Spatial Distribution of Some Macro and Micro Nutrients in Relation to Land Evaluation Classes in Undulating Bushland Valleys of Melbourne Area

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Abstract: *Fourteen locations for soil samples were selected from bushland valleys of Melbourne area to represent an undulating landscape where soils positioned on different settings of landforms to study the geo-spatial distribution of some available macro and micro nutrients in soil and their relation to some topographical features. Measured nutrients were available nitrogen N, carbon C, phosphorous P, potassium K, calcium Ca, magnesium Mg, sodium Na, manganese Mn, iron Fe, sulfur S, copper Cu, barium B, aluminum AL. these nutrients showed different geo-spatial distribution due to soil properties and topographical features. High amounts of Aluminum and iron were available in soil due to the mild acidic reaction in soil also, calcium occurred in some noticeable values where that was related to the origin of the parent materials in the area of study. pH and Organic matter were the main two soil properties that influenced the availability of macro and micro nutrients. The hierarchical analysis showed three grouping of soil variability, The first group included N, Cu, Na, P, C, B, S, K, and Mn, and the second group was Fe, Mn, K, and S. Mg and Al were classified together and Ca was a whole one group. Elevation and flow accumulation were the most topographical features influencing the distribution of nutrients in soil. Another regression analysis was done to find the relationship between land evaluation classes and the spatial distribution of nutrients in an attempt to see the dominance of nutrients in relation to land evaluation class.*

Keywords: macronutrients, micronutrients, land evaluation, variability, GIS

1. Introduction

Zonneveld 1983 has reported that evaluation of natural resources based on natural resources surveys is necessary to obtain the optimal land use to stop and prevent deterioration. Also FAO 1984 stated that the basis of land evaluation is a process of comparison between lands and their uses where decisions should be made for the use of lands that they are always part of human society. And to reduce human influence on natural resources and identify a suitable land use, there are some essential land evaluation processes to be carried out scientifically (AbdelRahman et al 2016).

Land evaluation is only part of the process of land use planning (Oldmen et al. 1991, FAO 1979) where the process of land evaluation plays a major part in formulation of proposals, recognition of delineation of land use types present in the area of study, and the comparison and evaluation process of each type of land for different uses. Rossiter 1994 described evaluation unit as they are always map units of soil resources inventories, and they are usually of soil surveys suitable for farm plans. Therefore some evaluation process are done for purpose uses, where Kavitha and Sujatha 2015 have done an evaluation process of soil fertility status in different agro ecosystems in India, where macro and micro nutrients levels were measured to be evaluated in those different ecosystems where they found significant differences in levels of macro and micro nutrients.

The main objective of land evaluation is to forecast the ingrained capability of a land unit to hold up a specific land use for a long period of time without deterioration (Eze 2014). Uses of lands can be done when the suitability of land is available, besides the spatial data that is needed for the agricultural development of land resources potentials (Suryana et al 2005).

Kumar and Somashekar 2014 studied the spatial distribution of macronutrients in some river basin soils in India, where they found that there was not much variation in soil fertility status developed on different landforms in the area, but they found some differences in organic carbon content in soil from 0.05-1.5 %. Understanding spatial distributions of macro nutrients and impact factors can be helpful to practice some specific magnitude to modify the availability of macronutrients for soil ecosystem management, thus Qu et al 2014 found that the availability of macronutrients is controlled by multiple factors, and they are spatially varied.

Verma et al 2005 collected surface samples to analyze the spatial distribution of macronutrients in soils of arid tract of Punjab, India and they revealed that there is a wide variation in soil fertility status of soils developed on various landforms, also they were low in N, P content, and medium to high content of K.

Sokouti and Mahdian 2011 studied the spatial variability of macronutrients for soil fertilization management in Urmia plain, Iran, where they used the geospatial techniques in GIS system to evaluate that. Krigging method using Gaussian semi variogram was found to be precise in estimating and interpolating nutrients rates in soil. Also Wang et al 2009 used the geostatistics and geographic information systems to study some nutrients affected by some factors and their spatial variability n cropland in China, where they found that the experimental variogram of the log-transformed data of soil organic matter, total nitrogen and extractable

phosphorus was fitted with an exponential model, while soil extractable potassium was fitted to a spherical model.

Sharma et al. 2010 investigated the profile distribution of total extractable micronutrients (Zn, Mn, Cu, and Fe) in soil developed on six physiographic units of semiarid area in India where none of the micronutrients exhibited any consistent pattern of distribution with depth on different geomorphic surfaces, besides Contents of all micronutrients and their forms were higher in fine-textured and uneroded soils than in coarse-textured eroded soils where soil texture is mainly affected by slope and physiographic position. The study of Bulta et al 2016 showed that the means of all micronutrients except Boron showed significant differences among Damboya, KedidaGamela and KechaBira Districts, KambataTambaro zone, Southern Ethiopia and showed moderate spatial dependences, and the range of semivariogram for all studied micronutrients was greater than the average sampling distance indicating that it was adequate enough to catch spatial variability of them.

The main objectives of this study is to Measure soil content of macro and micro nutrients important for plant growth, and Mapping them spatially, besides testing the relationship between land evaluation classes and spatial distribution of measured nutrients. Where questions of this study were aimed to be answered as is there a relationship between nutrients content in soil and their land evaluation classes? And can one or a combination of these nutrients control land evaluation classes? And changing the class to a different one?

2. Materials and Methods

Sampling logistics:
Area of study was selected because it represents an undulating landscape where soils positioned on different settings of landforms. The reason is to study the effect of elevation, slope and some other topographical features on the distribution of soil elemental contents.
The area of study was covering 10,000 Km^2, samples were selected depending on topographical features of the area where diverse topography been put in the consideration of sampling location.
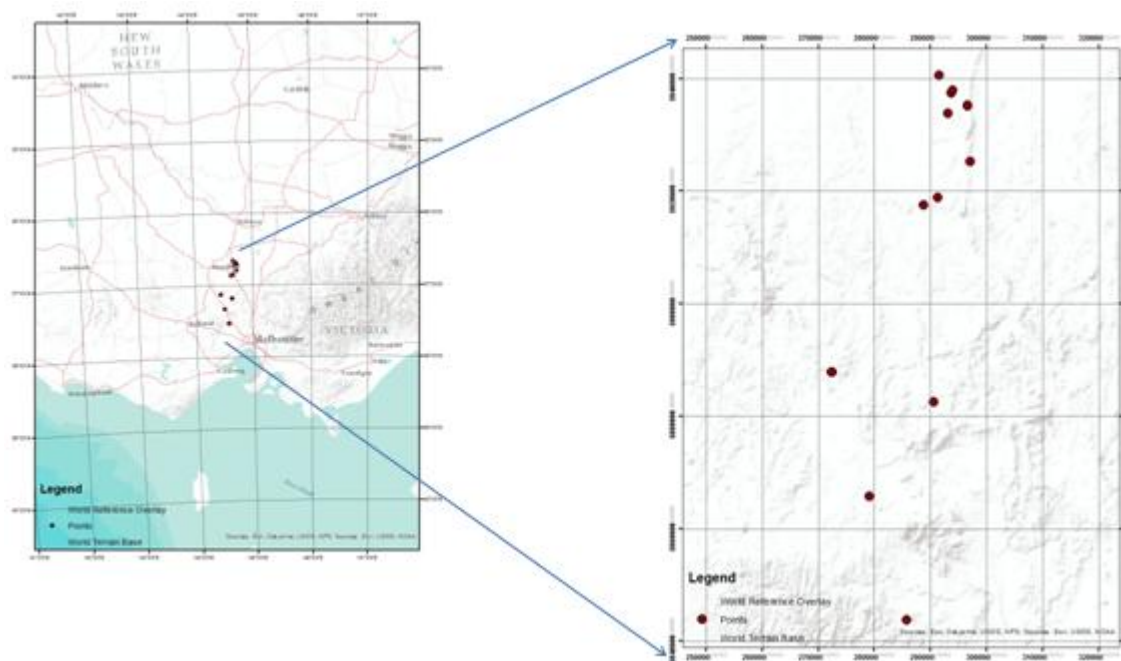

Figure 1: Area of study and samples location

Measurements:
Soil properties:
Physical properties: Soil Texture, Clay, Silt, Sand, P.W were measured due to Black 1965

Chemical properties: PH, EC, ESP, HCO3, CO3, O.C, O.M, Gypsum, CaCO3, CEC meq/100g soil were measured due to Richards 1954.

Macro/Micronutrients analysis: available nitrogen N, carbon C, phosphorous P, potassium K, calcium Ca, magnesium Mg, sodium Na, manganese Mn, iron Fe, sulfur S, copper Cu, barium B, aluminum AL were measured in soil samples due to Johansson et al 1996

Topographical features:
A DEM was created from LiDAR data collected for the area of study of resolution of 25 by 25 meters of a pyramids level: 6, resampling: Nearest Neighbor. And cell size of : 0.00027777778, 0.00027777778. andGCS D_WGS_1984. Topographical features extracted from this DEM were: elevation in meter, slope, flow direction, and flow accumulation due to protocols of ArcGIS 10.3 (ESRI, 2013). Table 3 shows the topographical features of sample locations.

Table 1 shows the Topographical features extracted from this DEM

Pedon no	east	north	elevation	slope	flow direction	flow accumulation
1	290581.2	5882530	672.555	89.986	16.000	4.835
2	297054.4	5925232	193.715	89.962	1.000	96.769
3	296598.8	5935145	275.558	89.986	16.000	6.192
4	296591.1	5935199	273.151	89.987	16.000	5.713
5	293732.7	5937433	186.959	89.951	16.000	16.808
6	293892.8	5937851	189.077	89.953	32.000	13.686
7	291588.4	5940506	167.122	89.770	32.000	123.641
8	293072.1	5933810	188.639	89.900	64.000	20.673
9	291319.1	5918773	249.867	89.968	64.000	19.966
10	288799.3	5917478	226.695	89.983	8.000	10.153
11	272451.4	5887843	406.539	89.980	34.834	1363.864
12	272393.7	5887796	405.156	89.979	64.000	295.435
13	290059.2	5918126	238.281	89.976	36.000	15.059
14	272422.6	5887819	405.847	89.980	49.417	829.650

3. Results and Discussion

Soil Properties
Table 2 shows soil properties of the studied samples, and they show that sand was a major component of the particle size distribution, and that could be related to the glacial parent materials that these soils were derived from. Beside locations was featured with amounts of rocks and cobbles in soil profile, where soil texture was ranged from loamy sand to sandy clay loam.
Clay content was not as high as other separates, and that influenced the values of CEC where they were low consistently.

pH values were widely varied, it ranged from slightly acid (6.37) to strongly alkali soils (8.98) and that affected the content of the available macro and micro nutrients in soil (see table 3). Soils with dropped pH showed lower content of lime due to the acidic soil condition that inhibit accumulation of lime in soil, it was also noticed that the lower pH value, the higher organic matter in soil, where organic matter content could be a controller to pH values due to the acidic compounds of the organic matter where it ranged from 12.5-61.5 gm.kg-1 soil.

Lime content ranged from 0.64-72 gm.kg-1 soil. It showed a wide variation within landscape. Lime content was also related to pH values and organic matter content where the lower values of lime showed higher pH values and content of organic matter. Gypsum did not show any significant content in soil due to the high amounts of precipitation received in these soils the matter that leached this compound in soil.

Table 2: Measured soil properties of the studied area

ID		%			dS/m	%	gm.kg-1	gm.kg-1	gm.kg-1	gm.kg-1	Cmolec/100gm soil
	Texture	Clay	Silt	Sand	PH	EC	ESP	O.C	O.M	Gyps-um	CaCO3	CEC
1	LS	8.3	5.55	86.15	7.06	21.6	6.809	0.86	1.5	0	17	10.7
2	SL	13.84	5.54	80.62	7.15	10.7	16.881	8.342	4.85	0	4.14	11.7
3	SCL	30.86	7.42	61.72	7.35	17	25.293	3.87	1.25	0	72	13.37
4	LS	5.67	11.37	82.96	7.16	21.5	19.088	4.128	2.4	0.001	49	15.51
5	SL	10.94	20	69.06	6.98	22.8	12.705	4.558	2.65	0.001	0.64	9.63
6	L	36.9	22.71	40.39	8.98	34.5	20.291	6.278	3.65	0	17.1	11.77
7	SL	18.87	14.44	66.69	7.14	95.9	6.725	6.45	3.75	0	24.8	11.23
8	SCL	20.17	28.83	51	6.98	35.4	13.625	4.816	2.8	0	22.1	14.44
9	LS	8.43	19.69	71.88	6.85	18.4	4.339	5.16	3.0	0	40.4	10.16
10	SCL	22.06	22.08	55.86	8.26	17	2.593	13.158	7.65	0	4.07	9.09
11	CL	32.26	29.35	38.39	7.26	10	4.467	2.666	1.55	0	18.5	10.7
12	SCL	28.76	20.49	50.75	7.42	97.2	20.23	2.58	1.5	0	19.4	13.37
13	SCL	24.62	19.14	56.24	6.77	82.9	7.0736	8.686	5.05	0	7.3	10.7
14	SCL	13.59	20.35	66.06	6.37	24	9.746	10.578	6.15	0	5.5	16.05

Available Macro/Micro Nutrients analysis:
Available elemental analysis of macro micro nutrients were conducted, availablenitrogen N, carbon C, phosphorous P, potassium K, calcium Ca, magnesium Mg, sodium Na, manganese Mn, iron Fe, sulfur S, copper Cu, barium B, aluminum AL were measured. Table 3 showed the available elements in soil samples. Table 3 shows that the content of nitrogen was low because these soils are virgin and not used for cropping system, the reason when compare to soils used in cropping, it reflects low levels of nitrogen content. The

possible losses of that element could be related to leaching as nitrate more of volatilization as ammonium due to the high amount of received precipitation (Valiela and Teal 1979). Phosphorous content was higher than what is expected in soils without fertilization (virgin soils) and that also could be related to pH ranges of soils. Phosphorus was directly affected,where in alkaline pH values, greater than pH 7.5 for example, phosphate ions tended to react with calcium and magnesium to form less soluble compounds (Grant et al 2001).

Potassium, and Sulfer are major plant nutrients that appear to be less affected directly by soil pH than many others, but still are to some extent, they were showing a relative high contents in some sites, where potassium contents varied from 0-34 mg/l, and sulfer was higher than what average soil content of that element is where it varied from 1.8-9.9 mg/l. Most of the other nutrients (micronutrients especially) tend to be less available when soil pH is above 7.5, and in fact are optimally available at a slightly acidic pH, e.g. 6.5 to 6.8and that what was reflected when we look at the content of Fe

and Al where they showed high content, because of the mildly acid and neutral pH soils were(Bohn et al 2002)

Sodium did not show high content as for it was washed out from the exchange complex due to the high amount of precipitation received in this area, but calcium and magnesium content did not show that behavior, where that could be related to the origin of the parent material, and the original content of carbonate compounds in the soil (Jenny 1994).

Table 3: The Macro/Micronutrients analysis of soil samples

ID	N	OC	P	K	Ca	Mg	Na	S	Mn	Fe	Cu	B	AL
1	0.2	2.6	0.9	1.2	71.4	24.7	0.6	9.5	8.2	50.7	0.2	0.1	63.7
2	0.2	2.2	0.2	0	176.2	64.3	0.6	9.4	22.6	15.8	0.4	0.02	92.5
3	0.32	3.4	2.1	1.8	251.4	103.6	1.6	9.8	31.2	16.2	0.8	0.05	86.5
4	0.35	3.7	0.8	0	193.8	96.5	0.6	9.4	27.9	8.9	0.6	0.1	70.3
5	0.18	2.3	1.7	12.9	117.3	31.3	0.4	9.7	4.4	45.4	0.2	0.04	47.9
6	0.22	2.6	2.5	9.7	197	37.2	0.4	9.9	23.8	19.4	0.2	0.1	57.3
7	0.16	2.0	0.9	8.8	62.9	30	0.4	9.6	22.9	16.6	0.2	0.0	54.4
8	0.27	3.0	2	34	102.6	56	1.4	9.8	8.7	31	0.2	0.0	62.2
9	0.2	2.2	4.7	6.4	40.2	15.3	0.4	9.2	5.2	58.8	0.2	0.01	35.6
10	0.19	2.0	0.7	5.1	24.7	16.7	0.4	9.1	6.5	25.4	0.1	0.05	39.4
11	0.37	4.2	1.4	8.2	41	19	0.4	9.3	11.7	16.4	0.1	0.05	89.5
12	0.36	4.0	0.9	3.5	21.2	12.9	0.4	9.5	3.7	31.6	0.1	0.1	41.8
13	0.08	1.0	1.8	5.8	95	73	0.4	1.8	15.4	29.1	1	0.05	51.8
14	1.1	5.5	0.1	9.3	98.2	149.6	0.4	9.4	10.9	21.3	0.4	0.05	47.3

Spatial distribution of macro/micro elements:
Macro and micro nutrients, Nitrogen, and organic carbon were geospatially plotted using Inverse Distance Weighting

(IDW) deterministic method (ESRI 2013). Figure 2(a-l) shows the spatial distribution of macro and micro elements in the studied area
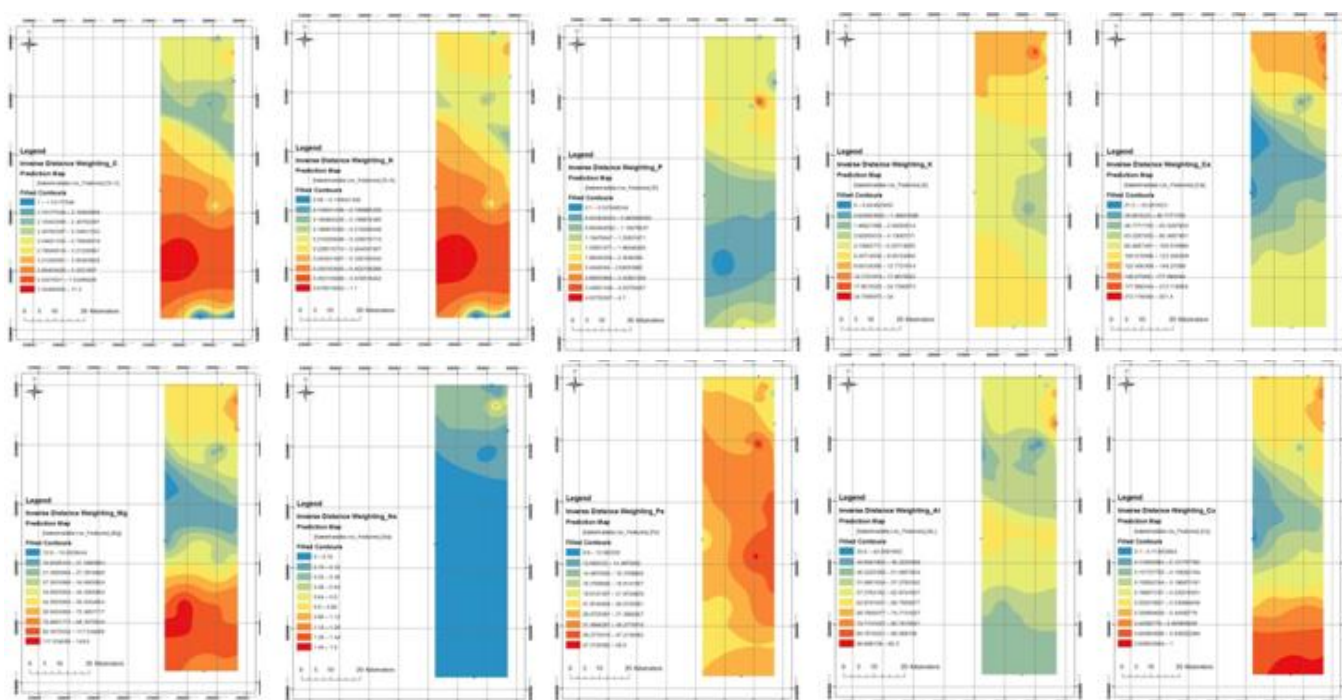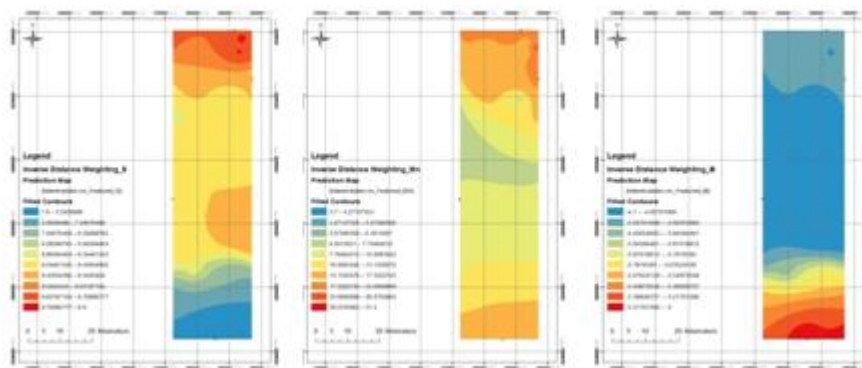
Figure 2: Spatial distribution of macro and micro nutrients

The overall variability that could be noticed from figure 2, is that elements were varied differently, some of them showed similarity in variability the matter that we can divide them into categories, ten classes were selected in the procedure of IDW used for mapping contents and variability of the area of study soils but these categories differed in how they plotted spatially.

A cluster analysis results showed thatdendogram tree of group variables of micro/macro elements content in soil (figure 3).Four groups were clustered. The first group included N, Cu, Na, P, C, B, S, K, and Mn, and the second group was Fe, Mn, K, and S. Mg and Al were classified together and Ca was a whole one group.

Although the N and C showed same variability so far, and that could be related to the C/N ratio of soils where they were mostly homogenous, besides the same climate conditions of the area of study (add reference confirming such result). Also, some other elements were included in this group and that could be related to low content of these elements in soil the matter they were clustered together.

The other group of micro/macro elements included Fe, Mn, and K and these elements were showing closer concentrations in soil, the matter they were clustered together, also clustering could be a result of the fact of availability of these elements as they were discussed in previous paragraph.
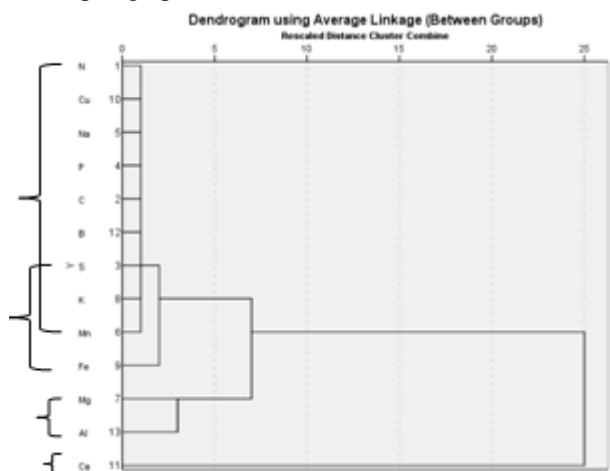

Figure 3: Dendogram tree of element grouping in clusters

Land Evaluation and suitability for crop production:
Table 3 shows the suitability class of each pedon for crop production for different grain crops where the limitation

factor was the slope only where soils were not showing other limitations such as salinity because the area of study is receiving quite good quantities of precipitation the matter that leach salts from soil, therefore classes were determined due to slope factor as shown in table 3.

Most of suitability classes were N1 class because of the main topography of the area of study is being undulating bushlands that makes the slope the main limiting factor. Also there was matching in suitability classes for wheat and barley grain crop in all points of study, and that is related to the fact that limitation factor is affecting these crops the same (figure 4).

Pedons 7-10 showed different classes of suitability because they are geographically lay in less undulating areas of the whole bushland valley, the matter that enhanced class N1 to S2 and S1.

The dominant class that shown in the area of study was N1 followed by S2, S3, and S1. Class N1 does not show good suitability for grain crops production where this class is suitable for other purposes other than farming (sys 1980) while class 2 is mildly good for crop production and S1 is super suitable while S3 shows more slope limitations where it was more undulating and steep than the other classes. Therefore

Table 4: Land Classes due Slope as a Limiting Factor

Crop	Wheat	Barley	Rice
Limitation	Slope		
Pedon no.			
P1	N1	N1	N1
P2	N1	N1	N1
P3	N1	N1	N1
P4	N1	N1	N1
P5	N1	N1	S2
P6	N1	N1	S3
P7	S2	S2	S2
P8	S1	S1	S2
P9	S2	S2	S2
P10	S2	S2	S2
P11	S1	S1	S3
P12	N1	N1	N1
P13	N1	N1	N1
P14	N1	N1	N1

Inverse distance weighting method under geostatistical analysis was used to interpolate the prediction map of land suitability classes. Figure (4) shows the prediction map of

land classes for wheat, barley, and rice crops. It is very clear that wheat and barley have the same land classes while rice was different, and the reason could be related to the fact that wheat and barley are share the same impact for some limitation other than slope such as salinity, soil depth etc., the matter that led to have the same spatial distribution of classes. Moreover, rice is more affected by slope because slope is affecting the movement and quantity of water for plant rotation, therefore different classes were shown in this prediction map.

It is important to mention that major land class was not suitable for cropping (N) could be related to the fact the way land class was evaluated through, where the multiplication method suggested by Sys 1980 is always going low in values because of the multiplication processes where the more small fractions multiplications, the smaller value will be resulted, that leads to low values eventually, then land class will be also low.
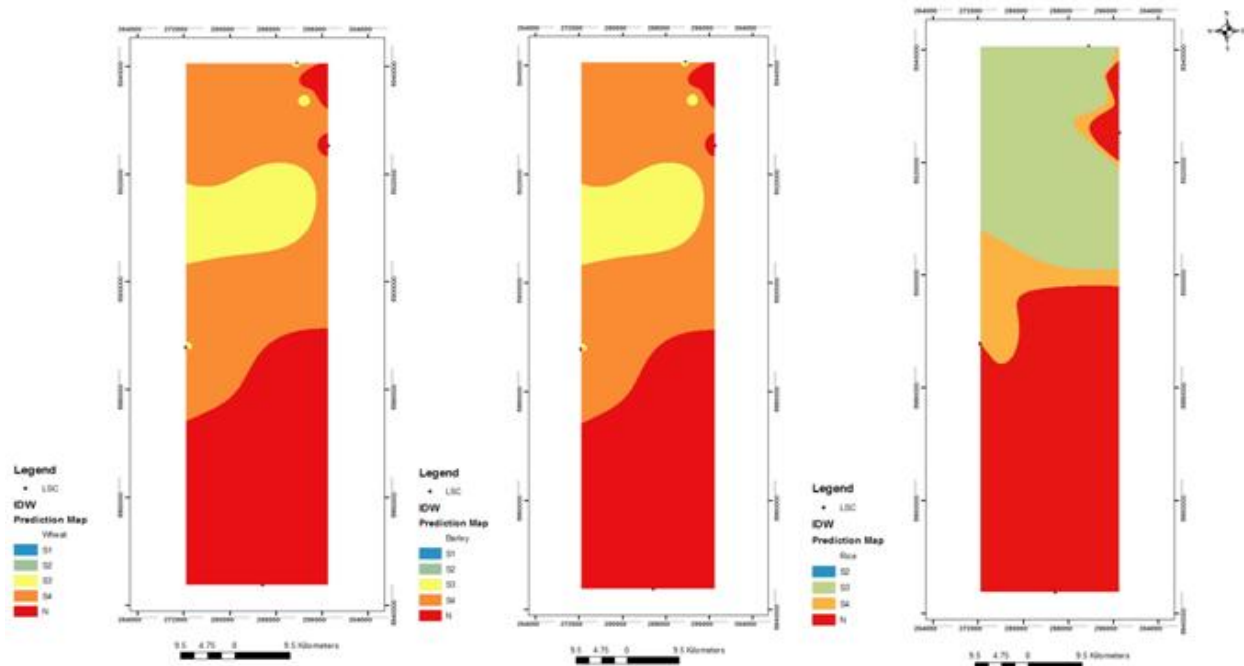

Figure 4: Land Suitability Classes for Wheat, Barley, and rice crops

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