Study on the LandCover Classification using UAV Imagery

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ABSTRACT *: The study was carried out using the UAV for analyzing the characteristics of debris in order to present the methodology to estimate the quantitative amount of debris caught in small river facilities. A total of six small rivers that maintained the form of a natural river were selected for collecting UAV images, and the grouping of each target in the image was carried out using the object-based classification method, and based on the object-based classification result of the UAV images, the land cover classification for the status of factors causing the generation of debris for six target sections was carried out by applying the screen digitizing method. In addition, in order to verify the accuracy of the classification result, the error matrix was performed, securing the reliability of the result. The accuracy analysis result showed that for all six target sections, the overall accuracy was 93.95% and the Kappa coefficient was 0.93, showing an excellent result.*

KEYWORDS : *Debris, land cover classification, river,screen digitizing method,UAV imagery*

I. INTRODUCTION

A low-resolution satellite image can be obtained repeatedly on a short cycle, but for a space with a relatively small area such as a small river, such an image has low spatial resolution so that it is not suitable for monitoring purposes. On the other hand, a high-resolution satellite image enables periodic monitoring, but due to the limitations imposed by costs and time periods, it is not suitable for monitoring a small river. In addition, a satellite image using a manned aircraft can be applicable in the right place, but it is too costly.

As a measure to solve and supplement this type of problem, monitoring using UAV (unmanned aerial vehicle) is emphasized as an excellent countermeasure, and studies regarding remote sensing of a river using a drone are being carried out actively both at home and abroad among various application fields [1-4].

Especially, the technology using the UAV has features that enables regular monitoring to be carried out in the case of a disaster and environmental elements (grass, tree, etc.) that may become debris can be classified in a narrow basin such as small river basin. In addition, the remote sensing method using a hyperspectral image whereby a unique wavelength range can be detected has also been launched [5-6] and studies regarding the investigation and analysis of tidal current using a drone are also being carried out [7-8].

However, river monitoring and field application cases remain at the level of basic research, and almost no analysis of causes for debris in a small river using a drone has been carried out.

Therefore, image collection was carried out for six river basins using the UAV and proper object classification for each image was carried out by adjusting the scale, shape and compactness. Based on the object-based classification result of the UAV images, the land cover classification for the status of factors causing the generation of debris was carried out by applying the screen digitizing method.

II. RESEARCH METHOD

2.1 Characteristics of UAV

The UAV used for carrying out the analysis of causes and characteristics for the occurrence of debris using the land cover classification was DJI ’ s Inspire 1.0 that featured 22 m/s for the maximum speed, 18 minutes for the flying time and 2 km for the flying distance and it was equipped with the Sony EXMOR 1/2.3 image sensor. Table 1 shows the characteristics of UAV.

Table 1.Characteristics of Dji Inspire 1

Weight	2.935kg
Maximum flying speed	22m/s
Flying time	18min
Operating temperature	- 10 ~ 40℃
Flying distance	2000m
Image sensor	Sony EXMOR 1/2.3, Pixels 12.4M
Image size	4000 x 3000
Video format	UHD: 4096x2160p 24/25, 3840x2160p 24/25/30 FHD: 1920x1080p 24/25/30/48/50/60 HD: 1280x720p 24/25/30/48/50/60

2.2 Image collection plan and method

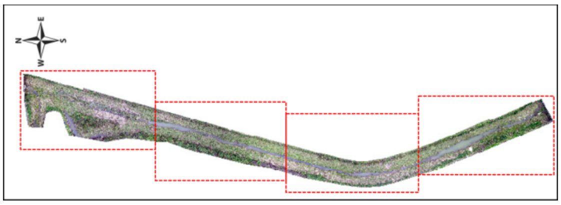
The image collection using the UAV was carried out in a similar fashion with the aerial image production procedure. The image collection procedures were carried out in the order of prior planning, data collection, calibration of sensor, setting of filming path, image correction and image matching. A total of six areas targeting small rivers that maintain the form of a natural river were selected as the target areas of study. The field survey targeting the selected six areas (Bonggokcheon(1), Bonggokcheon(2), Pyeongchoncheon, Seogokcheon, Amgolcheon, Deoksancheon) was carried out, and the study was conducted using the land cover classification in order to analyze elements that may become debris affecting facilities in small rivers.

At first, the grouping of each target in the image was carried out using the object-based classification method, and the land cover classification was carried out for the status of factors causing the generation of debris on the target sections using the screen digitizing method. Moreover, in order to verify the accuracy of the classification result, the error matrix was performed, securing the reliability of the result.

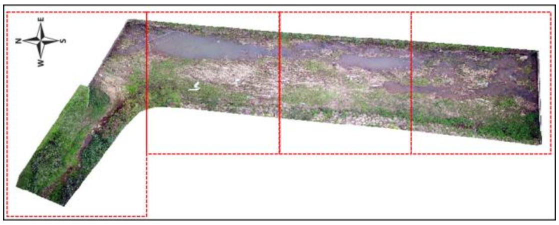
III. CONTENTS OF STUDY

3.1 Classification of images using the object-based classification method

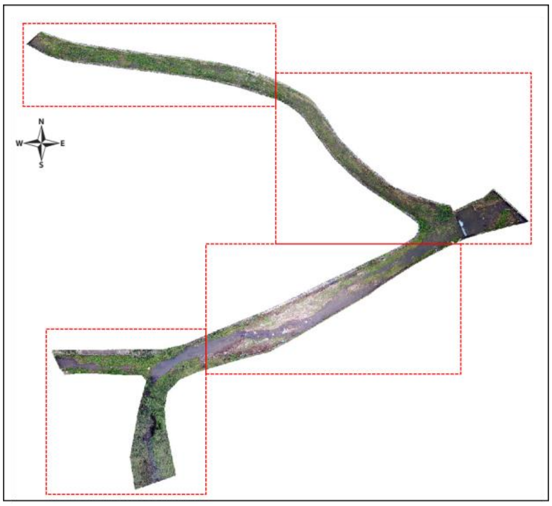
Six rivers were classified into four sections using the UAV images and the object classification suitable for each image was undertaken by adjusting the scale, shape and compactness. Fig. 1 shows the UAV images for the six basins, and Fig. 2 shows the object-based classification result of the representative sections among the six basins.



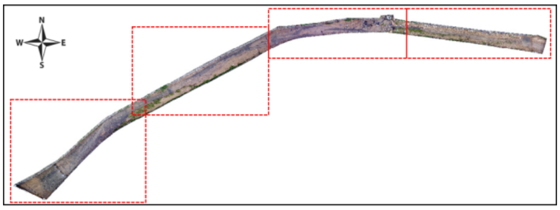
(a) Bonggokcheon(1)



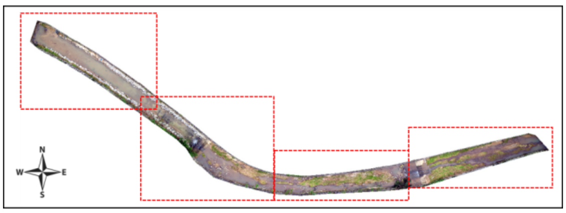
(b) Bonggokcheon(2)



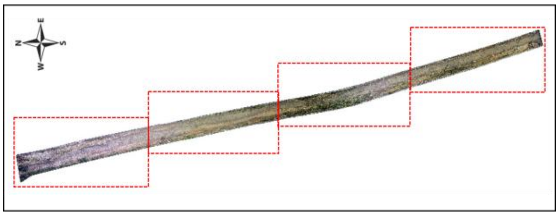
(c) Pyeongchoncheon



(d) Seogokcheon

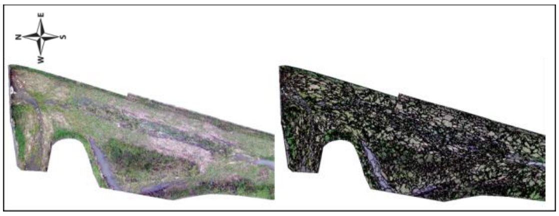


(e) Amgolcheon

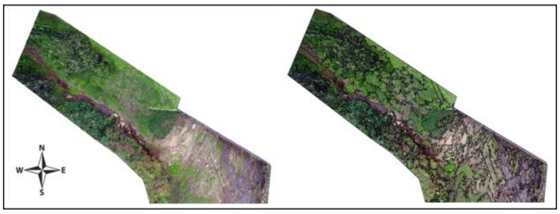


(f) Deoksancheon

Figure.1 UAV images for six basins

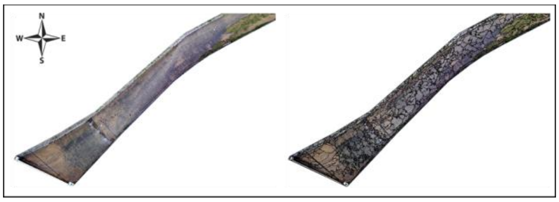


(a) Bonggokcheon(1)-1

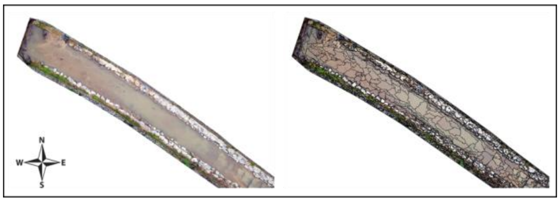


(b) Bonggokcheon(2)-1

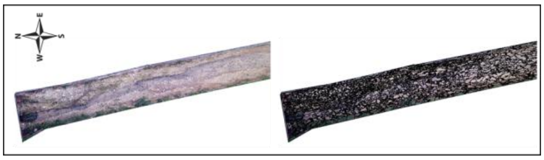
(c) Pyeongchoncheon-1



(d) Seogokcheon-1



(e) Amgolcheon-1



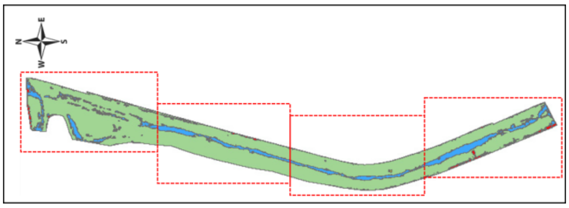
(f) Deoksancheon-1

Figure.2 Object-based classification of UAV images for six basins

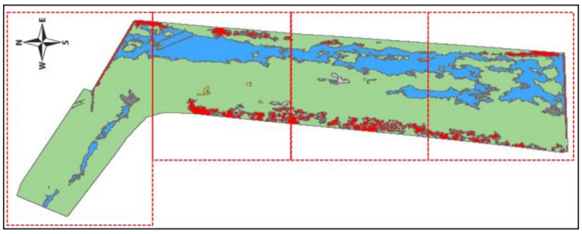
3.2 Status of factors causing the generation of debris in target basins

Based on the object-based classification result of the UAV images, the land cover classification for the status of factors causing the generation of debris for six target sections was carried out by applying the screen digitizing method (Fig. 3). The land cover classification result of Bonggokcheon(1) showed 85% for grass and 11% for waters and, the ratio of debris was in the order of structure, gravel, sand and others. The land cover classification result of Bonggokcheon(2) showed 73% for grass and 19% for waters, and the ratio of debris was in the order of structure, gravel, sand and others. The land cover classification result of Pyeongchoncheon showed 61% for grass and 24% for waters, and the ratio of debris was in the order of structure, sand, gravel and others.

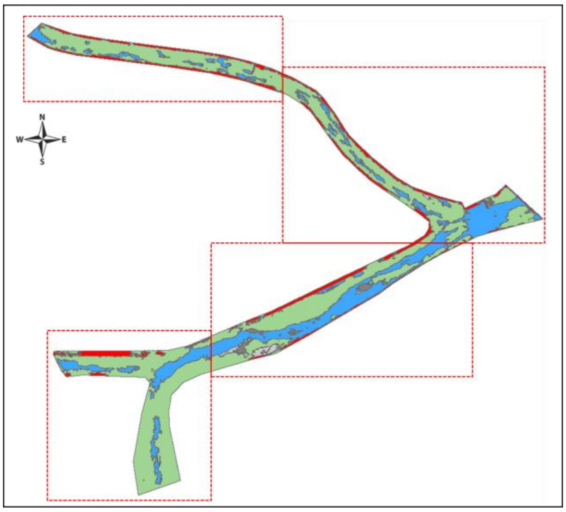
The land cover classification result of Seogokcheon showed 48% for waters, 19% for sand and 12% for structure, and the ratio of debris was in the order of grass, gravel and others. The land cover classification result of Amgolcheon showed 49% for waters, 22% for grass and 21% for structure, and the ratio of debris was in the order of tree, sand, gravel and others, and the land cover classification result of Deoksancheon showed 39% for waters, 26% for grass and 14% for sand, and the ratio of debris was in the order of structure, gravel, tree and others (Tables 2 ~7).



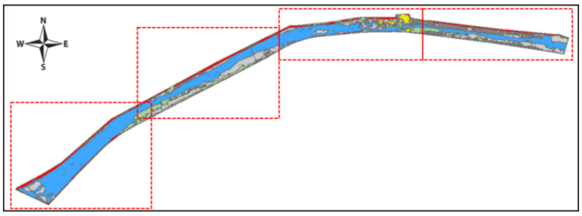
(a) Land cover classification map of Bonggokcheon(1)



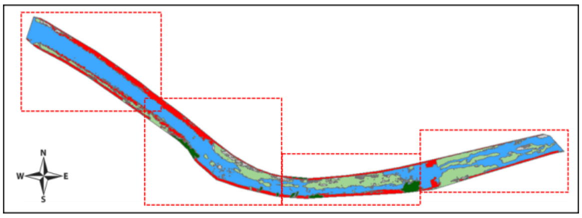
(b) Land cover classification map of Bonggokcheon(2)



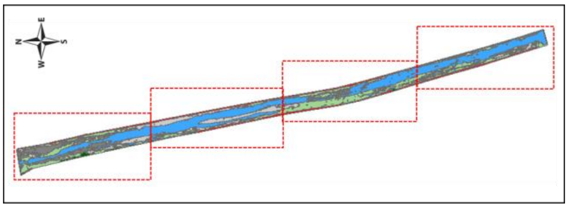
(c) Land cover classification map of Pyeongchoncheon



(d) Land cover classification map of Seogokcheon



(e) Land cover classification map of Amgolcheon



(f) Land cover classification map of Deoksancheon

Figure 3. Land cover classification map of target areas of study

Table 2. Land cover classification result of Bonggokcheon(1) using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	0.00	0.00
Grass	3,346.45	85.43
Waters	452.92	11.56
Structure	105.53	2.69
River bed (gravel)	7.24	0.19
River bed (sand)	1.38	0.04
Others	3.54	0.09
Total	3,917.07	100.00

Table 3. Land cover classification result of Bonggokcheon(2) using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	0.00	0.00
Grass	730,12	73.15
Waters	197.67	19.81
Structure	61.30	6.14
River bed (gravel)	4.85	0.49
River bed (sand)	2.73	0.27
Others	1.43	0.14
Total	998.09	100.00

Table 4. Land cover classification result of Pyeongchoncheon using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	0.00	0.00
Grass	471.87	61.82
Waters	187.22	24.53
Structure	88.15	11.55
River bed (gravel)	7.64	1.00
River bed (sand)	8.08	1.06
Others	0.36	0.04
Total	763.32	100.00

Table 5. Land cover classification result of Seogokcheon using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	0.00	0.00
Grass	106.49	10.65
Waters	482.68	48.26
Structure	129.75	12.97
River bed (gravel)	63.65	6.36
River bed (sand)	190.31	19.03
Others	27.30	2.73
Total	1,000.18	100.00

Table 6. Land cover classification result of Amgolcheon using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	45.66	3.06
Grass	329.31	22.11
Waters	734.97	49.35
Structure	319.40	21.45
River bed (gravel)	19.07	1.28
River bed (sand)	39.73	2.67
Others	1.18	0.08
Total	1,489.32	100.00

Table 7. Land cover classification result of Deoksancheon using UAVimages

Legend of land cover	Area (m^2)	Ratio (%)
Tree	31.35	1.69
Grass	485.35	26.13
Waters	736.67	39.67
Structure	184.63	9.94
River bed (gravel)	142.89	7.70
River bed (sand)	270.2	14.55
Others	5.89	0.32
Total	1,856.98	100.00

3.3Verification of accuracy of land cover classification result

For the land cover map prepared using an image, the accuracy of the classification result according to the intended purpose should be verified in order to obtain an objective value. The accuracy was verified by comparing the image classification result and the field investigation data according to the object-based and screen digitizing method, and the overall accuracy, producer’s accuracy and user’s accuracy were calculated and the accuracy was evaluated with Kappa coefficient through the normalization process. In order to obtain reference data, 60 positions for each section were selected randomly through the expert’s field investigation and the visual reading result and the verification was carried out. The overall accuracy is obtained by dividing the number of pixels classified accurately by the number of pixels for the whole test area, and the accuracy is displayed only using the accurately classified result, so a highly approximate result is provided. For the supplementation, the Kappa coefficient was calculated additionally, and the Kappa coefficient calculates the accuracy by considering the accurately classified result as well as classification errors, so it becomes the standard to display greater objective accuracy than the overall accuracy. Table 8 shows the score card for the Kappa coefficient.

Table 8. Kappa coefficient

Kappa	Quality	Kappa	Quality
<0	Worst	0.4~0.6	Good
0~0.2	Poor	0.6~0.8	Very good
0.2~0.4	Reasonable	0.8<	Excellent

The accuracy analysis result for the target areas showed that in the case of Bonggokcheon(1), the overall accuracy (OA) was 98.33% and the Kappa coefficient was 0.98 (Excellent) as the accuracy analysis result, showing an excellent result. In the case of Bonggokcheon(2), the overall accuracy (OA) was 90% and the Kappa coefficient was 0.88 (Excellent) as the accuracy analysis result, showing an excellent result. In the case of Pyeongchoncheon, the overall accuracy (OA) was 93.33% and the Kappa coefficient was 0.92 (Excellent) as the accuracy analysis result, showing an excellent result. In the case of Seogokcheon, the overall accuracy (OA) was 95% and the Kappa coefficient was 0.94 (Excellent) as the accuracy analysis result, showing an excellent result.

In the case of Amgolcheon, the overall accuracy (OA) was 91.43% and the Kappa coefficient was 0.90 (Excellent) as the accuracy analysis result, showing an excellent result. In the case of Deoksancheon, the overall accuracy (OA) was 95.71% and the Kappa coefficient was 0.95 (Excellent) as the accuracy analysis result, showing an excellent result (Tables 9 ~14). For all six target sections, the overall accuracy was 93.95% and the Kappa coefficient was 0.93 (Excellent), showing an excellent result (Table 15).

Table 9. Accuracy analysis of Bonggokcheon(1) (Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	10	-	-	-	-	-	-	10	100.0
	River bed (sand)	-	10	-	-	-	-	-	10	100.0
	Others	-	-	9	1	-	-	-	10	90.0
	Facility	-	-	-	10	-	-	-	10	100.0
	Grass	-	-	-	-	10	-	-	10	100.0
	Tree	-	-	-	-	-	-	-	-	-
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	10	10	9	11	10	-	10	60	-
	User's accuracy (%)	100.0	100.0	100.0	90.9	100.0	-	100.0	-	-
Overall accuracy (%)		98.33								
Kappa coefficient		0.98 (Excellent)								

Table 10. Accuracy analysis of Bonggokcheon(2) (Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	10	-	-	-	-	-	-	10	100.0
	River bed (sand)	-	6	-	-	4	-	-	10	60.0
	Others	-	-	8	-	2	-	-	10	80.0
	Facility	Facility	-	-	10	-	-	-	10	100.0
	Grass	-	-	-	-	10	-	-	10	100.0
	Tree	-	-	-	-	-	-	-	-	-
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	10	6	8	10	16	-	10	60	-
	User's accuracy (%)	100.0	100.0	100.0	100.0	62.5	-	100.0	-	-
Overall accuracy (%)		90.00								
Kappa coefficient		0.88 (Excellent)								

Table 11. Accuracy analysis of Pyeongchoncheon (Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	10	-	-	-	-	-	-	10	100.0
	River bed (sand)	-	8	-	-	2	-	-	10	80.0
	Others	-	-	8	1	1	-	-	10	80.0
	Facility	-	-	-	10	-	-	-	10	100.0
	Grass	-	-	-	-	10	-	-	10	100.0
	Tree	-	-	-	-	-	-	-	-	-
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	10	8	8	11	13	-	10	60	-
	User's accuracy (%)	100.0	100.0	100.0	90.9	76.9	-	100.0	-	-
Overall accuracy (%)		93.33								
Kappa coefficient		0.92 (Excellent)								

Table 12. Accuracy analysis of Seogokcheon (Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	7	1	-	1	1	-	-	10	70.0
	River bed (sand)	-	10	-	-	-	-	-	10	100.0
	Others	-	-	10	-	-	-	-	10	100.0
	Facility	-	-	-	10	-	-	-	10	100.0
	Grass	-	-	-	-	10	-	-	10	100.0
	Tree	-	-	-	-	-	-	-	-	-
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	7	11	10	11	11	-	10	60	-
	User's accuracy (%)	100.0	90.9	100.0	90.9	90.9	-	100.0	-	-
Overall accuracy (%)		95.00								
Kappa coefficient		0.94 (Excellent)								

Table 13. Accuracy analysis of Amgolcheon (Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	9	1	-	-	-	-	-	10	90.0
	River bed (sand)	1	8	-	-	1	-	-	10	80.0
	Others	1	-	8	-	1	-	-	10	80.0
	Facility	-	-	-	10	-	-	-	10	100.0
	Grass	-	1	-	-	9	-	-	10	90.0
	Tree	-	-	-	-	-	10	-	10	100.0
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	11	10	8	10	11	10	10	70	-
	User's accuracy (%)	81.8	80.0	100.0	100.0	81.8	100.0	100.0	-	-
Overall accuracy (%)		91.43								
Kappa coefficient		0.90 (Excellent)								

Table 14. Accuracy analysis of Deoksancheon

(Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	9	1	-	-	-	-	-	10	90.0
	River bed (sand)	-	10	-	-	-	-	-	10	100.0
	Others	-	-	9	-	1	-	-	10	90.0
	Facility	-	-	-	10	-	-	-	10	100.0
	Grass	-	-	-	1	9	-	-	10	90.0
	Tree	-	-	-	-	-	10	-	10	100.0
	Waters	-	-	-	-	-	-	10	10	100.0
	Total	9	11	9	11	10	10	10	70	-
	User's accuracy (%)	100.0	90.9	100.0	90.9	90.0	100.0	100.0	-	-
Overall accuracy (%)		95.71								
Kappa coefficient		0.95 (Excellent)								

Table 15. Accuracy analysis of all target areas

(Error matrix)

Land cover classification data		Reference data (field investigation and visual reading)								
		River bed (gravel)	River bed (sand)	Others	Facility	Grass	Tree	Waters	Total	User's accuracy (%)
Land cover classification	River bed (gravel)	55	3	-	1	1	-	-	60	91.7
	River bed (sand)	1	52	-	-	7	-	-	60	86.7
	Others	1	-	52	2	5	-	-	60	86.7
	Facility	-	-	-	60	-	-	-	60	100.0
	Grass	-	1	-	1	58	-	-	60	96.7
	Tree	-	-	-	-	-	20	-	20	100.0
	Waters	-	-	-	-	-	-	60	60	100.0
	Total	57	56	52	64	71	20	60	380	-
	User's accuracy (%)	96.5	92.9	100.0	93.8	81.7	100.0	100.0	-	-
Overall accuracy (%)		93.95								
Kappa coefficient		0.93 (Excellent)								

IV. CONCLUSION

The study was carried out using the UAV for analyzing the characteristics of debris in order to present the methodologyto estimate the quantitative amount of debris caught in small river facilities. At first, the control line for compensating the scale of UAV image was installed, and the images were taken from various directions in order to calculate the accumulated amount of debris. A total of six small rivers that maintained the form of a natural river were selected for collecting UAV images, and the grouping of each target in the image was carried out using the object-based classification method, and the land cover classification was carried out for the status of factors causing the generation of debris on the target sections using the screen digitizing method. In addition, in order to verify the accuracy of the classification result, the error matrix was performed, securing the reliability of the result. The accuracy analysis result showed that for all six target sections, the overall accuracy was 93.95% and the Kappa coefficient was 0.93 (Excellent), showing an excellent result.

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REFERENCES

[1] J. Mckean, D. Isaak, and W. Wright, Improving Stream Studies With a Small- Footprint Green Lidar, *Earth & Space Science News, 90(39)*, 2009, 341-42.

[2] T. Allouis, J.S. Bailly, Y. Pastol, and C. Le Roux, Comparison of LiDAR waveform processing methods for very shallow water bathymetry using Raman, near-infrared and green signals, *Earth Surf. Process. Landf., 35*, 2010, 640–50.

[3] A. Lucieer, Z. Malenovsky, T. Veness, and L. Wallace, Hyper UAS—Imaging Spectroscopy from a Multirotor Unmanned Aircraft System, *Journal of Field Robotics, 31(4)*, 2014, 571-90.

[4] J. McLean, Bathymetric Mapping From a Small UAV Compact, Lightweight Lidar System, *Sea Technology, 56(8)*, 2015, 23-26.

[5] E.L. Hestir, V.E. Brando, M. Bresciani, C. Giardino, and E. Matta, Measuring freshwater aquatic ecosystems: The need for a hyperspectral global mapping satellite mission, *remote Sensing of Environment, 167*, 2015, 181-95.

[6] D.V. Merwe, and K.P. Price, Harmful Algal Bloom Characterization at Ultra-High Spatial and Temporal Resolution Using Small Unmanned Aircraft Systems, *Toxins-Open Access Toxinology Journal, 7(4)*, 2015, 1065-1078.

[7] T. Fráter, T. Juzsakova, J. Lauer, L. Dióssy, and A. Rédey, Unmanned Aerial Vehicles inEnvironmental Monitoring—An Efficient Way for Remote Sensing, *Journal of Environmental Science and Engineering, 4*, 2015, 85-91.

[8] T. Su, and H. Chou, Application of Multispectral Sensors Carried on Unmanned Aerial Vehicle (UAV) to Trophic State Mapping of Small Reservoirs: A Case Study of Tain-Pu Reservoir in Kinmen, Taiwan, *Remote Sensing*, 2015, 10078-10097.

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