracted from sites known as material banks or open-pit mines, where explosives and heavy machinery are used to obtain various materials that are essential to produce concrete, mortar, embankments, and other items.

To control the material extracted from material banks, it is necessary to measure the configuration of the terrain before and after extraction to determine the volumes of material produced. These measurements are made by means of topographic surveys and traditionally use tools considered to be conventional.

Currently, technologies such as GNSS, 3D scanners, and drones are being incorporated into construction projects, as they offer a significant reduction in the execution times of topographic work compared to traditional methods. Despite their advantages, their use has not yet become widespread within industry, as their implementation requires a new way of executing some processes and there are no specific studies on their reliability and efficiency [3].

Its implementation in open pit mine terrain measurements for calculating extraction volumes has great potential to streamline production control processes and bring economic benefits to companies in this sector. For this reason, it is important to evaluate this technology to ensure its efficiency, as otherwise it could have a negative impact on the performance of these projects and, consequently, on the companies that use it [4].

The objective of this study is to compare the efficiency of topographic surveys using drone photogrammetry and total station surveying, applied to the calculation of extraction volumes in a rock bank on the Yucatan Peninsula. To this end, three key variables are integrated: accuracy, time, and costs, evaluated using a technical efficiency analysis with the Data Envelopment Analysis (DEA) method and a weighted multi-criteria analysis. The results provide evidence that contributes to guiding decision-making on the technical and economic feasibility of adopting drones in open-pit mining projects and in other areas of construction and infrastructure.

II. METHODOLOGY

This study had a quantitative approach and descriptive scope, with a quasi-experimental and cross-sectional design. The population corresponds to all open-pit mining projects. There are 748 registered material banks on the Yucatan Peninsula [5], of which one was selected for a case study, called "Trituradora Quintal."

For field measurements using modern methods, photogrammetry was employed using a DJI Phantom 4 drone, which is commercially available and affordable for most companies in the construction sector. For conventional methods, a Sokkia 650X total station was used.

The area selected for the study was 1300 m2 and was measured before and after the extraction of stone material, using a standardized procedure and the same personnel to avoid variations due to differences in the tasks performed or the skills of the equipment operator.

To evaluate efficiency, the data envelopment analysis (DEA) method was used, which is based on linear programming models with the purpose of studying the relative efficiency of several decision units, known as DMUs (Decision Making Units). Two DMUs were used in this study, one for total station surveys and the other for photogrammetric surveys with drones. Three variables were taken into consideration in each DMU: accuracy, time, and costs. Fig. 1 shows the flowchart of the fieldwork for photogrammetry with drones.

In the case of the DJI Phantom 4 drone, the recommended flight altitude for surveys in small areas ranges from 50 to 80 m. For this study, to maximize the level of detail in the images acquired, the lowest altitude within the suggested range was selected. This equipment incorporates a 1/2.3" sensor, with active dimensions of 6.17 mm wide by 4.55 mm high, capable of generating images with a resolution of 4000 × 3000 pixels. The camera has a focal length of 3.61 mm, which, in combination with the established flight height, allowed for a Ground Sample Distance (GSD) of 21 cm/pixel to be calculated. This parameter represents the actual distance on the ground that corresponds to one pixel in the captured image, constituting a fundamental indicator of the spatial resolution achieved during the survey.

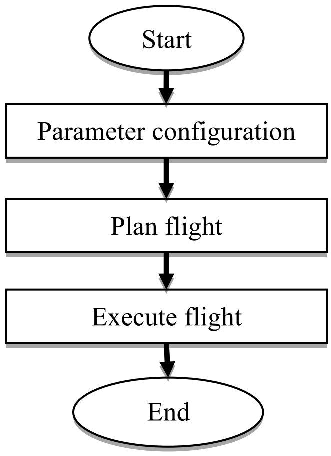

Figure 1. Fieldwork for photogrammetry

Pix4D software was used for flight planning, which sets optimal parameters of 80% longitudinal overlap and 60% transverse overlap between images. These conditions ensure that each interior point of the photogrammetric model is recorded in at least five different shots, which increases geometric redundancy and, consequently, the accuracy of the generated model. The mission was executed at a flight speed of 3.4 m/s, a value that helps maintain stability in image acquisition and avoid motion-related distortions [6].

In the case of fieldwork carried out with a total station, the procedure described in the flowchart presented in Fig. 2 was followed.

The process began with the selection of a strategic point that would allow for the greatest possible coverage of the study area. Subsequently, the equipment was installed, leveled, and oriented according to the manufacturer's established procedure. The points were measured using an imaginary grid with 5 m spacing between axes, which facilitated the systematization of the survey.

Additionally, complementary points were recorded in areas where the terrain presented significant variations in elevation, steps, or other irregularities, in order to improve the accuracy of the topographic model.

Similarly, office procedures were defined, ensuring uniformity in the treatment of data obtained both before and after the extraction of the stone material. This allowed for methodological consistency in the comparative analysis of the results.

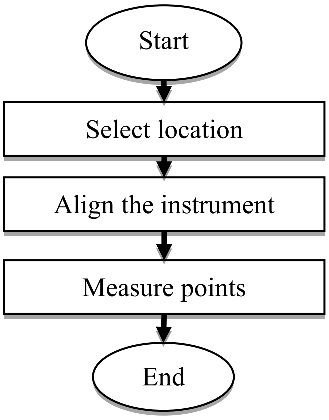

Figure 2. Fieldwork for total station

The information collected by the drone was processed using RealityCapture software, utilizing the selection and cropping tool. This function allowed us to identify and eliminate elements foreign to the terrain, such as machinery or other objects, to obtain a refined model. Once this process was complete, a point cloud was generated in XYZ format. In contrast, data collected with a total station does not require this step, as the equipment itself directly records the point cloud in that format.

Subsequently, the point clouds obtained with the drone, both before and after extraction, were analyzed in Autodesk Civil 3D software, which allowed the compact volume of extracted material to be calculated, i.e., the volume of the material in its natural state, without modifications due to extraction. The same procedure was applied to the point clouds generated by the total station to establish a fair comparison between the two techniques.

Throughout all stages, from data collection to volume generation, detailed records were kept of the execution time, and the associated costs were calculated, considering the equipment used, the operations performed, and the software licenses required.

The purpose of calculating volumes was to evaluate the accuracy of the results by comparing them with the bank's material output control records. It should be noted that this volume corresponds to the material in a loose state and therefore differs from the compact volume obtained from field measurements. This difference is explained by the swelling, understood as the relative increase in volume that a material experiences when it changes from its natural state to a loose state after excavation.

To estimate the equivalent volume in compact condition, an abundance coefficient is used, which is determined from specific geotechnical studies of each material. The relationship between loose volume (Vs) and compact volume (Vc) is expressed in (1):

$$Vc = \frac{Vs}{(1+fw)} \qquad (1)$$

Vc = Compact volume (m³)
Vs = Loose volume (m³)
fw= Abundance coefficient

Based on the definition of precision, understood as the degree of agreement between the results obtained in repeated measurements on the same object under identical experimental conditions [7], the volumes determined using both methods were compared using (2) for photogrammetry and (3) for total station:

$$p_{Dron} = \frac{\mathrm{V_f}}{\mathrm{V_{ct}}} * 100 \qquad (2)$$

$$p_{Mt} = \frac{\mathrm{V_{Mt}}}{\mathrm{V_c}} * 100 \qquad (3)$$

P_{Dron} = Accuracy of the model generated by UAV
P_{Mt} = Accuracy of the model generated by total station
V_f = Volume obtained using photogrammetry
V_{Mt}= Volume obtained using total station

For the cost analysis, a comparison was made between the total expenditures associated with drone photogrammetry and surveys conducted with a total station, considering both field and office activities. Labor costs related to information processing and analysis were obtained from the Ministry of Economy [8], while equipment purchase prices were consulted directly on the websites of official distributors, thus ensuring the reliability and timeliness of the references used.

Finally, by integrating the variables of accuracy, time, and costs, the two Decision Making Units (DMUs) of the Data Envelopment Analysis (DEA) method were defined, assigning the following nomenclature:

Photogrammetry DMU j=1:
Total station DMU j=2:

For the analysis using Data Envelopment Analysis (DEA), the Variable Return to Scale (VRS) approach, also known as the BBC model, was adopted. This approach allows for the construction of linear combinations in which all variable contribution weights (λ_j) are positive and their sum equals 1. This ensures that the assigned weights are realistic and proportional, which facilitates the interpretation and robustness of the results obtained [9].

The BBC model is based on the following constraints (4) and (5):

$$\lambda_1 + \lambda_2 = 1 \qquad (4)$$

$$\lambda_j \geq 0 \ to\ j = 1{,}2. \qquad (5)$$

λ_1= weight assigned to DMU J=1
λ_2= weight assigned to DMU J=2

DEA analysis under the BBC model allows us to determine which decision-making units (DMUs) make efficient use of available resources to achieve maximum results. A DMU is considered efficient when it is located on the efficient frontier, while those below are classified as inefficient, as they require greater input or produce lower results compared to the best practices observed.

This model provides a measure of relative efficiency, expressed as an index between 0 and 1, where a value of 1 indicates fully efficient performance and lower values reflect proportional degrees of inefficiency.

When evaluating a DMU, the aim is to determine whether there is any weighted combination of other units that, with the same resources, can produce an equal or higher level of output. To control this comparison, the model introduces the efficiency coefficient φ, which reflects the degree to which the unit converts its inputs into results with respect to the efficient frontier.

In the output-oriented BBC (VRS) approach, one of the fundamental constraints establishes that the convex combination of the results of the reference DMUs must be at least equivalent to the performance of the evaluated DMU multiplied by the efficiency φ. This coefficient reflects the degree to which the unit converts its inputs into outputs compared to the efficient frontier.

In practical terms, for output variables, the constraint can be expressed as (6):

$$\sum_{j=1}^{n=2} \lambda_j \Upsilon_j \geq \varphi \Upsilon_i \qquad (6)$$

Y_j= Output value (variable) of DMU j.
λ_j= Weight assigned to DMU j.
Υ_i= Output value of the evaluated DMU.
φ= Technical efficiency coefficient hat is sought to be maximized.

This study adopted an output-oriented approach, which involves keeping inputs constant and expanding outputs until the DMU under evaluation reaches the efficiency frontier.

To ensure consistency in comparison with other units, a second constraint is established to ensure that the weighted combination of reference inputs does not exceed the inputs used by the DMU under evaluation. This condition is expressed as (7):

$$\sum_{j=1}^{n=2} \lambda_j \chi_{kj} \leq \chi_{ki} \qquad \forall \kappa \in \{Time, cos\} \qquad (7)$$

X_{kj}= Value of input k of DMU j
X_{ki}= Value of input k of the evaluated DMU

Given that the variables used in the model are expressed in heterogeneous units of measurement, it was necessary to apply a normalization process to transform all values to a common scale within the range [0–1]. This procedure ensures the comparability of the data and prevents any variable from exerting a disproportionate weight in the analysis due to its magnitude. This study established that time and cost are inputs that should be minimized, while accuracy is an output that should be maximized.

To unify the variables under the same criterion, ideal normalization was applied, defined by (8):

$$X_{IJ\ Norm} = \frac{X_{ij}}{Max\ X_{ij}} \quad (8)$$

X_{ij}=Original value of the variable
Max X_{ij}= Maximum observed value of the variable
$X_{ij\ Norm}$= normalized value in the interval [0–1]

For the variables to be minimized (time and cost), normalization by the maximum value was used directly, while for the variable to be maximized (accuracy), the same formula was used but adjusting the order so that the highest value represents the best relative performance.

Once the normalized values were obtained, priorities were assigned using the simple ranking method, which consists of classifying the criteria according to their relevance within the analysis. In this study, greater priority was given to accuracy, as it was the main objective of the research, while time and cost were considered secondary variables, although relevant. Consequently, the following weightings were adopted: 40% for accuracy and 30% for each of the cost and time variables.

Finally, to integrate the results and obtain an aggregate efficiency index, the weighted multi-criteria method was used, expressed by (9):

$$W_i = \sum_{j=1}^{n} w_j * x_{ij} \quad (9)$$

W_i= Final weighting or efficiency index of alternative i
W_j= Weight assigned to variable j
X_{ij}= Normalized value of variable j for alternative i

This procedure made it possible to synthesize the relative performance of each decision-making unit (DMU) into a single value, combining the information from the different variables under a previously defined weighting scheme. In this way, the aggregate index simultaneously reflects the relative importance of each criterion and the level of performance achieved by each alternative within the efficiency analysis.

III. RESULTS

The output control report for the analyzed material bank recorded a loose volume of 6,965 m³. According to geotechnical studies, the material has a swelling coefficient of 30%, which allows us to establish the necessary relationship to obtain the equivalent volume in compact condition. Applying (1):

$Vc = 6965/((1+0.3)) = 5357.69\ m^3$.

This result forms the basis for comparing the volumes determined using the different surveying methods employed in the study.

This compact volume was compared with the values obtained from the topographic surveys carried out using both methods. Fig. 3 shows the superimposed models from a plan view, allowing the spatial correspondence between the generated surfaces to be observed. Fig. 4 illustrates the comparative results: the upper part shows the data derived from the total station, while the lower part shows the data obtained using drone photogrammetry.

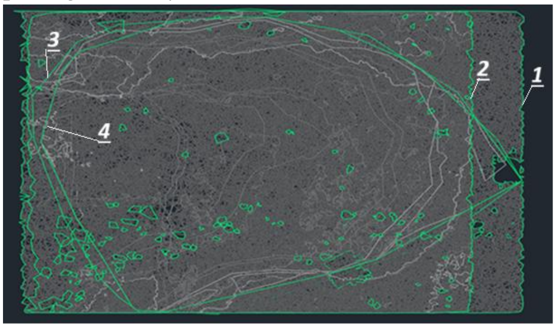

Figure 3. Overlapping models

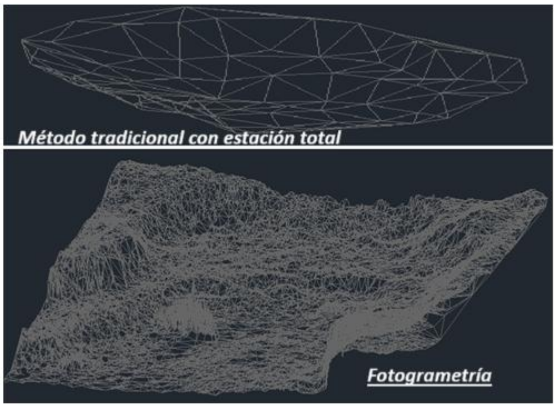

Figure 4. Comparison of project sites

It can be observed that, although both methods adequately represent the general morphology of the terrain, the model obtained with the drone presents a higher level of surface detail, which allows for clearer identification of irregularities, local variations in elevation, and elements present on the surface. This fine capture capability is due to the high number of points generated in the photogrammetric cloud, which exceeds the regular mesh defined with the total station.

Autodesk Civil 3D software was used to calculate the compact volumes, obtaining the results presented in Table 1.

Table 1 Summary of methods

Method	Volume m^3
Photogrammetry (UAV)	4,327.38
Total station (TS)	4,033.92

Subsequently, applying (2) and (3), the relative accuracy value of each method was determined, allowing for an objective comparison of the performance between the two techniques. This result is presented in Table 2.

Table 2. Accyrancy

Method	Volume	Accuracy
UAV	4,327.38	80.77
TS	4,033.92	75.29

The times recorded during field data collection are presented in Table 3 for both the natural terrain survey (first survey) and the first project terrain survey (second survey). The office work time was registered and added ti the time surveys en Table 4

Table 3. Time surveys

Method	Survey 1		Survey 2		Total	
	Min	Hr	Min	Hr	Min	Hr
UAV	6.95	0.1158	6.98	0.1164	13.93	0.2321
TS	64.93	1.0822	81.32	1.3553	146.25	2.4375

Table 4 Time spent on fieldwork and office work

Method	Surveys		Office Work		Total	
	Min	Hr	Min	Hr	Min	Hr
UAV	13.93	0.2321	406.20	6.77	420.13	7.00
TS	146.25	2.4375	94.80	1.58	241.05	4.02

The cost analysis included the values associated with the drone, laptop, and total station, considering the hourly active cost for each piece of equipment. This approach is justified because the study focused exclusively on the effective time of use of the equipment during surveying and processing activities. Table 5 presents the breakdown of estimated costs for each of these items

Table 5. Summary of results regarding direct machine hour cost (USD)

Item	Drone	Total station	Laptop
Fixed charges	4.50	3.24	0.37
Operation Charges	7.67	10.68	7.67
Direct cost per machine hour	12.17	13.92	8.04

The cost per operation of the total station was higher due to the need for an assistant or helper, whose job was to hold the surveying prism during the topographic surveys.

Based on the previously estimated hourly costs and the times recorded in Table 4, the total cost of each method was calculated. The results of the fieldwork are presented in Table 6, and Tables 7 and 8 show the costs associated with the office phase.

Table 6 Costs in the field stages

Method	Time Hr	Cost per hour (USD/h)	Total (USD)
UAV	0.2322	12.17	2.82
TS	2.4375	13.92	33.93

Table 7 Office work cost using photogrammetry

Resource	Cost (USD/h)	Time (h)	Cost (USD)
Pix4D	0.46	0.2	0.09
Reality Capture	0.00	4.81	0.00
Civil 3D	0.39	4.06	1.60
Laptop whit labor	8.22	6.77	55.63
Laptop without labor	- 7.67	2.1	- 16.10
Total			41.22

It was decided to reduce part of the computer's operating time, corresponding to periods when the equipment was only processing images, without requiring active intervention by the operator. The reason for this exclusion is that, during these intervals, the computer did not require direct manipulation or additional labor, so it was not considered appropriate to count this time as effective operating time. In this way, the cost analysis more accurately reflects the actual and productive use of the resources involved.

Table 8 Cost of office work using traditional methods

Resource	Cost (USD/h)	Time (h)	Cost (USD)
Prolink	0.00	0.12	0.00
Civil 3D	0.39	1.46	0.57
Laptop	8.22	1.58	12.98
Total			13.55

Likewise, the costs corresponding to each method were integrated, considering separately the field and office stages and the sum of both. The results are presented in Table 9, which details the values obtained for each phase and their contribution to the final cost of the methods evaluated.

Table 9. Final cost (USD) per method

Method	Office work	Field stages	Total
UAV	41.22	2.82	44.04
TS	13.55	33.93	47.48

With the values obtained for accuracy, time, and cost, the Data Envelopment Analysis (DEA) model was applied. These three variables were selected for their relevance in evaluating the efficiency of the methods analyzed: accuracy as an output variable to be maximized, and time and cost as input variables to be minimized. In this way, the DEA model allows these indicators to be integrated together and establishes a comparative measure of the relative efficiency between the survey techniques evaluated.

For the application of the DEA model, two decision units (DMUs) were defined corresponding to the methods evaluated: photogrammetry (DMU j=1) and total station (DMU j=2). In each case, execution time and direct cost were considered as inputs, while accuracy achieved was used as output. The values used are shown in Table 10.

Table 10. Input and output variables considered in the DEA model.

DMU	Time (Min)	Cost (USD)	Accuracy (%)
DMU UAV	420.13	44.04	80.77
DMU 2-TS	241.05	47.48	75.29

In the first phase of the analysis, an output-oriented approach is adopted, in which inputs are kept constant and the objective is to expand outputs as much as possible. This expansion is represented by the coefficient φ, which reflects the degree of technical efficiency achieved by each decision-making unit (DMU).

Solving λ_1 from (4):

$\lambda_1 = 1 - \lambda_2$

Substituting in (6) with data from the photogrammetry method outputs:

$80.77\lambda_1 + 75.29\lambda_2 \geq 80.77\varphi$

$\varphi \leq (80.77\lambda_1 + 75.29\lambda_2)/80.77$

Substituting in the same (6) for the time and cost outputs:

Time:

$420.13\lambda_1 + 241.05\lambda_2 \leq 420.13$

Substituting λ_1 from (4) solved:

$420.13(1 - \lambda_2) + 241.05\lambda_2 \leq 420.13$

$420.13 - 420.13\,\lambda_2 + 241.05\lambda_2 \leq 420.13$

$420.13 - 179.08\lambda_2 \leq 420.13$

$-179.08\lambda_2 \leq 0$

Then:

$\lambda_2 \geq 0$

These calculations are applied similarly for the cost input:

$44.04\lambda_1 + 47.48\lambda_2 \leq 44.04$

Substituting λ_1 from (4= solved:

$44.04(1 - \lambda_2) + 47.48\lambda_2 \leq 44.04$

$44.04 - 44.04\lambda_2 + 47.48\lambda_2 \leq 44.04$

$44.04 + 3.44\lambda_2 \leq 44.04$

$3.08\lambda 2 \leq 0$

Then:

$\lambda_2 \leq 0$

The objective is to maximize the outputs of the DEA-BCC model, for which a combination of weights must be found that allows the technical efficiency value to remain equal to 1 without violating the restrictions imposed by the inputs. The only feasible solution is to assign $\lambda_2 = 0$.

$$\varphi \leq \frac{80.77\lambda 1 \ + 75.29\lambda 2}{80.77}$$

$$\varphi \leq \frac{80.77(1) \ + 75.29(0)}{80.77}$$

$$\varphi \leq \frac{80.77}{80.77}$$

$$\varphi \leq 1$$

It is concluded that photogrammetry is efficient

Applying similarly for total station surveys (DMU2)

Accuracy:

For the DMU evaluated with a total station (accuracy = 75.29%), the output condition is:
$80.77\lambda_1 + 75.29\lambda_2 \geq 75.29\varphi$

Which is equivalent to:
$\varphi \leq (80.77\lambda_1 + 75.29\lambda_2)/75.29$

For the time constraint, which is an input:
$420.13\lambda_1 + 241.05\lambda_2 \leq 241.05$

Substituting $\lambda_1 = 1 - \lambda_2$
$420.13(1-\lambda_2) + 241.05\lambda_2 \leq 241.05$
$420.13 - 420.13\lambda_2 + 241.05\lambda_2 \leq 241.05$
$420.13 - 179.08\lambda_2 \leq 241.05$
$-179.08\lambda_2 \leq 241.05 - 420.13$
$-179.08\lambda_2 \leq -179.08$

Then:
$\lambda 2 \geq 1$

For the cost constraint, which is an input:
$44.04\lambda 1 + 47.48\lambda 2 \leq 47.48$

Substituting λ_1 from (4):
$44.04(1-\lambda_2) + 47.48\lambda_2 \leq 47.48$
$44.04 - 44.04\lambda_2 + 47.48\lambda_2 \leq 47.48$
$44.04 + 3.44\lambda 2 \leq 47.48$
$3.44\lambda_2 \leq 47.48 - 44.04$
$3.44\lambda_2 \leq 3.44$

We obtain:
$\lambda_2 \leq 1$

From the time ($\lambda_2 \geq 1$) and cost ($\lambda_2 \leq 1$) constraints, we conclude that:
$\lambda_2 = 1$ and $\lambda_1 = 0$
$\varphi \leq (80.77(0) + 75.29(1))/75.29 = 1$

$\varphi \leq 1$

This implies that DMU 2 (total station) is on the technical efficiency frontier defined by the BCC–VRS model, as is DMU 1 (photogrammetry). Consequently, both methods are efficient independently, without requiring a combination of weight from the other unit to achieve efficiency.

Weighted multi-criteria Analysis

The values in Table 10 were normalized to standardize the information and ensure that the unit used does not distort the result and is within the general range [0, 1]. Since the aim is to minimize cost and time, equation 8 is used. The results are shown in Table 12.

Table 12. Normalized variables

Method	Cost	Time	Accuracy
UAV	1.00	0.57	1.00
TS	0.93	1.00	0.93

With this data and using the weightings that prioritize accuracy (40%) over cost (30%) and time (30%) as indicated in the methodology.

Applying (9) to determine the economic efficiency of the methods analyzed, Table 13 is obtained.

Table 13. Calculation of economic efficiency

Method	Cost	Time	Accuracy	Total *(Wi)*
UAV	0.3	0.17	0.4	0.87
TS	0.28	0.3	0.37	0.95

The results of the weighted multi-criteria analysis show that, when integrating the variables of cost, time, and accuracy into a single index, both methods achieve high relative efficiency values, although with notable differences in the weighting of each criterion.

In photogrammetry, the best results were obtained in cost (1.00) and accuracy (1.00), reflecting its competitiveness in terms of economics and data quality. However, execution time (0.57) is its main disadvantage, reducing its overall index to 0.87.

With the total station, performance is more balanced: it achieves the best score in time (1.00), while in cost (0.93) and accuracy (0.93) it has slightly lower values than photogrammetry. This balance allows it to obtain a higher overall index of 0.95.

In summary, the analysis shows that the traditional method is more efficient in the weighted scenario, due to the strong weighting of time in the evaluation, although photogrammetry has clear advantages in terms of cost and accuracy, which could tip the balance in favor of its use in projects where data quality is a priority.

IV. CONCLUSION

The results show a marked difference between the time spent in the field and in the office. In the field, drone photogrammetry took 13.93 minutes compared to 146.25 minutes with a total station; the difference translates into significantly lower direct costs in the field for the drone (2.82 vs. 33.93). In the office, the opposite is true: photogrammetry took 406.20 min, equivalent to a cost of 41.22, well above the total station, which took 94.80 min at a cost of 13.55. Integrating both phases, photogrammetry had a total cost of $44.04, making this technique more economical than the total station, which had a cost of $47.48.

On the other hand, photogrammetry achieved the highest relative accuracy (80.77% vs. 75.29%), similar results to those obtained in the research carried out by Erdenebat and Waldmann [10], who determined that photogrammetry is 45% more accurate than the total station. However, this study focused only on the measured magnitudes, not on overall accuracy, considering other factors such as time and cost.

Methodologically, the study adopted the output-oriented DEA–BCC (VRS) model. With the two DMUs analyzed, both are technically efficient ($\varphi = 1$), indicating that, with the observed combinations of inputs (time, cost) and output (accuracy), neither can proportionally improve its output without violating input constraints.

The weighted multi-criteria analysis, with weights of 0.40 (accuracy), 0.30 (cost), and 0.30 (time), yielded an index of 0.87 for photogrammetry and 0.95 for total station. The superiority of the total station method stems from its shorter total time (4.02 h vs. 7.00 h) and the weighting given to time. This highlights the sensitivity of the result to the weights: if the project priority shifted the emphasis to accuracy or cost, photogrammetry could become the preferred option. In projects with short field operation times, the drastic reduction in field time offered by drones can be decisive, even assuming a higher cabinet load. The practical recommendation is to perform weight sensitivity analyses before deciding on the method.

Technical efficiency (DEA–BCC). With the variables precision (output) and time/cost (inputs), both alternatives—photogrammetry and total station—are efficient (φ=1) with respect to the estimated VRS frontier; neither can proportionally expand its output without exceeding its observed inputs. MDPI

Photogrammetry minimizes field time and costs and maximizes surface detail, at the expense of higher cabinet loads. The total station exhibits the opposite pattern.

Multi-criteria result. With weightings of 0.40/0.30/0.30 (accuracy/cost/time), the total station obtained 0.95 and photogrammetry 0.87; the final preference depends on the weights. Sensitivity analysis is recommended for robust and explicit decisions.

Although in this study photogrammetry outperformed the traditional method with a total station in terms of both greater accuracy and cost, when the office phase was integrated, the results were reversed, as this technique was considerably slower and required more technological tools, which are still expensive. Despite this, it remains a viable option, especially for larger surveys where the difference in field phase times can increase considerably, while the office phase would increase on a smaller scale.

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