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Landsat Modeling of the Spatial Distribution of Water Quality Index Using Landsat Imagery

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Abstract. Most of the creatures for their life need for water directly or indirectly, and the human as part of the life of this system is no exception. Statistics show that the exponential increase in world population and consequently increase the need for water. Improper use of available resources is causing many problems, one of which is under water pollution, mostly due to a variety of urban sewage, industrial and agricultural. . This river is the most central of the snowy mountains of Chaharmahal va Bakhtiari province comes Zard and Koohrang. This river followes a path full of twists and turns in this city from the West into the province. For this reason, because in the long run from source to Gavkhoony wetland areas through agricultural, industrial and urban pollution will happen. Thus, the growth of pathogenic bacteria and algae, Aquatic River decay, insect-transmitted diseases, including the risk of possible contamination of the river. The use of pollutant water of the river in the agricultural sector makes imported agricultural products and various diseases in humans and animals are caused.

Keyword: Landsat, Water Quality, Modeling, Spatial Distribution

1. INTRODUCTION

Data and remote sensing techniques are widely used in past decades to evaluate water quality in different regions of the world have been used. Sntyny Federico et al. (2010) to assess the deterioration of water using satellite images and blur water as a water quality parameters have been considered. Wolpe et al. (2010) studied suspended sediment in the water using a simplified model of radiative transfer. Rndlvf Kyle et al. (2008) and Mark Matthews et al. (2010) used a method based on satellite data and remote sensing methods for early detection of biological risks Bloom Jlbg including aesthetic degradation of water resources, production stench and toxins that cause a risk to humans is presented. Since the field. It could use the chlorophyll concentration in water quickly and economically detect algae and prevent its adverse consequences.identification of algae bloom is costly It could use the chlorophyll concentration in water quickly and economically detect algae and prevent its adverse consequences. David Zavada et al. (2007) the concentration of TSS (total suspended solids), which is another water quality parameters, on the Chesapeake Bay from September 1997 to December 2003 were evaluated. In this study, the highest concentration of suspended solids in the winter and lowest in summer, were identified. Dyvfntvs Glafkv Hyjymytys et al (2010) using Landsat imagery and satellite data using statistical spectral relationships with water quality parameters to assess the quality of water in Cyprus paid back centuries. Therefore, the statistical relationship between satellite data and water quality index (WQI) hydrometric stations in areas with harvesting, quantitative data for the whole of the river water quality in river pollution dispersion maps provided. Finally, a spatial modeling related activities in the path of the river, such as agricultural, industrial and urban pollution intensity of their relationship determined.

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2. STUDY OF AREA

Almost the entire course of Zayande rood river from Shahrkord (longitude "55 '42 $_{o}$32 and latitude" 56' 46 $_{o}$50) to Isfahan (longitude "17 '56 $_{o}$51 and latitude" 5' 31 $_{o}$32) in this research study area is located. In this area the river passes through some cities such as: Shahrekord, Lenjan, Mobarake, Flavarjan, Khomeini Shahr and Isfahan. The position of 12 hydrometeric stations using for Zayanderood river monitoring are shown in fig.1.

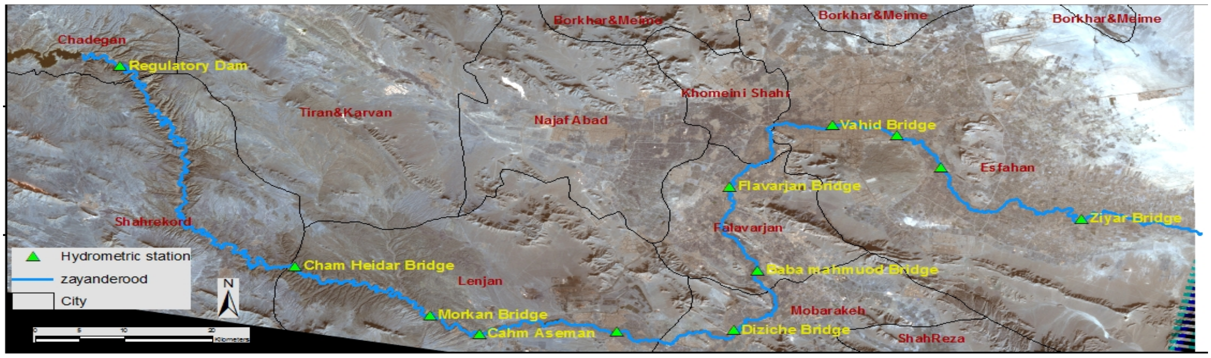

Figure 1. The study area and location of 12 hydrometric stations along the river.

3. SATTELITE DATA

In this study Landsat TM images for 29th desember 2010 was used. For information extraction from satellite images, image values must turn into radiance (hamm,2010). The recorded energy of a pixel is a function of incident energy, physical and chemical properties of an object.because of atmosphere and its effect, image interpretation is more complex. So atmospheric correction is necessary and radiance values must turn into emissivity which is the ratio of reflected energy to incident energy. In order to statistical modeling, the emmisivity of river pixels were calculated. To analyze the water quality in the station, water quality index was used. The index was developed by NSF[1] in 1970 and has been used in many studies of water quality. WQI for flowing waters and lakes used to be very good and also useful to quantify results in determining the water quality. WQI factors are measured to obtain the number corresponding to the index, are shown in Table 1:

Table 1. Parameters of water quality index.

Unit of measurement	Parameters of WQI	number
mg/L	(BOD) Biochemical oxygen demand in river	1
mg/L	(DO) Dissolved oxygen	2
Mpn/100	FecalCholiform	3
mg/L	(NO3) Nitrate	4
	pH	5
mg/L	Total solids	6
mg/L	(PO4) Tatal Phosphate	7
n.t.u	Turbidity	8

Using variables (Table 1) in the hydrometric stations, water quality index in equation (1) is calculated (Dadollahi,2009).

$$WQI = \sum WiQi \qquad (1)$$

[1] . National Sanitation Foundation

WQI: Water Quality Index

WI: Weight (0 100)

Qi: The number of quality index curves (0 100)

In this equation, several water quality parameters can be calculated and with a numerical value the quality of water can be determined. Since water quality is not a factor in measurable units, the above-mentioned equation requires a qualitative inference. The mechanism used to determine the relationship is standard curves and tables(Karimiyan, 2006). Classification of the index from 0 to 100 in five rated is shown below (Table 2):

Table 2. Water Quality Index Ranking (colors are based on standard norm).

Status	WQI
Excelent	100 91
Good	90 71
Medium	70 51
Relatively poor	50 26
Poor	25 0

parameters of water quality index in 12station in the river are in the table (8). As water spectral diagram (Figure 2shows, water reflecting is significant within the range 0.45-0.52 µm (green band TM), 0.52-0.60 (blue band TM) and so shows a different spectral behavior in these areas. After careful consideration of all spectral bands of TM, spectral bands 1 and 2 were selected for this study.

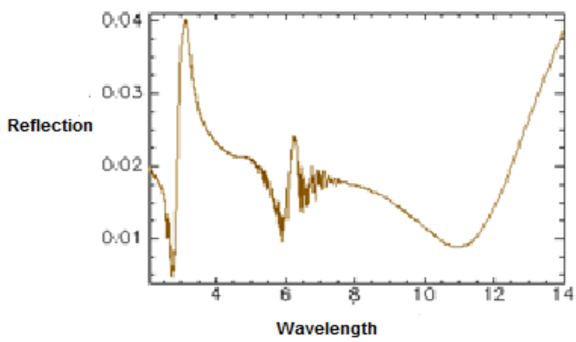

Figure 2. Spectral curve of water in the electromagnetic spectrum from ENV spectral library.

Table 3. 12 hydrometeric station WQI data of Zayande Rood River in January.

WQI	Index Band	Band2	Band1	Station name
88.40	14.	5.04	6.78	Tanzimi dam
73.10	35.	6.90	7.42	Cham Heidar bridge
70.90	36.	7.36	8.06	Morkan bridge
72.00	37.	8.29	9.13	Cham Asman bridge
68.20	38.	8.76	9.74	Zarrin Shahr bridge
61.30	37.	9.22	10.20	Diziche bridge
58.00	38.	9.69	10.84	Bab Mahmoud bridge
50.80	35.	11.55	11.91	Felavarjan bridge
48.00	31.	12.01	11.27	Vahid bridge
31.00	31.	12.94	11.91	Shahrestan bridge
23.60	34.	12.48	12.33	Choum bridge
24.50	31.	14.33	13.19	Ziyar bridge

4. METHODOLOGY

After gathering required sattelite information for modeling water quality, it,s necessary to show the relationship between variables in an equation. Linear regression is a method which calculates the relationship between variables and determines the Couse and effect relation between costant and dependent valuables.by regression intensity changes in a variable (function) per change in another variable (constant) is measured and the contrast is meaningless.

Y= a + bX, this equation shows a linear and also a nonlinear relationship between variables. In this equation *Y* is the function variable, *a* is the cross point where the line meet the *Y* axis, b is the offset which could be positive or negative and equals tagα، a is the angle of line to X and Y axis and is constant value.

$$b = tag\ \alpha = \frac{(Y_2) - (Y_1)}{(X_2) - (X_1)} = \frac{\Delta y}{\Delta x}$$

Therefor the above equation represents a straight line that connects points A and B (fig.3).

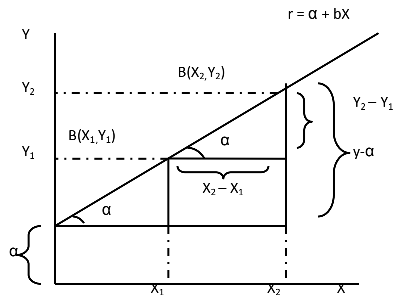

Figure 3. The equation of straight line axis.

In this study the water quality index assumes as a criteria or dependent variable and the values of spectral bands as a predictor variable were considered. Regression analysis is used for predicting one or more criteria variables of one or more constant variables. The multiple regression equation used in the equation (3):

$$Y = a + b1*X1 + b2*X2 +... + bp*Xp \qquad (3)$$

To accept or reject the regression equation in this study, Equality or inequality with zero regression coefficient test or β=0: H0 was used and tested by comparing the regression variances and deviations from regression. F represents the ratio of these two variance, if the calculated F is greater than the F for degrees of freedom table, then it is concluded that most of the diversity and distribution of Y values lie around the regression line. In other words, the regression line explains the diversity of observations. Figure 4 shows the distribution of b values under the null hypothesis and rejection and acceptance domain (Rezaei, 2006).

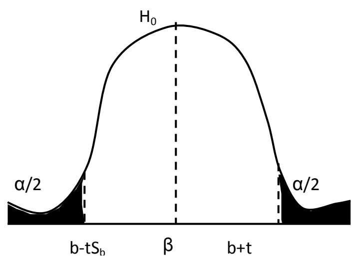

Figure 4. Domains to accept or reject the null hypothesis in the case β = 0: H0.

To determine accuracy of the relationship between water quality index and each band pixels cross validation method was used. In this method, at any stage, one of the measured data is removed from the equation that is useful for evaluating the accuracy of the model and then the relationship between the rest of data and the water quality index is calculated. This is repeated per the total number of water quality index. To determine the accuracy of the values were estimated between measured and estimated values (Darvishzade,2008).

5. RESULTS

Landsat TM5 bands correlation between index band and water quality index were obtained and The results are in table 5 that shows the high correlation between band 1 and 2 TM and WQI.but index band has no correlation with WQI. So to get regression model the bands 1, 2 and WQI was used which results is given in the regression model (Table 6).

Table 4. Correlation between variables.

Index band and WQI	And Band 1,2 TM WQI	variables
0.038	0.92	Correlation coefficient (R^2)

Table 5. Analysis of water quality index Regression variance with band 1 and 2 Landsat TM5.

F	Mean-square	Sum of squares	Degrees of freedom	Resource of changes
54.603	2198.218	4396.436	1	Regression
		362.321	10	Deviation of regression
		4758.757	11	Total

Because calculated F (603 / 54) is more than F table (9646/4) with ten degrees of freedom and with a confidence level of 5%, the null hypothesis that the regression coefficient is zero will reject. The result says that most of the variations in WQI values lie around the regression line. In other words, diversity justified the regression line well and much of the value points focus around the line (Fig. 5)

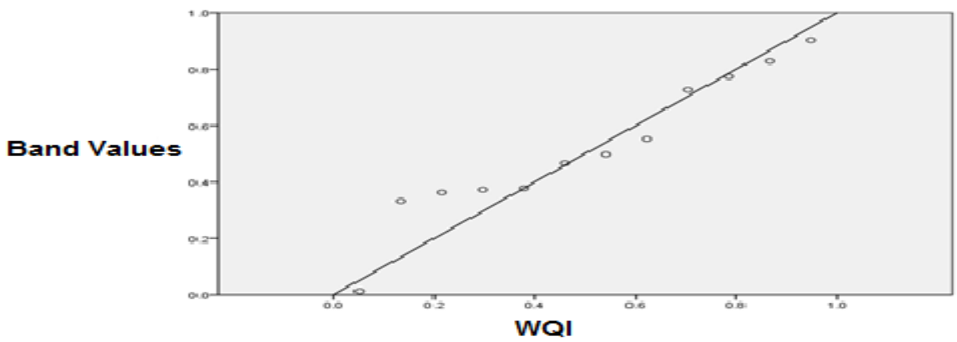

Figure 5. Landsat spectral bands 1, 2 and WQI values regression line.

After the regression calculation model for Band 1 and 2 Landsat TM5 and water quality index , accuracy was calculated using cross validation. The result of this method shows the high accuracy of this model. The result is shown in figure (6).

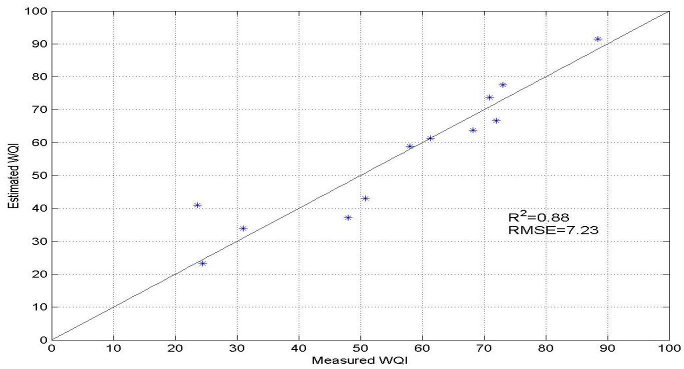

Figure 6. The results of cross validation.

According to the model extracted from the data, this model was applied for bands and output map shows the Zayanderood water quality index (Figure 7).

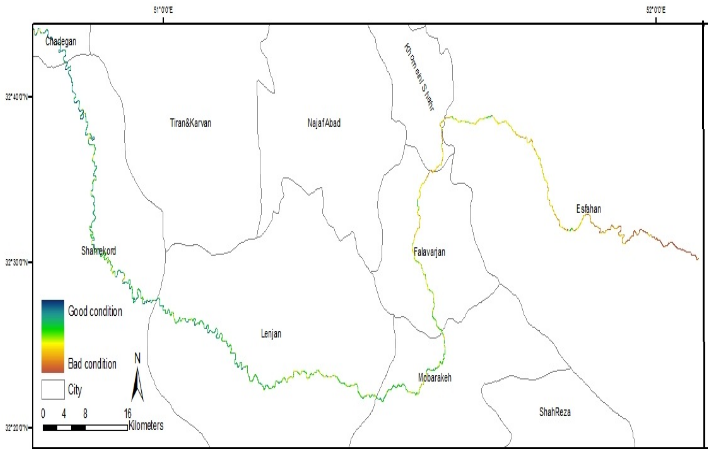

Figure 7. Water quality index of Zayanderood.

To study the river related to economic activity, the land use map for a radius of 6 km of river and its discharge assessed with water quality index in January(Tables 7 and 8). According to the table the most cause of the pollution relates to industrial urban areas and factories from Zarrinshahr Bridge to Felavarjan Bridge. Industrial and urban wastewater entering increase the river pollution. This has caused that the amount of TDS reaches to 2088 and this amount compared to the beginning of the river where TDS= 171 is very different (Table 9). As well as phosphate and nitrate levels have dramatically increased in comparison to other stations indicating that agricultural lands in these areas have intensified river pollution. Although there is no urban area from Shahrestan bridge to Ziarat bridge, there is a very high rate of pollution due to the very low river flow there. In places Where good water quality index exist, there are pastures at the beginning of the river and lower number of urban and rural areas high river flow and agricultural lands.

Table 6. Land use to a radius of 6 km river.

	Tanzimi dam	Cham heidar bridge	Morkan bridge	Cham asman	Zarrin shahr bridge	Diziche bridge	Babamahmood bridge	Felavarjan bridge	Vahid bridge	Shahrestan bridge	Choom bridge	Ziyar bridge
Pastures (dense, semi-dense, low density)	48296	17547	3860	2488	4433	3125	3760	2541	3961	4646	8202	82943
Agricultural land, dry and Gardens	8086	3948	4139	14837	9572	12231	11082	1124	4506	13929	9103	78276
Urban and rural areas	113		20	492		98	1566	4363	30			0
Industrial towns, large factories			22	130	693	249	1991	314	187	822		5286
Total	56495	21495	8041	17947	14697	15703	18400	8342	8684	19397	17305	166505

Table 7. Zayanderood flow in January 2009.

Varte bridge	Choom bridge	Felavarjan bridge	Babamahmood bridge	Diziche bridge	Morkan bridge	Cham heidar	Tanzimi dam	Station
0.392	5.99	3.48	9.73	7.57	2.84	19.20	14.60	Amount of discharge
16.30	23.60	50.80	58.00	61.30	72.00	73.11	88.40	WQI

Table 8. Results of the measured parameters of Zayanderood in January 2009.

Fecal coliform	Turbidity	T	EC	NO3	PO4	TDS	BOD	DO	pH	Station
Mpn/100	n.t.u	°C	ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L		
91	8	9.5	0.335	19	0.5	171	>5	3	7.20	Cham heidar
150	8.4	8.3	0.364	19.5	0.4	181	>5	2.6	7.24	Morkan bridge
230	7.9	9.5	0.364	19.5	0.4	183	>5	2.6	7.31	Cham asman
230	12.1	6	0.59	13.1	0.9	302	6.2	4.5	7.32	Zarrin shahr bridge
91	11.8	8.5	1	22	1.3	2088	>5	7.4	7.54	Diziche bridge
3600	10.1	7	1.06	22.9	1.4	553	>5	9	7.08	Babamahmood bridge
36	21.5	6	1.275	11.5	2.1	633	13.1	10.6	7.34	Ziyar bridge

6. CONCLUSION

In this study, the numerical values of bands 1 and 2 Landsat TM5 significantly related to quality of river water and river pollution. This study shows that pollution has a great impact on the reflections of water and it can be achieved with satellite imagery. Since the highest concentration of population exist around this so a significant amount of wastewater (urban, rural and industrial) is produced. And lack of attention to proper elimination and refined of each of the items mentioned in the river could endanger the environment.
From Zarrin bridge to Felavarjan bridge were set as the largest source of pollution due to

discharge of industrial and human waste in Zayanderood. Especially at times of year when the water is flowing in the river bed the pollution causes severe pollution and makes it it even more difficult for agriculture. We recommend to use other satellite images with high resolution and extract water quality index. So water Spectral reflection with suspended solids in it is detected.

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