Application of GIS in Gezira Scheme and Managil Extension in Sudan

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***Abstract*– The utilization of Geographical Information System (GIS) in agricultural projects can assist in decision making, planning and development. In this study GIS has been applied in Gezira scheme and Managil extension project for the first time in Sudan. Soil, information was collected to be used for determination of suitable areas for growing suitable crops. Thematic maps of scale 1:2,000,000 was produced showing soil type, soil property, cultivated crops, farms, canalization system, roads, towns, blocks, and the groups of the scheme. Database and attribute tables was developed. Some relationships between land suitability in salinity and sodicity with crop requirements was created. Analysis and results showed that some new crops can be cultivated in the scheme such as sugar cane, barley, acacia, maize and fruits. Moreover, some extracted information could assist in understanding human behavior so that it could be modified and improved to reduce the effort of production of people and government towards improving human health and to make mere sustainable development.**

***Keywords*–** GIS, Gezera Scheme and Managil Extension, Salinity and Sodicity Factors

I. INTRODUCTION

Few agricultural ventures in the developing world have evoked as much international attention as Sudan's Gezira Scheme. It has some major characteristics such as:

i. It is pioneer and successful experiment in the field of direct foreign investment in export oriented production in the third world.
ii. Widely known as the Sudan's most successful economic scheme.
iii. It is sheer size over two millions acres.
iv. For long, Sudan government greatly depends on the scheme for its hard currency returns when exporting crops.
v. It was the earliest proof of the visibility of shraka and muzara (partnership),

This research work aims to use modern systems to assist in orientation of agricultural polices and provide a new approach to agricultural system applications by developing and utilizing GIS in determining the suitable soil for a certain crop and possibility of cultivating new crops.

II. GEZERA SCHEME

The Gezira scheme is a vast plain with few isolated rocky hills in the Southern part. Relatively high land stretch from Sennar to Managil and from Wad Elhadad to El massed with varied from 3 – 15 kilometers from the Blue Nile. The Gezira scheme is almost flat with very gentle slope from South- east to North- west, the difference in level is varied from 405 to 420 above mean sea level. The land holds the best condition of the general slope of 15cm per each kilometer towards the White Nile. The topographical phenomenon of the Gezira scheme facilitates irrigation operation to be gravity flow.

In some parts of the area, sedimentary rocks which indicate to the existence alluvial sand top soil. The geological formation in the Gezira scheme is as follows:

i. The basement complex rocks: These form the structural platform on which all geological formation was deposited; they are former sediments and volcanic rocks that had been completely altered by high grade metamorphism, granisation and intrusion by igneous rocks. They are assumed to be mainly of pre-Cambrian age although other formation may be younger.
ii. The Nubian sand stones: Lies uncomfortably over the basement complex rocks. They compose sand stones and sandy mudstones and assumed to be of lower age.

The Gezira formation: It rests uncomfortably on the Nubian sand stone and consists of unsoiled unconsolidated, clay, sand and gravel. The upper part of formation is the dark clay. It is more than 11,300 years old [17].

The climate of the Gezira scheme is arid in the North part and Semi- arid in the South part of the scheme [10]. The mean annual rainfall range from 472mm at Sinnar to 1600mm at near Khartoum in the period between may to October. The temperatures are varied from 46º in April to 7º in December with the average of 28º. The scheme climate classified into three seasons:

i. Short rainy season, (From July to October),
ii. Winter season, (November to January) and
iii. Summer season (February to June).

The scheme (2.1 million Feddan = 0.9Million Hectares) is irrigated by graving from Sinnar Dam by twin main canal running northward 57 km to a group of regulators forming a large pool. The Gezira main canal has in intake of 14 roller grates with dimensions of 3m width and 5m height, could carry ready 16 million cubic meters of water per day. The Managil canal has intake of 11 openings with the same dimensions. Its capacity reaches about 15 million cubic

meters per day. The two canals run parallel to each other to meet in common pool at a cross-regulator at 57km. Canalization sprawls from there on. To serve the Gezira and Managil area, the Gezira and Managil canals maximum capacityies are 186 ms-3-1 and 186 ms-3-1 respectively.

III. GIS TECHNOLOGY

Geographical Information System (GIS) is a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems [16]. GIS can be divided into five components: Hardware, Software, modules, Data and People.

1) Hardware

Hardware consists of the technical equipments needed to run a GIS including a computer system with enough power to run the software, enough memory to store large amounts of data, and input and output devices such as scanner, digitizers, GIS data logger's media disks, and printers.

2) Software

There are many different GIS software packages available today. All packages must be capable of input, storage, retrieving analyzing, transforming, presentations, of data. Before this innovation, the geo-relational model was used. In this model, graphical and descriptive data sets were handled separately. The modern packages usually come with asset of tools that can be customized to the user needs.

3) Data

Perhaps the most time consuming and costly aspect of initiating a GIS is creating a database. There are several things to consider before acquiring geographic data. It is crucial to check the quality of the data before obtaining it. Errors in the data set can add many unpleasant and costly hours to implement a GIS and the result and conclusions of the GIS analysis most likely will be wrong.

4) Procedures

Procedures include how the data will be input to the system, stored, retrieved, managed, transformed, analyzed and finally presented in a final output. The procedures are the steps taken to answer the question need to be resolved .the ability of a GIS to perform spatial analysis and answer these questions in what differentiates this type of system from any other information system. The transformation processes include tasks such as adjusting the coordinate system, setting, protection correcting any digitized error in a data set, and converting data from raster to vector or from vector to raster.

5) People

The people are the component who actually makes the GIS work. They include a plethora of positions including GIS managers, database administrations, application specialists, system analysts and programmers. They are responsible of maintenance of the geographic database and provide technical support. People also need to be educated to make decisions on what type of system to be used.

IV. GIS MODEL DEVELOPMENT

The basic data sources in this research are line maps, tables and reports for different geographical features in the Gezira scheme and Managil extension project. Spatial data represent the heart of GIS applications that stores geometric locations of particular features, along with the attributes information describing these features and their properties. Eight features classes had been derived from the main basic line maps to meet the objectives of this study. These features were:

1. Soil types,
2. Blocks,
3. Water resources,
4. Transportation,
5. Towns,
6. Canalization, and
7. Areas.

Basic maps were then scanned to transform them from hard copies format, to soft copies. Control points –points of a known coordinates– were then utilized to adjust digital maps to a ground space coordinate system (Georeferencing).

The established Gezira scheme bench mark soils distribution data obtained from detailed soil surveys (1987 – 1992) in South, North, Centre and Northern – west Groups revealed the presence of Bench mark soils. In general very fine soil in south Gezira and fine soil in centre In Northern Gezira and Managil extension is a high degree of soil compaction which makes a different problem in irrigation hard because the water could not reach the roots of crop comfortably. The evaluation of soil as recognized from existing map at scale 1:150,000 was digitized for soil layer preparation. The chemical classification of the scheme soil was grouped into five main bodies represented with different colours.

These were:

a. Non – sodic very fine clay soils.
b. Fine sodic and non sodic clay soil (30 – 59%) clay
c. Fine moderately deepmelanic horizon clay
d. Very fine sodic and nonmelanic horizon clay soil (60 % or more clay)
e. Non – sodic fine clay soils
f. Moderatly deep melanic horizon fine clay soil.

Fig. 1 shows the different soil types of the scheme i.e., soil layer.

The blocks layer represents the backbone of analysis and results processes in this research 103 blocks in the scheme divided into 50 blocks in Gezira and 53 blocks in Managil extension of different areas were represented in this layer as shown in Fig. 2.

The Gezira scheme and the Managil extension have been divided into 14 groups shown in Fig. 3.

Each group is divided into 7-10 blocks as shown in a Table 2 with a block inspector on top of each, assisted by a numbers if inspectors to facilitate the flow of information from the management to the farmers as production conical - which include some farmers as members - plan in each block.

Applying the same procedures, water resources, transportation, towns, canalization and areas layers and attribute tables were developed on the GIS system.

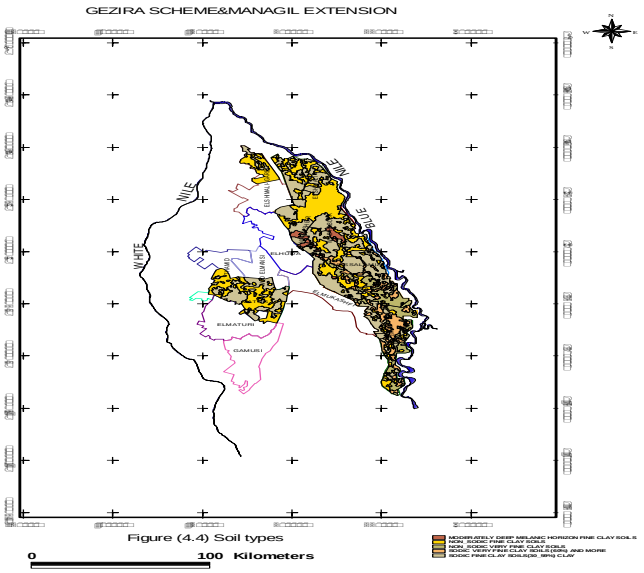

Fig. 1: Soil types of the scheme

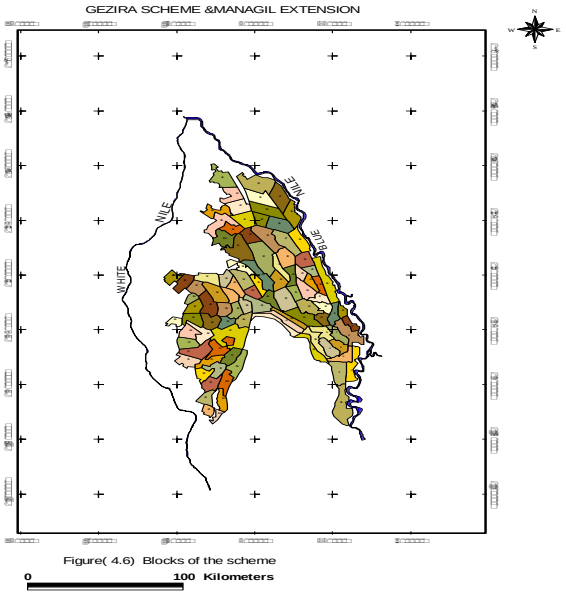

Fig. 2: Blocks of the scheme

V. ANALYSIS AND RESULTS

After developing the GIS system of the Gezira scheme and the Managil extension, analysis and results were based on number of queries. These queries were developed to determine:

i. Suitable block that can be cultivated by different crops.
ii. Good blocks, derived from suitable blocks with respect to the roads in scheme, as a first differentiation.
iii. Better Blocks, those reduced from good blocks by considering towns in the scheme as a second differentiation
iv. Suitable groups which could be cultivated by different crops.

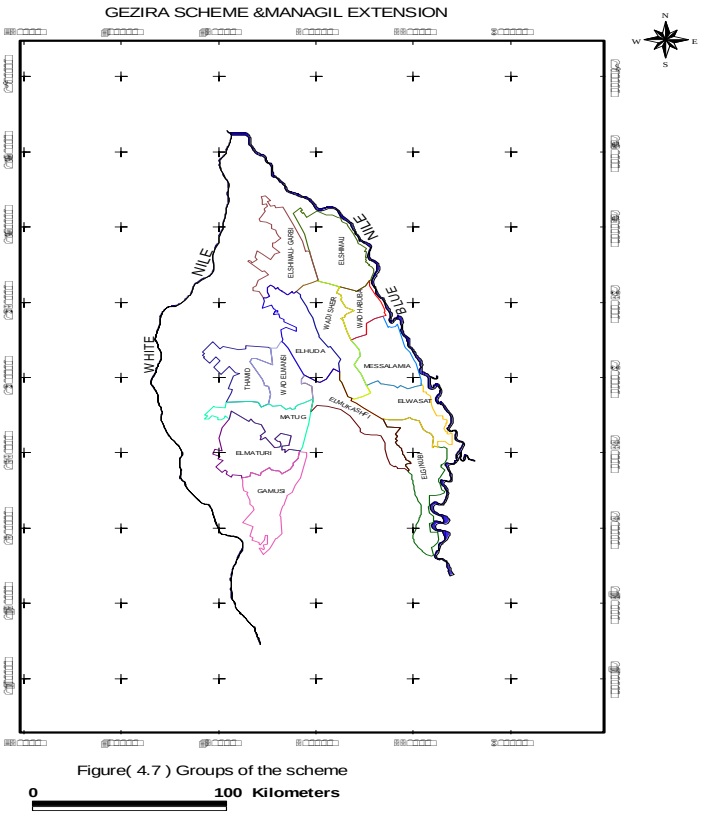

Fig. 3: Gezira scheme and Managil extension groups

To determine block suitability for a particular crop cultivation, two main factors has to be taken into account. These factors are salinity (E.C) and sodicity (E.S.P). Through (E.C) and (E.S.P) analysis, suitable blocks can be determined. Fourteen different Crops requirements (C.E.C, E.S.P and term of season) were collected and arranged as summarized Table 1.

Table 1: Crops Requirements

NO	CROP	C.E.C	E.S.P	Season
1	Sorghum	8	20	Summer
2	Maize	4	20	Summer / winter
3	Millets	4	25	Summer
4	Barley	8	25	winter
5	Cotton	10	20	Summer
6	Kenaf	8	20	Summer
7	Sesame	4	20	Summer / winter
8	Vegetables	4	26	winter
9	Fruits	4	20	Summer / winter
10	Acacia	8	27	Summer / winter
11	Fababean	8	25	winter
12	Wheat	8	25	winter
13	Groundnuts	8	20	Summer
14	Sugar cane	5	20	Summer

Better blocks should be close to transportation facilities, considering the location of the blocks to be near to asphalt street or road embalmment.

To facilitate analysis, codes such as (200) were given to blocks that closer to transportation facilities. Code (600) given to those blocks far away from the roods, as illustrated in building up data model section.

Blocks that closer to transportation facilities and near to a town of scheme, were classified as best blocks and coed with (1). Otherwise code (0) was used.

For crop such as cotton which require E.C. to be 10 and E.S.P = 20 GIS links the spatial data (layer of blocks) with the attribute data throuh assumed (ID), to answer the query.

Suitable blocks for cotton cultivation were found to be as shown in Fig. 4.

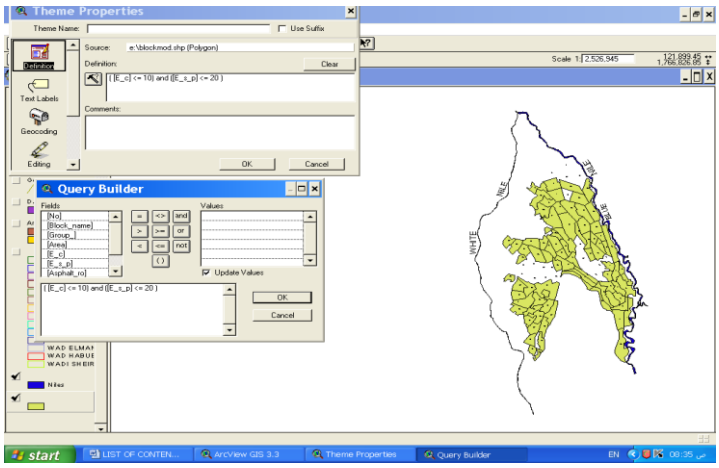

Fig. 4: Operation of suitable blocks

Then to find better blocks that satisfies cotton growth (E.C. and E.S.P.) and transportation facilities as well as town closeness, query was build in query builder as [(E.C) <=10 and (E.S.P) <=20 and (Road) =200]. Result was found to be as illustrated in Fig. 5.

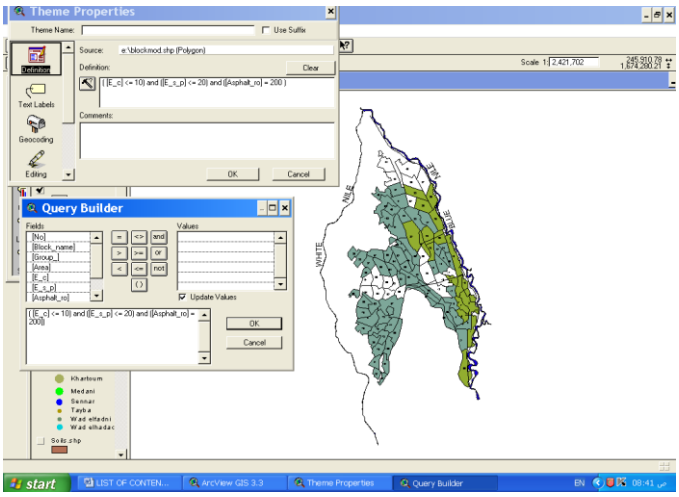

Fig. 5: Second operation for good blocks

Best blocks were those blocks that satisfied betterness requirements and closer to a town scheme.

Again by building query, best blocks for cotton cultivation were found as shown in Fig. 6.

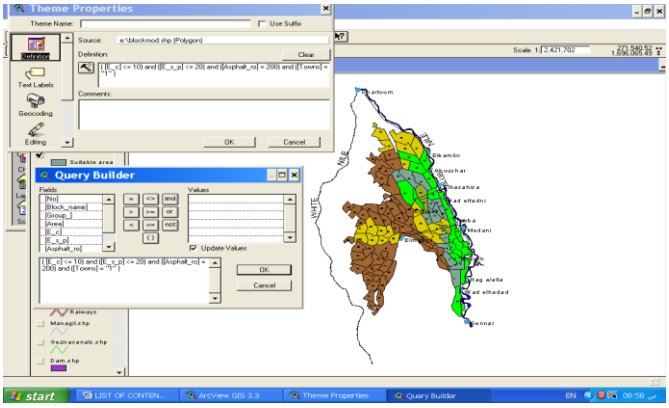

Fig. 6: Best blocks for different crops

Finally by buffering operation done to suitable blocks layer, joint with groups layer of the scheme, a new coverage can be produced. This new coverage represents suitable blocks that can be cultivated by different crops as shown in Fig. 7.

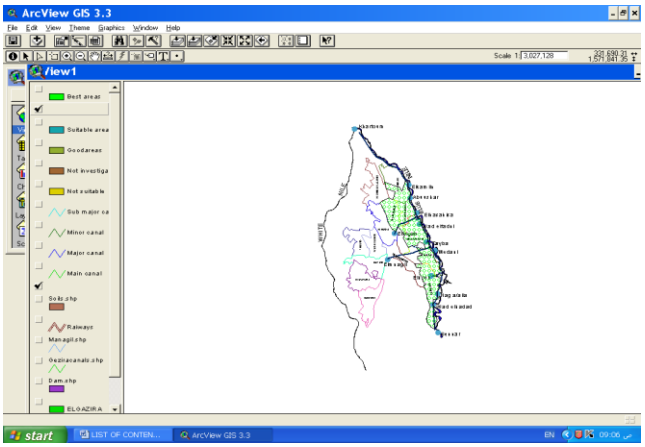

Fig. 7: Suitable blocks that can be cultivated by different crops

VI. CONCLUUSIONS

Development in digital mapping and data base systems, integrated with geographical information system become an important tool in planning and decision making in different fields.

This research is oriented to apply a GIS in agricultural project for the first time in Sudan. Importance of Gezira scheme and Managil extension leads to select the project for this study.

This study tried to divide the scheme according to its suitability of cultivation particular crops, transportation and town (adjacency to residential areas) in Sudan and utilizing this system in selecting suitable areas that can be cultivated by ascertain crops.

By referring the analysis and results of this research work, it can be concluded with the following:

i. Application of GIS in agricultural projects can easily provides the visual integration of all data sources related to the agriculture field and all other required information for decision making.
ii. Some new crops can be cultivated in the scheme such as sugar cane, barley, acacia, maize and fruits.
iii. Application of GIS in the project can easily leads to understand the production system and assist to modify them to reduce the effort of production and improving human health.
iv. Relationships between different parameters can be created in order to analyze and a particular problem.
v. Study also showed that new crops that can be cultivated in the scheme. Table 2 includes summary of different crops that can be cultivated in the scheme. Note that the word (ALL) stand here for the fourteen assigned crops in this research study.

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Table 2: Groups of the scheme

Block No.	Block Name	Group	Area (Feddan)	E.C	E.S.P	ROAD Code	TWON Code	UNIT
1	Hagabdalla	Elgenubi	35402	1.20	16	200	1	11
2	Fahal		28765	1.20	165	600	0	11
3	Gubshan		11825	0.72	16	600	0	30
4	WadNuman		20463	072	16	600	0	30
5	El Hosh		15775	0.81	20	200	1	10
6	Remietab		21406	0.81	20	600	0	10
7	Wad Ataia		16631	1.20	12	200	1	10
95	Wad hadad		29742	0.72	16			30
8	HamdElneil	Elwasat	4504	1.20	16	200	1	11
9	Seed farm		12574	0.81	20	200	1	10
10	Brakat		12433	0.81	20	200	1	10
11	Dirwish		1554	1.20	16	200	1	11
12	Kumur		13624	0.72	16	600	0	30
13	El Radma		25893	3.10	24	200	0	40
14	A/elhakam		13947	0.72	12	200	0	5
15	Emadina		25244	3.10	24	200	1	40
16	Typa	Messalemia	25457	0.72	16	200	1	30
17	Sulemi		14247	2.40	22	600	0	50
18	Tebub		18975	0.72	16	600	0	30
19	Wad bur		13682	0.81	20	600	0	15
20	Al galil		13013	0.72	16	600	0	30
21	Wad saadalla		13295	0.72	16	600	0	30
22	Al Rahman		12972	0.72	16	600	0	30
23	Wad Hussein		17695	0.72	16	200	0	30
24	Nediana		2102	0.72	16	600	0	30
25	Wad sulfat	Wadhaboba	20207	0.70	20	200	1	30
26	Dolga		23228	0.70	20	200	1	30
27	Istrihna		23755	0.70	20	600	0	30
28	El Rukun		26683	0.70	20	200	0	30
29	El Nuila	Wadishaiar	17156	3.10	24	600	0	40
33	Turis		31725	2.20	24	600	0	6
30	Feties		18391	0.70	20	600	0	30
31	Amara kassir		26531	0.70	20	200	1	8
32	Ketier		28412	7.50	6	200	1	43

34	Fawar		25840	7.50	6	600	0	43
35	Um Degarsi		26481	3.80	25	200	1	45
36	debeba		29981	2.70	26	200	1	30
37	Turabi		32049	7.00	26	200	1	45
38	Melieg		42464	0.70	20	200	1	40
39	Kab elgidad	**Elshimali**	24450	7.00	26	200	0	60
40	Laaota		14009	7.00	26	200	1	60
92	Ruwina		31872	3.10	24	600	0	60
62	Maturab		14526	2.10	22	600	0	60
63	Elnour		18388	2.10	22	600	0	60
64	ABUHAwa		15111	2.10	22	600	0	60
65	Kartoup		15236					
66	Elhashaba		19894	2.10	22	200	1	60
67	Umhiglig	**Matug**	12450					
71	Affan		14260					
72	Elhigerat		15021					
50	W/ Elzien		40125					
51	Elmalan		35261					
52	shandi		35698					
91	sourhan	**Elhuda**	35626					
93	gozelriheid		40123					
103	a/elmagid		40256					
90	frigab		33256					
54	raselfeel		40125					
56	mabrouk		42153					
58	elgadid		16253	6.10	27	600	0	111
59	eltayef	**Elmansi**	18524	6.10	27	600	0	111
83	elkireimit		17000					
53	geite		36259					
55	niema		37154					
47	hamadnalla		30251					
48	abudigin		38524					
49	murad	**Elmukashfi**	15423					
84	w/abied		25261					
85	tuns		32651					
102	elwaha		14589					
82	eltomat		15241					
81	elrangouk		18963					
79	gabuga		16589					
101	sagadi	**gamusi**	16523					
99	kuit		15423					
78	radi		19875					
80	kielik		17896					
100	wageealla		15243					
69	eltamad		14521					
68	aguba		13245					
77	dishinat		18569					
73	elnayer		15243					
76	umsinita		13256					
70	zafeer	**Maturi**	11024					
74	gebal		11254					
75	rahama		12451					
69	eltamad		14521					
68	aguba		13245					
77	dishinat		18569					
44	fragin		23514	6.10	27	200	1	111
43	sidira		26536	6.10	27	200	1	111
98	abuguta		20193					
46	bajega		21762					
42	elguiz		24151					
41	abugin	**Shimali_garb**	20193					
54	abuidiena		21913					
94	w/keriel		20325					
44	fragin		23514	6.10	27	200	1	111
43	sidira		26536	6.10	27	200	1	111
98	abuguta		20193					
878	umshadida		39256					
57	shakier	**Eltahamid**	36542					
88	mihiela		36523					
89	nala		38256					

86	shuirief		33654					
61	tarfa		37214	6.10	27	600	0	111
60	bieda		30156	6.10	27	600	0	111
878	umshadida		39256					
57	shakier		36542					
88	mihiela		36523					
89	nala		38256					

Table 3: Summary of suitable areas for different crops in the scheme

GROUP	BLOCK NO.	BLOCK NAME	AREA(FED)	SUITABLE CROP
Elgenubi	1	Hagabdalla	35402	All crops
	2	Fahal	28765	All crops
	3	Gubshan	11825	All crops
	4	WadNuman	20463	All crops
	5	El Hosh	15775	All crops
	6	Remietab	21406	All crops
	7	Wad Ataia	16631	All crops
	95	Wad hadad	29742	All crops
Elwasat	8	HamdElneil	4504	All crops
	9	Seed farm	12574	All crops
	10	Brakat	12433	All crops
	11	Dirwish	1554	All crops
	12	Kumur	13624	All crops
	13	El Radma	25893	Millets,Wheat, Barley, Fababean,Vegitable, and Acacia
	14	A/elhakam	13947	All crops
	15	Emadina	25244	Millets,Wheat, Barley, Fababean,Vegitable, and Acacia
Messalemia	16	Typa	25457	All crops
	17	Sulemi	14247	Millets,Wheat, Barley, Fababean,Vegitable, and Acacia
	18	Tebub	18975	All crops
	19	Wad bur	13682	All crops
	20	Al galil	13013	All crops
	21	Wad saadalla	13295	All crops
	22	Al Rahman	12972	All crops
	23	Wad Hussein	17695	All crops
	24	Nediana	2102	All crops
Wad haboba	25	Wad sulfab	20207	All crops
	26	Dolga	23228	All crops
	27	Istrehna	23755	All crops
	28	Elrukun	26683	All crops