DETECTING OLIVE OIL MILL WASTE DISPOSAL AREAS IN CRETE / GREECE WITH THE USE OF GIS AND REMOTE SENSING

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Olive oil mill wastes (OOMW) constitute a major factor in pollution in olive-growing regions and an important problem to be solved for the agricultural industry. The olive-oil mill wastes are normally deposited at tanks, or directly in the soil or even on adjacent torrents, rivers and lakes, posing a high risk to the environmental pollution and the community health. This study aims to develop integrated satellite remote sensing methodologies to detect and monitor OOMW disposal areas in the island of Crete, Greece in South Eastern Mediterranean. More than 1000 disposal tanks were mapped through an extended GPS survey that took place throughout the island depicted. Satellite images of both high (IKONOS) and medium (Landsat 8 OLI) resolution were pre-processed and analysed by applying geometric, radiometric and atmospheric corrections. A library with spectral signature of OOMW concerning different time periods as well as satellite sensors was developed. At the same time, ground spectroscopy campaigns were carried out and a complementary spectral signature library was developed. Both libraries were compared for their accuracy through statistical approaches and the optimum spectral range for detecting OOMW areas was estimated. In addition, vegetation indices were developed, applied and compared for their efficiency in detecting the wastes ponds. Furthermore, a final integrated methodology was developed in GIS environment employing, spatial analysis and classification algorithms for the detection of the wastes tanks. The study highlighted the potential of means of Geoinformatics to the semi–automatic detection of OOMW disposal areas in the context of the Mediterranean landscape.

1. INTRODUCTION

Olive oil mills wastes (OOMW) constitute an important pollution factor for the olive-oil producing regions such as Crete-Greece but also a significant problem to be solved for the agricultural industry. The uncontrolled disposal of OOMW in the land produces toxicity and soil microorganisms. Thus in some Mediterranean countries (France and Italy) doses of OOMW higher than m^3/ha are forbidden. In addition the principal effects of OOMW discharges on water bodies are related to the concentration, composition and to their seasonal production. The main aim of this project is the development of an integrated geoinformatic approach for performing monitoring of land pollution from the disposal of OOMW areas. (Fig. 1a).

2. STUDY AREA AND DATA

Waste disposal sites have been registered all over the island of Crete. Crete is the largest Greek island (area: 8336 km^2) and the fifth largest in the Mediterranean with a primarily temperate climate. This study is focused both in all registered OOMW disposal areas all over Crete and in a specific pilot area established in Western Crete (Chania Municipality), at Alikianos Village (located 12,5 km South-West of Chania) (Fig. 2 a; b). However the research team has visited more than 1000 tanks and recorded them with the use of GPS. The areas were then projected to GIS environment. (Fig.1b)

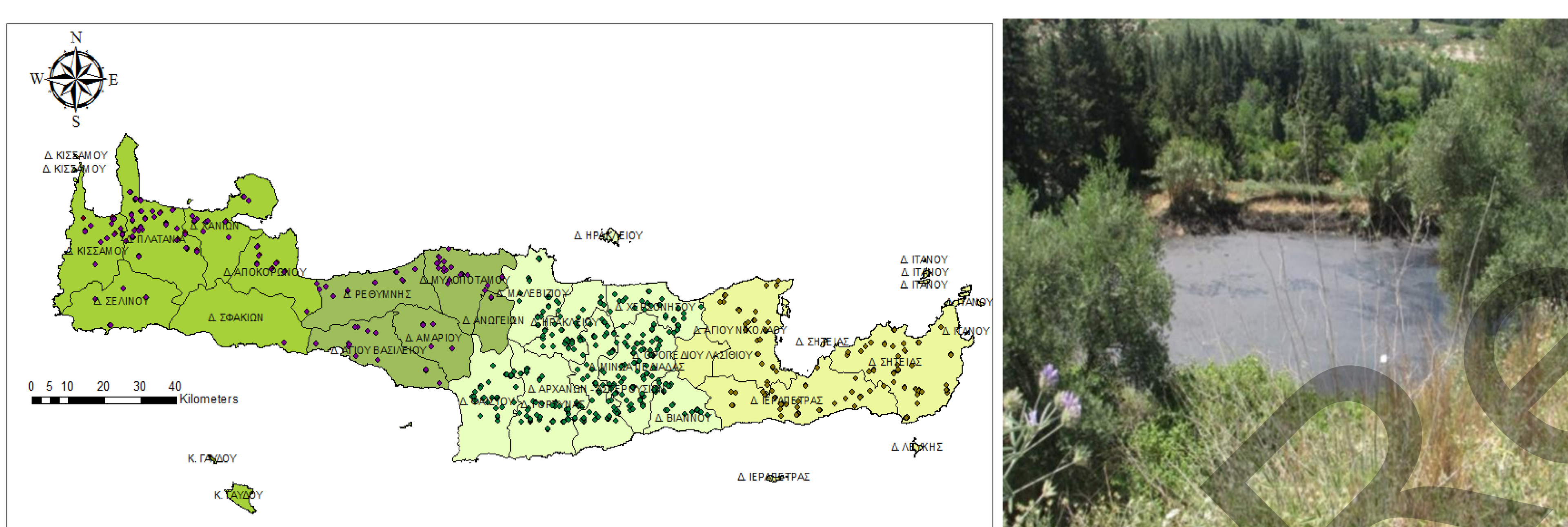

Figure 1. Distribution of OOMW in the island of Crete (left). OOWD area in Western Crete (right).

3. SATELLITE IMAGE PROCESSING AND FIELD SPECTROSCOPY

One of the main approaches of our research was the analysis of satellite remote sensing images (IKONOS, Landsat 8 OLI for the development of semi-automatic methodologies for detecting and monitoring OOMW areas. Pre-processing included geometric, radiometric and atmospheric corrections. The DN values were converted to reflectance values and the darkest pixel atmospheric correction was applied to all images. Following, different image analysis methodologies were applied such as PCA analysis, FCCs, image fusion and spatial filtering with promising results (Fig.2). Concerning vegetation indices (VIs), 10 different VIS were applied (Fig.4) and tested for their performance in detecting OOMW areas. In addition after applying certain statistic tests such as Pearson Coefficient and Factor Analysis for estimating the spectral correlation of Landsat 8 bands, the research team constructed a detection index (DI) for enhancing the spectral response of OOMWD areas in Landsat 8 images. Furthermore field spectroscopy provided an alternative remote sensing approach for the study and multi-temporal monitoring of OOMW disposal areas. Four different field campaigns were conducted in three specific OOMW disposal areas situated in the broader area of Chania Prefecture (Western Crete) using an ASD FieldSpec3 spectroradiometer (Fig. 3,5).

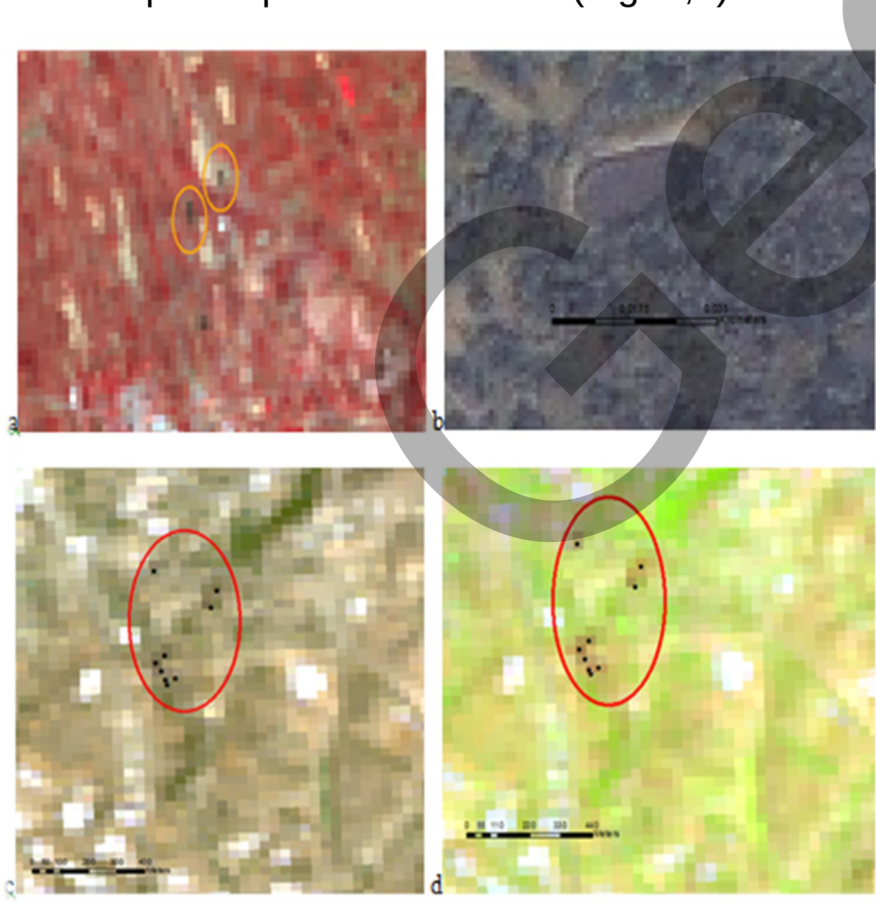

Figure 2. a) OOMWD areas as indicated in Landsat 8 –OLI image. b) OOMWD areas as indicated in IKONOS image. c) False Color Composite of Landsat-8 image, RGB – 321 (OOMWD areas are indicated as black dots inside the red circle). d) FCC RGB - 541. The improvement of optical interpretation of images is clear.

Figure 3. a) Conducting measurements in the field with the use of spectroradiometer b) Liquid pattern. c) Solid pattern

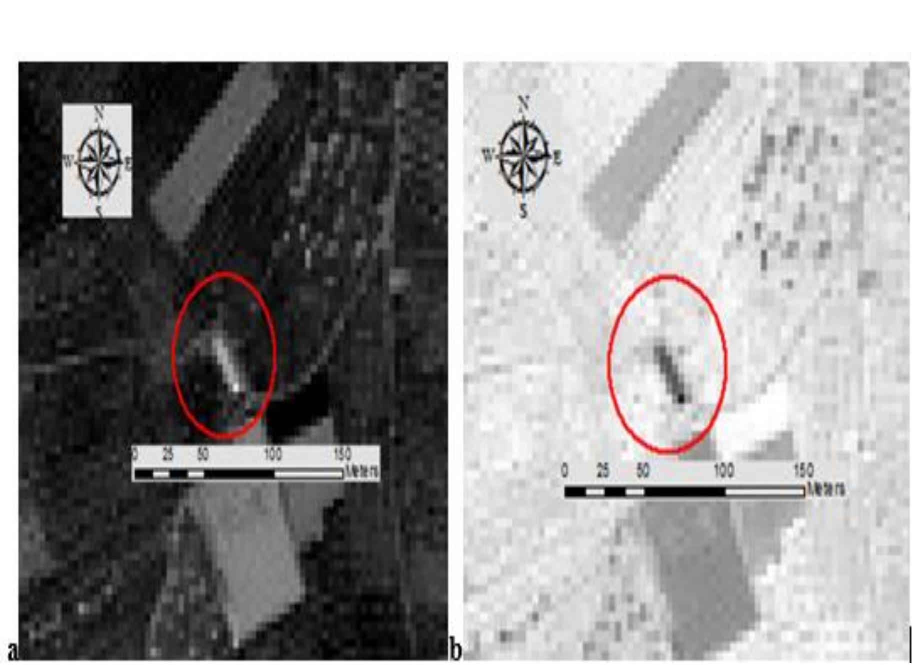

Figure 4. Implementation of NDWI index to IKONOS image b) Implementation of DI index to IKONOS image

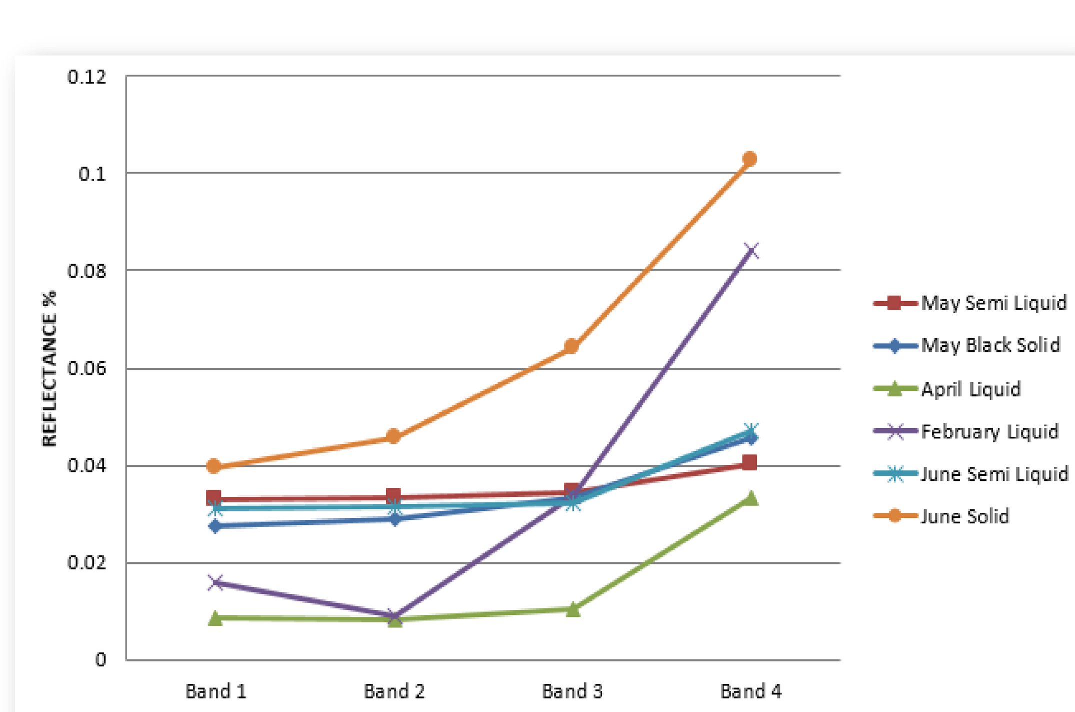

Figure 5. Reflectance spectral signatures from an Olive Oil Waste Disposal area in Western Crete.

4. DEVELOPMENT OF SEMI-AUTOMATIC METHODOLOGY FOR THE DETECTION OF OOMW DISPOSAL AREA

The final research approach of the study involved the development of a semi-automatic methodology for the improvement of time efficiency for detecting OOMW disposal areas with the use of VHR satellite images (Fig. 6; 7; 8; 9), (Table1).

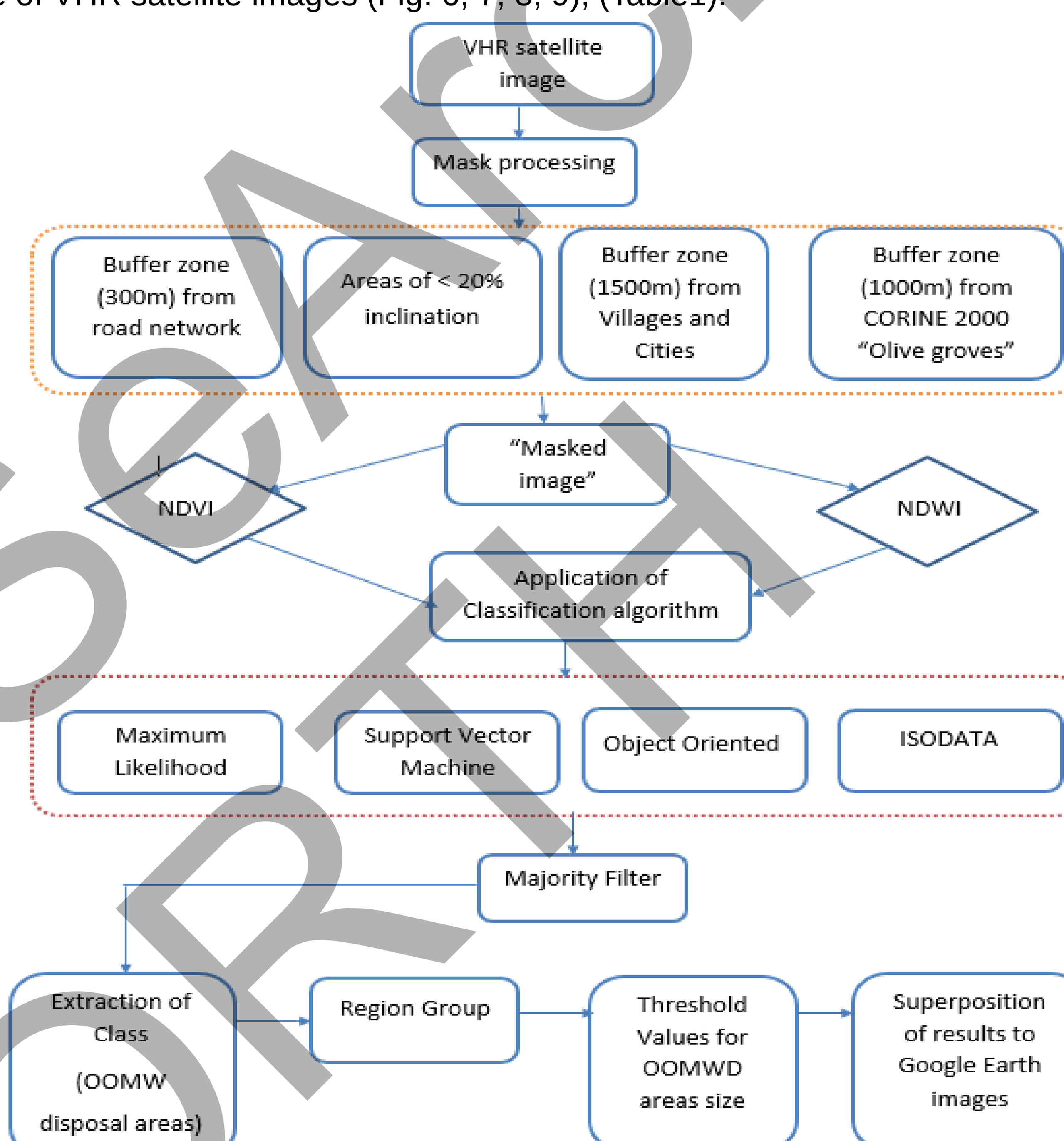

Figure 6. Flowchart outlining the methodology for semi-automatic detection of OOMW disposal areas

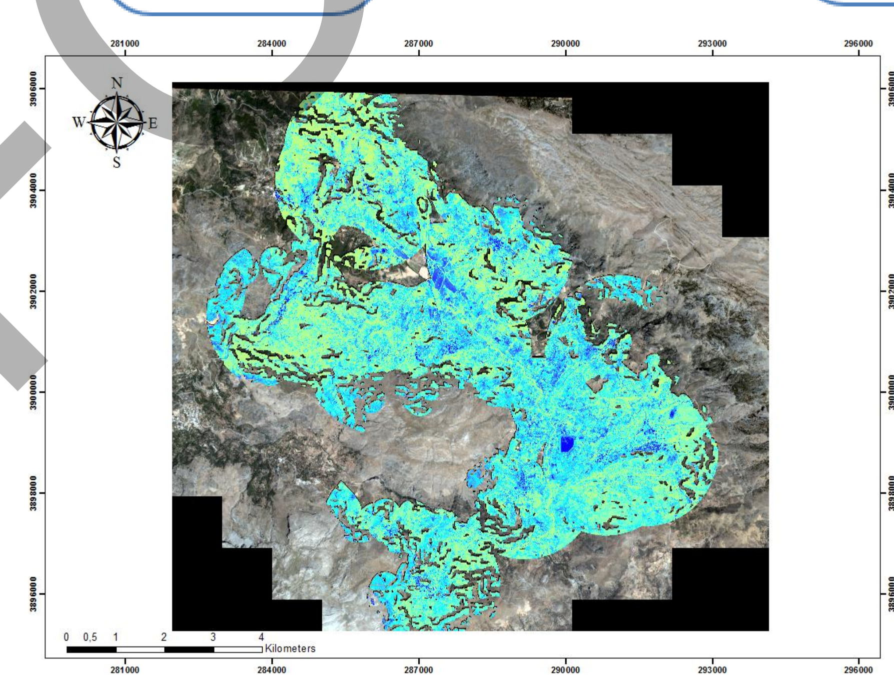

Figure 7. Comparison of study area extent before (grey area) and after (blue colour) the application of masking process

Classification methodology	Image 20/03/2007	
	Number of Detected Ponds	Number of pixels to be analyzed (Initial total number of pixels: 11.036.110)
ISODATA	13	13.460
SVM	12	15.763
ML	12	7.381
Object Oriented	9	1.919

Table 1. IKONOS images analysis statistics after Implementation of semi automatic methodology

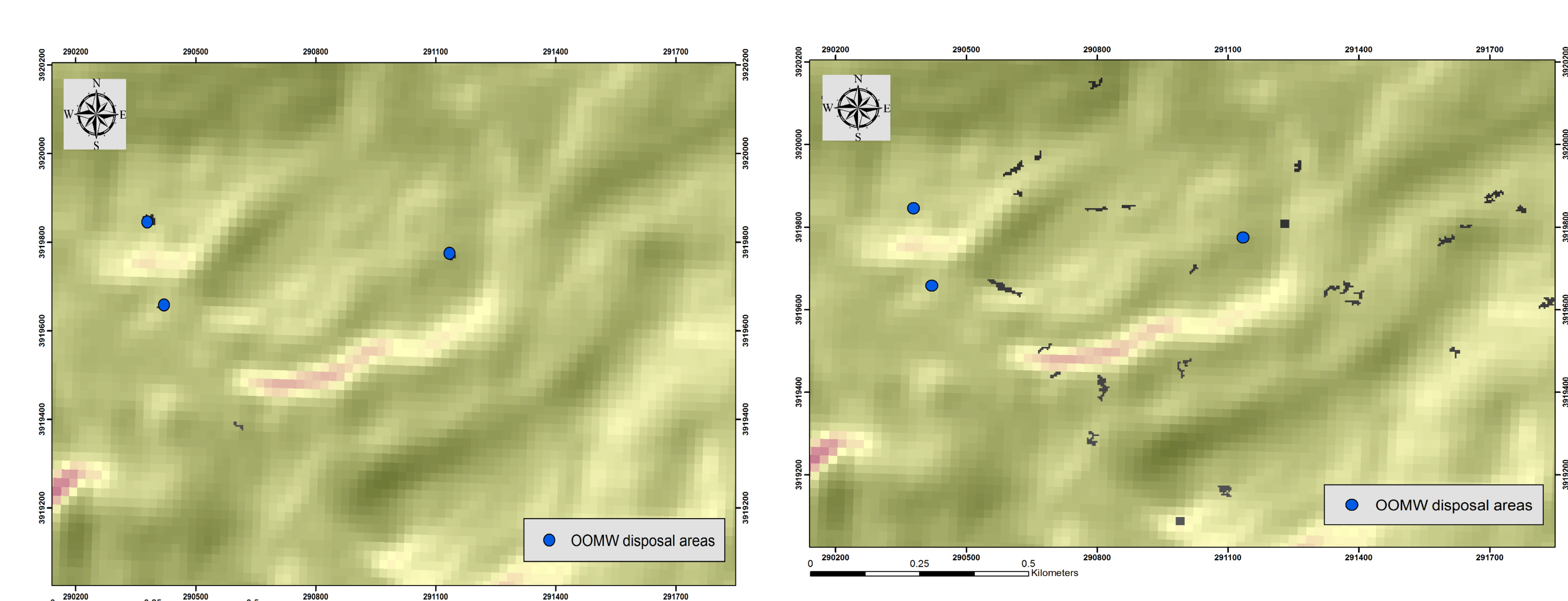

Figure 8. Application of different classification algorithms for the detection of OOMW disposal areas. The black pixels indicate the final detected areas (false or right). The blue circles indicate areas of already mapped OOMW disposal areas. Object Oriented algorithm (right). Support Vector Machine (left).

5. CONCLUSIONS

This study highlighted the application of satellite time series imagery in supporting semi-automatic detection of OOMW disposal areas in Crete. The results indicated that the integration of automatic or semi-automatic recognition methods based on both remote sensing and spectroradiometric data with the intervention of human operators and with spatially distributed geographic information is a necessity for the selection of the most likely contaminated sites.

ACKNOWLEDGMENTS

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