J. King Saud Univ., Vol. **3**, *Agric. Sci.* (2), pp. 319–332, Riyadh (1411/1991)

Land Potential for Irrigated Agriculture in Al-Qassim Region, Saudi Arabia

A.S. Al-Mashhady, M.A. Hammad and M. Reda
Soil Science Department, College of Agriculture, King Saud University, Riyadh, Saudi Arabia

Abstract. Map units of the map of Al-Qassim Region were interpreted to appraise land potential for irrigated agriculture. The appraisal was based on inherent limitations and constraints such as erosion hazard, wetness and soil characteristics. Assuming that irrigation is feasible, that salinity and/or sodicity of some areas are rectifiable and that drainage of some areas can be improved, the soils were rated for cultivation purposes. Where otherwise limitations are permanent, the land was classified for other nonagricultural purposes.

Each mapping unit of the soil map was placed into a land capability group that includes one or more capability subclass. The dominant class in every unit was determined and a capability map was constructed using 14 map units defined either as a single subclass or as an association of subclasses. The map can be used to identify both priorities and precautions for land development and utilization. Fourteen map units were recognized.

Introduction

Al-Qassim Region of Saudi Arabia is one of the most agriculturally productive areas for a variety of crops, especially wheat. The area is a part of Najd province, located northwest of Al-Riyadh (Fig. 1). The area studied is bounded by longitudes 42° and 45° east and latitudes 25° 30′ and 27° north, and occupies about 46374 km^2. Agricultural production depends mainly on irrigation provided by ground water. In spite of its considerable importance in the agricultural production in Saudi Arabia no studies have been made to evaluate its full potentialities. This can be carried out through land capability classification which is an interpretive grouping of the soils of an area based on their suitability for sustained production of the common cultivated crops, or permanent range or forest vegetation [1]. It takes into consideration the combined effect of climate and permanent soil characteristics limiting use, management requirements for productive capacity and the risk of soil damage. The system used has three levels of generalization, land capability class, subclass and unit. A land capability class is a group of soils having the same degree of limitation or hazard, but does not consider the kind of limitation.

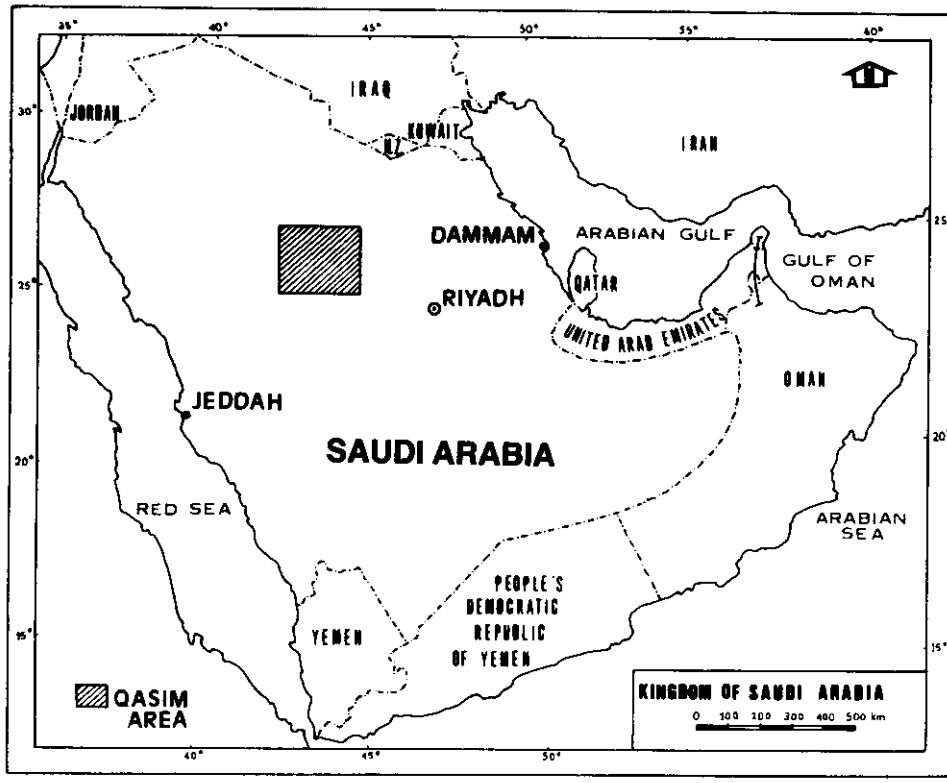

Fig. 1. Map of Saudi Arabia with the Qassim area outlined

At the subclass level, the soils are grouped together on the basis of the kind of limitations for agricultural use. The subclass thus provides information about both the degree and the kind of limitations. The lowest category, land capability unit, is a grouping of soils that have about the some resonses to similar systems of management.

The capability grouping reflects the prevalent conditions or those anticipated to prevail in the near future. Re-interpretation and regrouping of the soils might be necessary under changed economic conditions or after the installation of major reclamation projects that permanently modify the limitation. The aim of the present work is to evaluate the land potential for irrigated agriculture of Al-Qassim Region.

Materials and Methods

Interpretation of the soil map of Al-Qassim region produced by Al-Mashhady *et al.* [2] was interpreted to appraise the land potential for irrigated agriculture in the

region. The system adopted was the land capability classification of Klingebiel and Montgomery [1] as presented in Table 1. A few of the parameters used were taken from the framework for land evaluation of F.A.O. [3] and the Soil Survey Manual [4].

The mapping units were assembled into land capability groups which may include more than one land capability subclass. The dominancy of each subclass in every group was then determined and a capability map was constructed. Because of the nature of the soil survey (reconnaissance) and the level of soil categories used (subgroups), only the two higher capability groupings (class and subclass) have been employed for the present land capability classification.

Assuming that irrigation is feasible, that salinity and/or sodicity of some areas are rectifiable, and the drainage of some areas can be improved, the soils were rated for cultivation purposes according to inherent limitations and constraints such as erosion hazard, wetness, and soil characteristics.

The soils of the area were classified into appropriate capability divisions. The first category places all soils in eight capability classes. Soil and climatic limitations in relation to agricultural use, management and productivity are used to differentiate capability classes. The second category, the subclass, includes all soils that have the same kind of dominant limitations for agricultural use. Accordingly the area was classified into fourteen land capability groups.

Results and Discussion

The distribution of land capability groups given in Fig. 2 is discussed in the order of decreasing agricultural potential. The area covered by each group is given in Table 2.

1- Good arable land (IIs)

This group includes map units Dh,Jr,Mt,Nb and Uy. It is composed of deep to very deep, coarse loamy to clayey soils of the wadis and other alluvial landforms and has a flat or almost flat surface.

With adequate irrigation supplies and modern management, the whole of the unit can be made to be highly productive to a wide range of arable crops including orchards. The loamy soils are suited to intensive cultivation, especially of the high value crops, and do not require any special management techniques. On the other soils, cultivation practices, irrigation scheduling and crop choice has to be adopted to the particular soil conditions. The clayey soils would require careful seedbed preparation, optimum irrigation to avoid excessive wetness. The coarse loamy soils would need lighter but more frequent irrigation and comparatively higher doses of fertilizers.

Fig. 2. Land Potential for irrigated agriculture in Qassim Region.

LEGEND

Good Arable Land (IIs): well suited to a wide variety of crops including orchards.

Good, Moderate and Poor Arable Land (IIs–IIl–IVs) dominant part suitable for a variety of crops including fodders; subdominant part suited to general crops other than very deep-rooted; minor extent can be used for shallow-rooted crops only.

Good and Poor Arable Land (IIs–IVs): dominant part suitable for diversified cropping including rice on clayey soils; subdominant part suited to low-delta crops on sandy soils and shallow-rooted crops on others.

Moderate Arable Land (IIIw): can be used to general cropping after provision of appropriate drainage.

Moderate Arable Land (IIIs): mainly suitable for crops not very deep-rooted. slowly permeable clayey soils may be used for crops tolerant of short periods of anaerobic conditions.

Moderate Arable Land and Non-agricultural Land (IIIs–VIIIc): dominant part suitable for common crops other than the deep-rooted; subdominant part unfit for irrigated agriculture.

Poor and Good Arable Land (IVs–IIs): dominant part suitable for low delta crops especially the short-rooted; subdominant part can be used for a variety of crops including forages.

Poor, Moderate and Good Arable Land (IVs–IIIe–IIe): needs wind-breaks and protective plant cover during periods of strong winds, hilly (dominant) and rolling (subdominant areas suitable for pasture; undulating parts (minor) may be cultivated for general crops.

Poor and Moderate Arable Land (IVs–IIs): dominant part suited to shallow-rooted, low delta crops; minor part can be used for deeper rooted crops.

Poor Arable Land (IVs): generally suitable for shallow-rooted crops, deep sandy soils may be used for crops with low irrigation requirement.

Poor Arable Land and Non-agricultural Land (IVs–VIIIe): dominant part suitable for low delta crops; subdominant part comprising active dunes cannot; be used for agricultural purposes, but needs protection against wind blowing.

Poor Arable Land and Non-agricultural Land (IVs–VIIIc): dominantly suited to low delta crops, not very deep-rooted; subdominant part unsuitable for economic plant production due to very limited soil thickness.

Non-agricultural Land and Poor Arable Land (VIIIc–IVs): adverse conditions preclude irrigation over dominant part; subdominant part can be used for low delta crops, especially the short-rooted.

Non-agricultural lands (VIIi): not considered suitable for economic plant production.

(VIIie): active, high sand dune areas.

(VIIIw): undrainable sabkhas and salt marshes.

(VIIIs): rock outcrops and stony or gravelly deposits

(VIIIc): areas of very thin soils over rock or indurated horizon.

Table 1. **Frame-Work for Land Capability Classification**

Land Capability Class	Limitation or Hazard											Climate
	Erosion: wind/water (subclass e)		Permanent wetness (subclass n)		Rootzone limitation (subclass s)							
	susceptibility	previous damage	saturation	overflow	depth cm	coarse fragments	permeability	water holding capacity	workability	farti response	recuring salimity	Climate subclass
I Very good arable land	none to slight: flat or almost fiat (slopes <2%)	none to slight: patchy, <15cm thick shifting sand cover over <15% of the area of few rilis	none to 150cm depth	none	very deep >120	<2%	moderae moderately slow	good	easily workable to favourable tilth	high or very	non:EC <4 mmhos	none irrigated irrigable
II Good arable land	moderate: wavy or undulating (2-6% slopes)	moderate:15-30cm thick shifting-sand cover 15-35% shallow gullies of the area. or few	saturated at 90-150cm depth	occasional with likelihood of slight crop	deep: 90:120	2-15%	slow or moderately rapid	somewhat low-or high	seedbed preparation slightly problematic	high	slight: EC 4-8 mmhos	- do -
III Moderate arable land	high: rolling (6-14% slopes)	high: 30-50cm thick shifting sand cover over 35-50% of the area-or common shallow or few deep gullies	saturated at 50-90cm depth	common with slight to moderate crop damage	moderate deep: 50-90	15-35%	very slow or rapid	low or high azou-	seedbed preparation or creation rable tilth moderateilly problematic	moderate	moderate EC8-16	- do -
IV poor arable	severe: hilly (14-25%	sever:60cm thick shifting sand cover over	saturated at 30-50cm depth	common with severe crop	shallow: 30-50cm	30-50 %	very rapid	very low	- -	low	severe: EC15-32 mmhos	- do -

Table 1. (cont)

Table 1. Frame-Uork for Land Capability Classification

Land Capability Class	Limitation or Hazard											Climate Climate subclass
	Erosion: wind/water (subclass e)		Permanent wetness (subclass n)		Rootzone limitation (subclass s)							
	susceptibi-	previous damage	saturation	overflow	depth cm	coarse frag-ments	permea-bility	water holding capacity	workabi-lity	farti resp-onse	recuring salimity	
land	slopes)	50% of the area or common deep gullies		damage								
V Fair pasture range of woodland	none to slight	——	saturated at 30cm depth with non-saline water	frequent pre-venting arable crop production	—	50-90%	—	—	—	—	—	—
VI Moderate pasture, range or woodland	very severe: 25-50%	very severe: thick shifting sand cover over most of the area or many deep	water - table at or above the surface	-do-	very shallow: <30cm	-do-	—	—	—	—	very severe: EC 32 mmhos	arid
VII poor range or woodland	extremely severe >50% slopes	gullies	-do-	-do-	-do-	-do-	-	-	-	-	-do-	arid
VIII Non-agri-cultural land	-do-	shifting dune fields or intensely dissected areas	deep-open water	-	lack of soil cover	>90%	-	-	-	-	-do-	very arid

Table 2. The areas (Hectare) of the land capability units

Land capability unit	Extent	
	Hectare	%
IIs	132500	2.9
IIIs - IIIs - IVs	90000	1.9
IIs - IVs	67500	1.5
IIIw	27500	0.6
IIIs	59500	1.3
IIIs - VIIIc	47500	1.0
IVs - IIs	17500	0.4
IVe - III - IIe	72500	1.6
IVs - IIIs	773300	16.7
IVs	937500	20.1
IVs - VIIIe	8700	0.2
IVs - VIIIc	462500	10.0
VIIIc - IVs	55000	12.0
VIII	1886000	40.6

2- Good, moderate and poor arable land (IIs-IIIs-Ivs)

This group represents map unit Md. It comprises almost flat to gently undulating plains having residual soils associated with limestones and shales. Under natural conditions, the area is generally a barren waste with only a few scattered shrubs. It is mostly agriculturally unproductive. However, if irrigation is provided, the land can be used for crop production.

The dominant soils of this group are deep and coarse loamy. These soils are well suited for irrigated cultivation of a variety of crops including leguminous fodder crops. Due to their moderately rapid permeability, the soils would need lighter but more frequent irrigation. With modern management, a high level of production can be achieved on these soils. Subdominant soils are moderately deep and fine loamy. These soils are suitable for common crops that are very deep rooted. A minor proportion of the group consists of shallow, coarse loamy soils that are suitable only for shallow rooted crops.

3- Good and poor arable land (IIs-IVs)

Mapping units included in this group are Rm,Sf,Sh and Iq. This group occupies the almost flat to gently undulating parts of rock plains, drainage basins, and wadis. Under natural conditions, most of the area is agriculturally unproductive. Some parts, especially the wadis, support a sparse vegetation cover used for poor grazing but small areas, especially in the Wadi Ar Rimah, are under irrigated cultivation which can be extended to the entire area if sufficient irrigation water is available.

The dominant part of the group has a high agricultural potential under modern management since it is deep, coarse loamy to clayey soils, that are well suited to diversified crop production. The loamy soils do not require any special management techniques, but the clayey soils need careful land preparation and optimum irrigation and suitable crops such as rice and other crops. The coarse loamy soils are suitable for crops with lower moisture requirements. Frequent, lighter irrigations and split-application of fertilizers would help prevent loss of water and nutrients on these permeable soils.

4- Moderate arable land (IIIw)

This group includes Fd, mapping unit. It occupies almost all of the flat drainage basins within the sedimentary rock plains. Most of the area is uncultivated and agriculturally unproductive but some parts, especially the peripheries of the basins, are used for irrigated crop production. The unit has a permanent drainage problem because of its depressed position surrounded by higher land. if suitable drainage is possible then the whole area can be used for the cultivation of a variety of irrigated crops.

The soils are deep coarse to fine loamy and are well suited to intensive irrigation. On the coarse loamy soils, more frequent and lighter irrigation amy be needed to achieve optimum moisture utilization. The rest of the soils require only orginary management techniques to attain a high level of production.

5- Moderate arable land (IIIs)

This group includes mapping units Jn and Z1. It consists of almost flat to gently undulating residual soils derived from shales and is generally uncultivated and barren. Under irrigation however, and with modern management, the land is at least moderately productive.

Soils of this group are moderately deep, coarse loamy soils and deep, stratified slowly permeable, clayey soils. The former need careful irrigation and fertilization to prevent unnecessary water and nutrients losses with the emphasis on crops with low moisture requirements. The clayey soils, because of their unfavourable physical conditions, are difficult to bring to a favourable tilth. They need the addition of organic matter, restricted irrigation to avoid excessive wetness and the selection of crops that can with stand short periods of anaerobic conditions.

6- Moderate arable land and non-agricultural land (IIIs-VIIIc)

This group occupies the Va mapping unit. Residual soils derived from limestone, are dominant. The landscape is almost flat. The area is generally uncultivated. Except for a few isolated shrubs, the land is devoid of any vegetative cover. At present, the area is agriculturally unproductive.

Most of the area has moderately deep coarse loamy soils, and if irrigation is provided it would have a moderate potential for all crops that do not have high irrigation requirement or very deep roots. With modern management, including optimum irrigation and fertilization, this part can become at least moderately productive. The remainder of the unit is occupied by very shallow soils over hard bedrock. These are considered unfit for irrigation development or for any other kind of improved agricultural use due to an extremely limited root zone therefore they should be left in their natural state.

7- Poor and good arable land (IVs-IIs)

This group includes soils in mapping units Bk and Qs. It consists of almost flat to rolling parts or rocky plains and wadis with the major part of the area being uncultivated. The natural vegetation varies from a few isolated shrubs on the rocky plains to a sparse cover of shrubs and grasses in the wadis. The former areas are agriculturally unproductive whereas the latter provide poor grazing land. Some parts mainly in the wadis are under irrigated cultivation. If adequate irrigation water is available the whole area could be used for crop production.

Shallow sandy and deep very rapidly permeable soils make up a dominat part of the area. Because of their very limited water-holding capacity and excessive permeability. These soils are suitable only for crops with low irrigation requirement and shallow short roots system. The soils would require frequent light irrigation and split-application of fertilizers.

A subdominant part of the unit has a high potential for irrigated agriculture since it has moderately deep, coarse loamy soils. With modern management, including suitable crop choice and careful irrigation, high returns can be obtained from this land.

8- Poor, moderate and good cropland (IVe-III-IIe)

This group includes the soil of Bs mapping unit that represent aeolian deposits subject to active wind erosion with the surface topography varying from gently undulting to hilly, but most of the area is barren waste at present. If irrigation and protection against wind blowing or burial can be provided, the area has a poor to good potential for arable cropping. The area dominated by sandy soils having severe susceptibility to wind erosion. This part is well suited for pasture development but needs wind breaks, initial stabilization of the surface, densely growing crops especially during period of strong winds, and very careful irrigation and fertilization. Deep coarse loamy soils subject to high wind erosion hazard constitute a subdominant portion of the area. These soils also need adequate protection against blowing as well as against burial. With a high level of management, including optimum irrigation, fertilization, and suitable crop choice, especially the pasture, the land could become at least moderately productive. There is also a minor extent of undulating,

coarse loamy soils that have a high potential for irrigated agriculture, and can be used for production of common crops if protection against wind erosion.

9- Poor and moderate arable land (IVs-IIIs)

This group includes map units Aq,Br,Ms,Rs and Tb. It occurs on flat to gently undulating rock plains having a mantle of residual soils. The area, is generally uncultivated but supports a very sparce vegetation of little agricultural value. With irrigation, the area could be used for crop production.

The dominant part of the unit is composed of shallow to moderately deep soils with excessive permeability and very limited available water. These soils are suitable only for crops with low water requirement and would need frequent light irrigation and split-application of fertilizers. On the shallow soils, the emphasis should be on the choice of shallow rooted crops. Deep to moderately deep, slightly gravelly to gravelly, coarse loamy soils are the second member of the association. These are less problematic to manage and have a wider range of suitable crops as compared to the former. With modern management, a moderately high production could be obtained from this land.

10- Poor arable land (IVs)

This group includes map units Ar,Bd,Bu,Kr,Mu,Sl,Sm,Ss and Tr. It extends over a number of major landforms of the area ranging from rocky plains to wadis and is almost flat to undulating. The major part is devoid of plant cover and is agriculturally unproductive but small patches are under irrigation. However, if adequate irrigation is provided, the entire area could be used for crop production. The group is composed of shallow to deep, sandy and loamy skeletal soils. These are characterized by very low available water. To avoid nutrients losses, fertilizer application would have to be split into a number of doses. With a high level of management, considerable production could be obtained.

11- Poor arable land and non-agricultural land (IVs-VIIIe)

This group is made up of aeolian soil materials in map units Bu and Nf and composed of deep sandy soils and some high sand dunes. The sandy soils are generally under irrigated cultivation, while the dune areas are subject to very severe wind erosion because of the lack of a protective vegetative cover. The dunes have no agricultural potential.

The dominant part, consisting of wide interdunal hollows, can be used for the cultivation of low-delta crops. The management has to be adapted to check undesired water and nutrient losses. This may be achieved by frequent light irrigation and split application of fertilizers. The cultivated areas need protection against burial beneath sand blown from the dunes. Suitably placed windbreaks and complete enclosure of the dune areas to prevent disturbance seems essential.

12- Poor arable land and non-agricultural land (IVs-VIIIc)

This group consists of Sq map unit on gently to moderately undulating to rocky sandstone plains with a veneer of residual soil. Under natural conditions, most of the area is a barren waste and is agriculturally unproductive. Under irrigation, areas having adequately thick soil cover can be used for arable cropping. The dominant part of the area unit contains moderately deep to shallow sandy soils. Because of their excessive permeability and very limited water retention. These soils need very careful irrigation and fertilization. Frequent light irrigation and split-applications of fertilizers would be required to prevent wastage.

The subdominant part of the area has soils that are too thin to be considered suitable for irrigation it should remain in its present state.

13- Non agricultural land and poor arable land (VIIIc-IVs)

This group includes map units Hb and Th on undulating rock plains. It has residual soils derived from igneous and metamorphic rocks. The area is generally barren and agriculturally unproductive. Except for small patches of soil that may be poor arable land, the area is unsuitable for irrigation development. Very shallow, fragmental, sandy, loamy or loamy skeletal soils dominate the area. Very adverse soil conditions render this part unsuitable for improvement for any kind of agricultural use. Shallow to moderately deep, sandy to loamy skeletal soils account for the rest of the area. They have some potential for irrigated agriculture and may be put to that use where they occur in sizable patches and the irrigation can be provided.

14- Non-agricultural land (VIII)

Four subclasses of non-agricultural land covers very diverse situations including either extremely unfavourable soil or environmental conditions, or both, make all of these areas unsuitable for agriculture. Nevertheless, some parts do offer prospects of utilization for non-agricultural purposes such as quarrying of stones and other building materials, wildlife protection and development. This group includes:

a- VIIIe

This subclass includes Nf mapping unit and is the most extensive of the whole area comprising the Nafud soil unit which includes the Nafud Ath Thuwayrat, Nafud As Sirr and other similar areas. These are areas of high, active sand dunes which are impossible to improve for agriculture. Generally, they should be better left in their natural state but some of the margins may need to be stabilized to protect adjoining agricultural land from burial.

b-VIIw

This subclass is made up of soil map units Aw, Sa and Su representing sabkhas and salt marshes. Drainage or any other improvement for agricultural use is not considered feasible. The area can, however, be developed for recreation or as a wildlife reserve.

c-VIIIc

This subclass includes soil map units Ag, Bt and Hu and is composed of very shallow soils over solid rock or a calcareous indurated layer part of the area as a desert pavement. The area is unsuitable for any type of economic agricultural development and left in its natural state.

d-VIIIs

This subclass includes map units As, Ig, Met, Rr, Sd and Tm and comprises land area devoid of adequate soil cover. It consists of rocky land and gravelly or pebbly deposits. The area has some potential for quarrying of stones and other building material.

References

[1] Klingebiel, A.A. and Montgomery, P.H. *Land Capability Classification.* Agriculture Hand-book No. 210. Soil Conservation Service, U.S. Department of Agriculture, Washington D.C. 1961.

[2] Al-Mashhady, S.A., Reda, M and Hammad, M.A. "Soil Association of Al-Qassim Region, Saudi Arabia." *J. King Saud Univ. Agric. Sci.* 3 No.1 (1991), 149-165.

[3] F.A.O. "Soil Resources Development and Conservation Service, Land and Water Development Division." *A Framework for Land Evaluation-Soils. Bulletin 32, Food and Agriculture Organization of the United Nations,* Rome (1976).

[4] Soil Survey Staff. *Soil Survey Manual.* Agriculture Handbook No. 18. Washington D.C.: United States Department of Agriculture, 1951.

تقسيم ترب القصيم بالمملكة العربية السعودية حسب قدرتها الإنتاجية

عبده سعود المشهدي، محمد أحمد مصطفى حماد و محمد رضا بيومي
قسم علوم التربة، كلية الزراعة، جامعة الملك سعود، الرياض،
المملكة العربية السعودية

ملخص البحث. تقع منطقة القصيم شمال شرق الرياض بالمملكة العربية السعودية وتتميز المنطقة بمناخ صحراوي جاف وأمطار قليلة، ولذلك تعتبر المياه الجوفية هي المصدر الوحيد لري المناطق الزراعية المتمركزة حول وادي الرمة وفروعه المنتشرة بالمنطقة.

الغرض من الدراسة هو تقسيم الترب حسب قدرتها الإنتاجية وذلك بناء على المعلومات المتوافرة في الدراسة الحقلية باستخدام الصور الجوية والتحليلات المعملية، ولقد تم تقسيم الترب إلى درجات مختلفة حسب نوع ودرجة المعوقات الموجودة سواء كانت مستديمة أو مؤقتة مع اعتبار أن الري ميسر والصرف لبعض الترب ممكن تحسينه. وتتكون خريطة تقسيم التربة حسب قدرتها الإنتاجية لمنطقة الدراسة من ١٤ وحدة خرائطية مختلفة وتغطى مساحة إجمالية قدرها ٤,٦٣٧,٥٠٠ هكتار.