Determining Water Conservation attributes, their effects on Soil and Plants, Distributions in the Fields of Gharecharian using GIS and RS

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Abstract

Studying the quantity and duration of water supply and the degree of its effect on plant cover, in different parts of the distribution field of flood water is of great importance in order to properly manage the water distribution system. Here, the degree of success in using satellite pictures pertaining to the flood water distribution has been well depicted in connection with water supply map. Preparation was examined and the best band or combination of bands produced by processing Aster data was selected. The boundary map of the flood water distribution station in Gharecharian was prepared at first and the position of the constructed installation was drawn using GPS. In field operations, hydrometer station was used to measure the amount of flood water entering into the field. 15 graded rulers for measuring the height of water in distribution canals were positioned and 12 transmission gates were randomly selected to record the height of the water at the time of flood water distribution. Then an aerial field map was prepared according to the water height changes and also quantity of plant cover in different parts of the field. With the use of desired factor variance and correlating factor among pictures and also visual observation, six pictures were selected for the final classification from among the 18 acquired pictures from different groups. Inspection of the degree of precision for the classification was done by confusion matrix. The highest index calculated (83.5) was of Kappa Index for FA1, PC1 and MND which indicated that the mentioned combination have the most Consistent with the ground truth map.

1. Introduction

The study of the degree of water supply and the duration of conservation, interpretation of their effects of flood water on the different soil surfaces i.e. water distribution is very important. It is of great help in understanding the planning for the area that never been affected by any water or damaged by excess water, also the duration that water lodging. Proper distribution of water is not only increases the efficiency but also decreases the cost and the degree of damage to the structures. Normally, a significant amount of money is spent to restore and maintain them.

In recent years, the use of Remote Sensing and Geographic Information System has extensively been used in the preparation of the maps. Satellite pictures are useful to bring information together using different plant indexes, techniques to combine the satellite data, make use of main components and factors' disintegration. It is not a difficult task to comment on the locations of water supplies using chronicle satellite data, related to the time of water distribution.

Geograficky UstavSAV organization from Slovakia has used Land Sat TM data in a research project to expose water supply of surfaces of soils in southern parts of Danub's low lands. In this study, the water supply map of the region's soils was prepared using physical signs of water supply. They found four classes for the shape of surfaces of water supply soils. Some experts used Remote sensing data, draining patterns and total area of the water sheet in the field to determine the land/water boundaries.

Satellite pictures (NOAA, TM, and SPOT) were used in Gharb, Morroco between 1990 and 1994 in order to evaluate the function of drainage and flood water control. The maps of flooded area and flood water spreading were prepared and the places that had drainage problems were identified. In this research, indexes such as NDVI and IB were used. The quantity of IB being high or NDVI being low in an area was blamed on poor drainage.

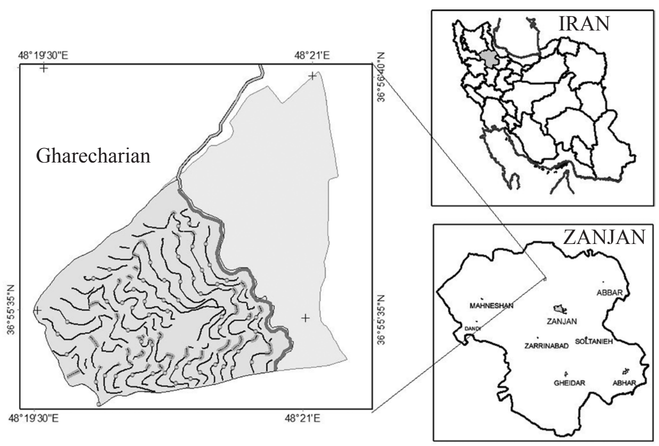
In this research the flood water distribution's effects on resources and plant cover were examined using Geographic Information System and Remote Sensing in addition to combination of bands resulted from processing Aster data.

2. Methods of Research

2.1. Geographic position of the studied area

The studied field was flood-water distribution station in Gharacherian. It is located 30 km NW of Zanjan city between 35^{0}48' to 36^{0}50' of northern latitude and 48^{0}15' to 48^{0}36' of eastern longitude (Figure 1).

According to meteorology station's statistics, the climate existing in the area is of the semi-arid type and the annual mean precipitation was 238.1 mm during 2004-07. The annual mean



temperature of the studied region is 11.5°C. Inspecting Sohrain plain Embrothermic's graph revealed that the temperature is quite high between April and September when compared with the annual temperature-precipitation correlation, therefore this period is considered arid period of the year (Khalafi, 2010). Pedology researches on the field showed that the soil on the surface of the field is mostly of average texture and contains 10-20% rubble stone. However, with increase in the depth, the soil turns to sandy soil that contains 40-50% rubble stone (Damavandi and Golchin, 1998). The area of the entire flood-water distribution field is 233 ha. There were about 23.3 km of stream, 36 small and big pools of water, 57 water gates and many mounds constructed. To deviate the flood water of Gharacharian's river, a dam was used to direct the water in the field through a 2100 m long canal. There is water supply usually for 30-80 days each year (mid-March to late May) from the river which indeed depends a lot on the annual precipitation. There was a need for on-time information in order to classify the data and maps acquired from the picture which was furnished through field researches. For this purpose, a GPS boundary of the station, position of distribution canals, embankments, little pools, gates etc. were first surveyed. Then the resulted data were transferred to ArcGIS software using DNRGARMIN's extension to produce our source map. Later, separate layers of information were produced for each one of the constructions, measuring tools and water transportation instruments. With regards to the layers of information produced and field scaling within the boundaries of the station, spots for installation of record keeping instruments and pieces for water height measurement were determined.15 graded rulers were placed and 12 water transportation gates were randomly installed to record the depth of water. In order to measure the quantity of water entering into the field and the excess water leaving the field, a hydrometric station was built at the entrance of the canal and a Limnograph was stabled established there to make the measurement of the height of the in going water possible (picture 1).

The measurements were taken place at designated spots since water entered the distribution field until it dried off. The Ground Truth Map was prepared using the collected statistics and field observations.

2.2. Processing the satellite pictures

Satellite pictures of ASTER from TERRA and 1-3 µm bands VNIR on May 9th, 2010 were used in this examination. First the pictures were geometrically compared with the studied area and were corrected to prepare the necessary data. To clip the satellite pictures in ILWIS 3.4, boundary station layer was used. Four groups of pictures produced from various analyses in different parts of the flood water distribution field were inspected in order to use satellite pictures (Table 1). Then the best pictures or combination of pictures from each group were selected for classification with regard to variance quantity, correlation coefficient amongpictures, optimal factor and visual observation.

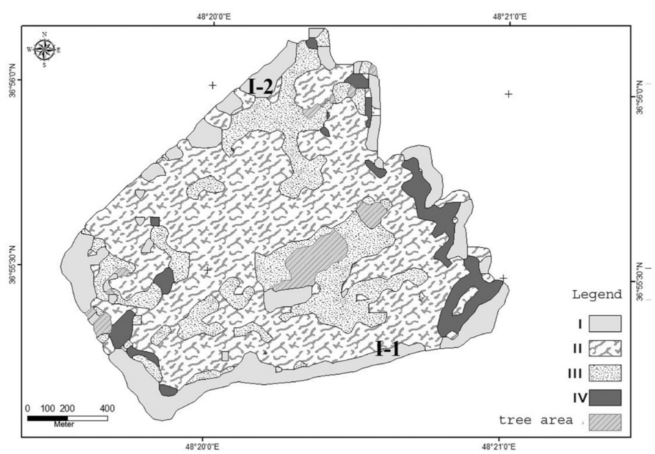
3. Results and Discussion

3.1. Ground Truth Map

Table 1: Different picture groups	
Main Group Pictures	b1 – b3
Pictures of main component disintegration	pc1 – pc3
Pictures produced from factorsdisintegration	fa1- fa3
Pictures acquired from plant indexes and ratio among pictures	MND,NDVI,RVI,SAVI

The degree of water-height changes in different parts of the field during the water distribution and after that was examined in the field studies. There were four different classes recognized according to the water supply degree, effectiveness and duration of water conservation for surfaces of soils. The Ground Truth Map was sketched using this information (figure 2).

Class I: In this part, less quantity of water is reached to distribution streams and as a result less water is distributed. Meanwhile, duration of water conservation in this part is less (part I-1). Graded rulers and established gates in this part indicate the entry of a high quantity of water. But because of the relatively



high slope of this region, the water is emptied quickly and the period of water stagnation decreases the positive effects of water distribution and plant cover density is also decreased as a result. In some parts, there is no proper water distribution because they do not get enough water (I-2). The area of this field was estimated to be 43.1 ha.

Class II: Water is distributed properly in these parts. Operation of the gates in these areas is relatively proper and water has been well transferred. But some of them functioned poorly and received less water. Plant cover in these parts is more than the last class. Area of this field is 141.1 ha.

Class III: In this part, water was distributed in accordance with the aim of designing a flood water distribution system. Water distribution was desirable while water supply was done properly. Position of established gates on embankment was in such a way that water was not emptied quickly and duration of water conservation increased. Operation of the gates was proportional to the quantity of water. The slope of these regions is about 3-5% and that is why water is slowly distributed on the surface of the field and as a result, the duration of water conservation is prolonged. In these parts, plant cover enjoys high density. The area in this field was 51.9 ha.

Class VI: saturated water supplied surfaces

This type of surfaces mostly contains little pools or valleys of water which is centralized there and water is flowing for a relatively longer period of time in the form of superficial or drainage. These little pools have turned into small ponds because of reduction in penetrability. Plentiful plant cover even in the form of trees and shrubs, such as: Pine, Willow and Manna are properties of this type of field. The area of this field was estimated to be 17.3 ha.

3.2. Maps produced from processing satellite pictures

Out of 18 acquired pictures from different picture groups, 6 pictures were selected for classification. Six three – pictured combinations of produced pictures were set aside for final classification and Minimum Distance Method was used to accomplish this. 15 produced maps from this classification were compared with Ground Truth Map using ILWIS 3.4 software in the end. The best combination of pictures from accurately classified point of view was introduced using confusion matrix.

3.2.1. Main pictures group

This picture group consisting of pictures b1 to b3 has 15 m of locality separation. They were clipped and examined using boundary file of floodwater distribution field, produced by geodesy using GPS, while necessary measures were taken to increase the contrast of these pictures using linear expansion method.

Pictures' variance and correlation coefficient among pictures were calculated (table 2 and 3) in order to select the proper bands. Then b3 was selected since it had the largest amount of variance.

3.2.2. Main components disintegration pictures' group

Combination of pictures b1 to b3 was analyzed inspecting the pictures of this group and pictures pc1 to pc3 were produced. In this method, variance–covariance matrix was calculated in a picture group first and using linear conversion a new group was produced. In this method, 2 or 3 prime parts (pc1 , pc2 , pc3) possessed more information and a larger variance and the next parts had less information and smaller amount of variance; a great deal of confusion was observed in the produced pictures (Table 4).

3.2.3. Factor disintegration pictures' group

Disintegration to factors follows similar objectives to Main components disintegration. The difference between FA and PCA method is that in PCA mathematical calculations is used while in FA statistics' Ratios are used as a special statistics model (Davis, 1986). Pictures b1 to b3 were analyzed using this method, too. In this group, fa2 and fa3 pictures were omitted because of low variance and vagueness. In the end fa1 was selected (Table 5).

3.2.4. Index calculation pictures comparison Groups

Different plant indexes, comparison of pictures and (IB) of the soils were calculated in this group. In order to select the pictures in this group, variance and desired factor were used (table 6, 7, 8) and in the end MND and SAVI pictures were picked out for classification.

3.3. Pictures' combination selection and classification

In this stage to select the most suitable 3-pictured combinations out of 6 selected pictures from different pictures' group, optimal factor was used. This index was calculated for all 3-pictured combinations. Then the first 6 combination which possessed the largest amount of optimal factor were selected for classification (Table 9).

Table 2: Correlation coefficient among pictures

	b1	b2	b3
b1	1.0	0.99	0.9
b2	0.99	1.0	0.89
b3	0.9	0.89	1.0

Table 3: Main Pictures' variance

Variance	2827.1	3003.3	5078.6

Table 4: Variance of pictures produced from disintegration to main components

	b1	b2	b3
Variance	9647.8	1028.6	1096.2

Table 5: Variance of pictures produced from disintegration to factor

	b1	b2	b3
Variance	9647.7	1028.8	1097.2

Table 6: Used Factors and their Equations

INDEX	Equation	INDEX	Equation
MND	(b3-(1.2*b3))/ (b3+b2)	IPVI	B3/b3+b2
NDVI	(b3-b2)/(b3+b2)	RVI(NIR)	B3/b2
IB	(b2+b3)*b3	Ratio1	B2/b1
SAVI	(1+L)/ (NIR+RED+L) ×(NIR-RED)	Ratio2	B3/b1
DVI	B3-b2		

Table 7: Optimal factor

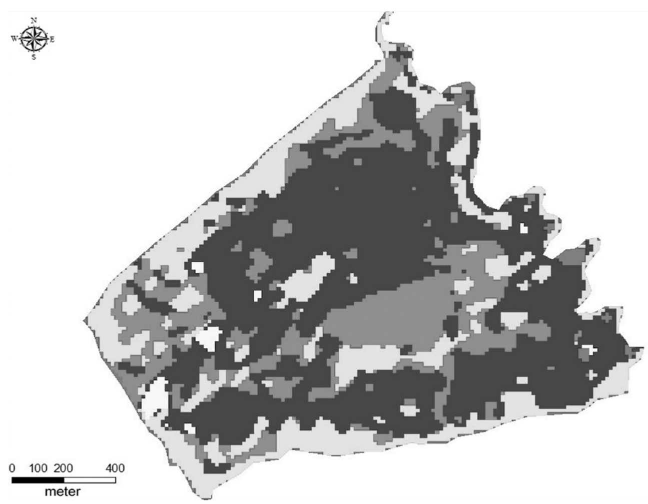
Combination	INDEX
SAVI & MND & Ratio1	91.7
SAVI & IB & Ratio1	88.85
DVI & SAVI & Ratio1	88.8
IB & MND & Ratio1	88.5
IPVI & SAVI & Ratio1	88.2
DVI & MND & Ratio1	88

3.3.1. Unsupervised Classification

In this type of pictures' classification, pixels are placed in specific groups on the basis of different bands' degree of brightness using a special algorithm. Next, according to the knowledge about the region, classes were recognized and separation confirmation of units was examined and justified. This classification was done for the 6 selected pictures 'groups. The produced results showed that only the pictures' combination of the third group (B3, FA1, PC1) among these six pictures' groups produced an acceptable map of the flood water distribution boundaries and also its distribution manner. The rest of the groups did not show any acceptable pictures. (Figure 3)

3.3.2. Supervised classification

In this method, classification of pictures was done using comparison of the quantities and spectral specification of each pixel with the specification already known to us. Hence, we needed information in connection with sample or training area which was provided through prior knowledge of the examined region



or through field observation. In this research, 282 samples resulting from the measurement of water depth in canals and gates were used.

20% of classified pixels in class (IV) pertained to little pools in which some of them had water until (mid-August). 7% of the classified pixels in class (I) were related to the parts in which water distribution had not taken place or little water had entered there. The steps taken in this part eventually lead us to select the minimum distance. Then the maps of the 6 selected pictures' combination were produced.

Examining the degree of classification accuracy was done using comparison of ground truth map with the six produced maps and the best combination of bands was determined using confusion matrix (Table 10, 11).

According to table 10, the highest percentage of average accuracy of classification for combined pictures (FA1, PC1, MND) was 83.5 and for combination of (FA1, RATIO1, MND) was 79.3 (figure 4).

The results acquired from analyzing the pictures, indicate the possibility of using Aster pictures in order to produce thematic maps in small regions of about 250 hectares. With regard to

Table 8: Variance of resulted pictures from indexes and pictures ratios

DVI	IPVI	SAVI	IB	MND	NDVI	RVI	Ratio1	Ratio2	Index
5807	4225	7205	5836	5868	3838	2215	5668	3532	variance

Table 9: Optimal factor for the first 6 combinations of picture groups

PCI, Ratio1, SAVI	PCI, Ratio1, MND	FA1, Ratio1, MND	B3, FA1, PC1	FA1, PC1, SAVI	FA1, PC1, MND	Pictures Groups
95.24	95.76	95,76	97.25	98.6		Desired factor

visual observation of the main pictures, picture of band 3 (infrared near VNIR) provided the highest possibility of single band interpretation in order to determine the position of distribution canals. FA1, PC1and MND had the highest degree of confusion matrix 83.5. This indicates that the mentioned pictures had the most unanimity with the Ground Truth Map (Table 12).

Replacing MND index by each one of the pictures or indexes in this group will cause the degree of classification activities ' accuracy to decrease.

Considering combined pictures which are the pictures possessing plant indexes, the relationship between the percentages of the plant cover's top and the manner of water distribution in the field is justified. Therefore, the plant cover's map can be used to interpret the manner of water distribution in flood water distribution fields or even to interpret water agricultural field. Comparing the resulted pictures of normalized power plant index (NDVI) with soil brightness' index and also field observations it was determined that the large amount of (IB) belonged to the places that water has not reached to, distribution of water has not been done properly, and as a result the surface of the soil contains thin plant cover. The large amount of normalized power plant index was related to the areas that flood water reached, the water distribution had been properly or like little pools water had stayed there for a while. The

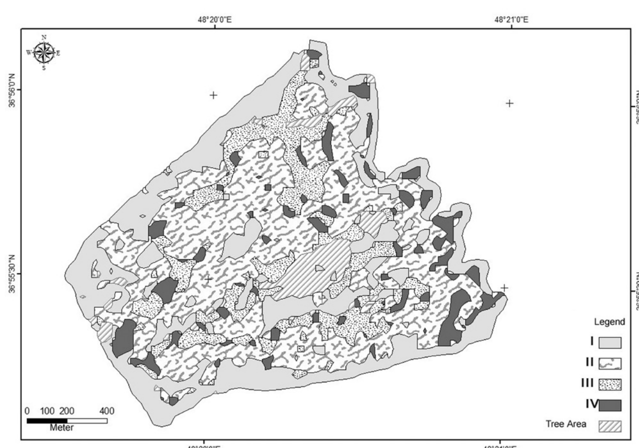


Table 10: Confusion matrix for combined pictures FA1, PC1, MND

Classification average accuracy percentage				Average Accuracy = 83.56%			
Classification Average reliability percentage				Average Reliability = 76.60%			
Classes				Accuracy percentage			
		I	Tree Area	II	III	IV	Accuracy
	I	1468	0	1	0	0	1
	Tree Area	7	433	0	0	0	0.98
	II	1375	0	3944	0	318	0.7
	III	499	140	122	1713	0	0.69
	IV	2	0	185	0	758	0.8
Reliability %	Reliability	0.44	0.76	0.93	1	0.7	

Table 11: Confusion matrix for combined pictures FA1, RATIO1, MND							
Classification average accuracy percentage				Average Accuracy = 79.30%			
Classification Average reliability percentage				Average Reliability = 76.60%			
Classes				Accuracy percentage			
		I	Tree Area	II	III	IV	Accuracy
	I	1406	0	61	2	0	0.96
	Tree Area	25	369	0	56	0	0.82
	II	937	0	4376	309	15	0.78
	III	109	128	404	1833	0	0.74
	IV	18	0	275	18	634	0.67
Reliability %	Reliability	0.56	0.74	086	0.83	0.98	

Table 12: Confusion matrix calculation results for selected groups						
B3, FA1, PC1	PC1, RATIO1, SAVI	FA1, PC1, SAVI	PC1, RATIO1, MND	FA1, RATIO1, MND	FA1, PC1, MND	Picture' groups
59.64	70.11	72.62	79.3	79.3	83.5	

water supply for Gharecharian flood water distribution field takes place until beginning of June through Season River. Therefore in many places in the field there is water flowing in the distribution canals until Mid-July.

There is water in some small basins' sources even until Mid-August. For that reason and considering high degree of humidity for many places in the field, heat data resulting from heat band can be useful in examining, the amount and duration of water supply and its effects on plant cover. Proper intermixture among Remote sensing, field work and Geographical Information system (GIS) can increase picture analyzing capabilities. GPS and ARCGIS were used to produce a highly accurate ground truth map in this research. Remote sensing is not beneficial and sufficient by itself. It will be useful only if it is done with field works and also geographical information system simultaneously.

4. Conclusion

Remote Sensing technique with highly accurate satellite data has the capability to assess the effects of water distribution. The highest index calculated (83.5) was of Kappa Index for FA1, PC1 and MND which indicated that the mentioned combination have the most Consistent with the ground truth map.

5. Related Literature

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