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OVERVIEW OF LAND COVER AND LAND USE IN SYRIA

BASE YEAR 1989/1990

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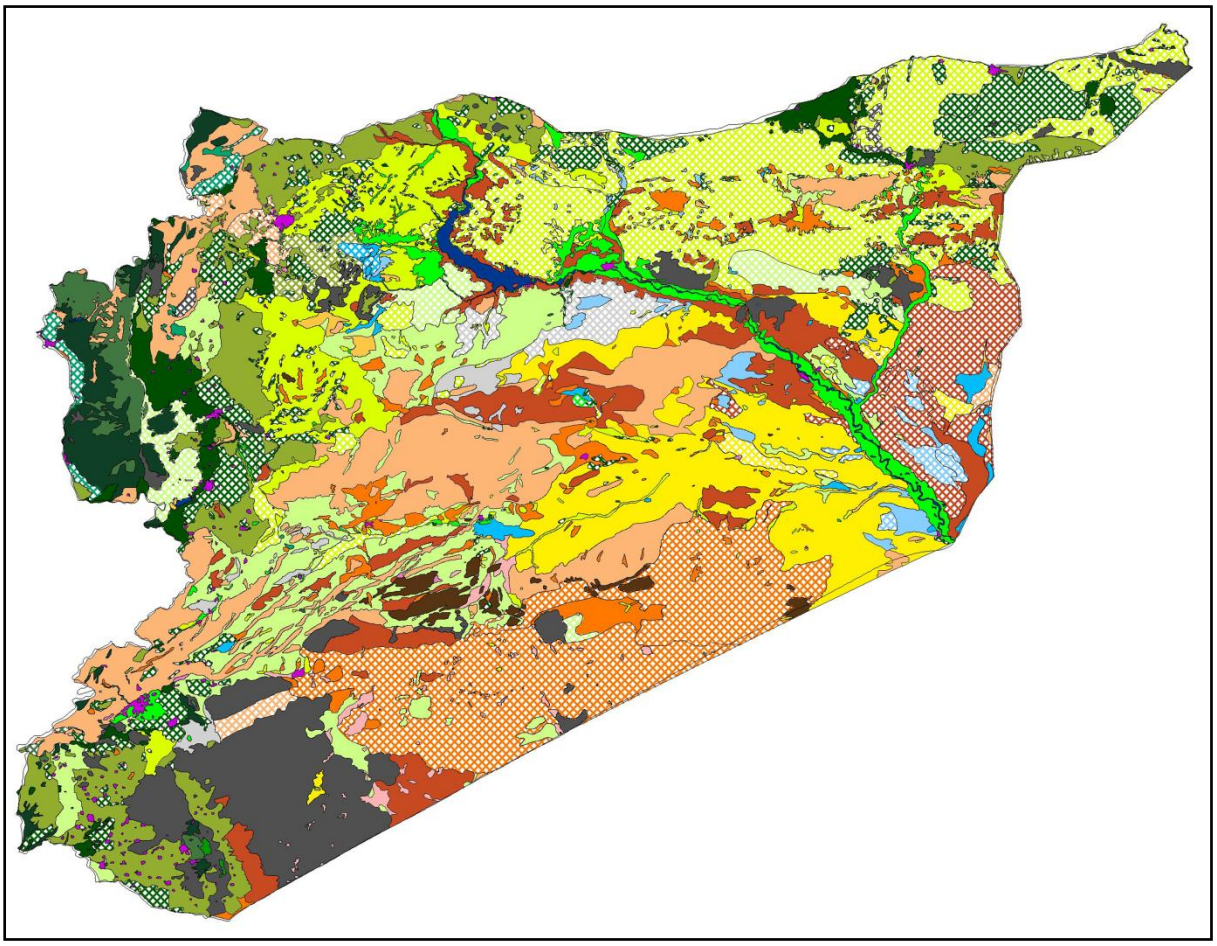

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Acknowledgements

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Abstract

This research report presents a study of land cover and land use in Syria as it existed during the period 1989/1990. It is based on an interpretation of satellite-derived products (Landsat 5 TM hardcopy images) and field checking. The main product is a Land Use/Land Cover map of Syria for the base year 1989/1990.

The major source of information was the 'Syria Space Image Atlas' prepared by the General Organization of Remote Sensing in Syria (GORS). For this land cover/land use map a local and *a-posteriori* classification system was been selected, with a flexible typology based entirely on the observed (and observable) features, and incorporating elements of both land cover and of land use. Map compilation was essentially a GIS exercise, based on visual interpretation of observed features.

The map legend consists of two main classes: *homogeneous units*, which can be considered relatively pure (80-90%), and *mixed units*, which are complexes of homogeneous units. Twenty four homogeneous classes were differentiated on the basis of the following major categories: (i) bare areas with or without sparse cover, (ii) cultivated areas, (iii) forests and other wooded areas, (iv) rangelands, (v) urbanized areas, (vi) water bodies. In addition, 43 mixed classes were distinguished.

For the base year 1989/1990 about one third of Syria (about 34%) was cultivated, mostly under rainfed systems. Considering the semi-arid or arid conditions in the country, this is a very high proportion of agriculture to the total land area. Of the cultivated area, about 8,000 km^2 was irrigated. This is probably an underestimation, and, if the areas are included of mixed units in which irrigated land use occurs as a minority land use, a total estimate of about 11,500 km^2 of irrigated land was obtained. Forested or wooded areas had a very limited extent in the country, about three percent.

Overall there is a good agreement between the land use estimates obtained from the remote sensing interpretation and statistics derived from the Food and Agriculture Organization of the United Nations database, FAOSTAT. However, some allowance needs to be made for features that can not be 'seen' but recorded in official statistics as 'land use'. The most conspicuous case is for the rangelands, which receive a rather low tally as a separate category from the image interpretation, but a high one in the FAO statistics. The explanation for this discrepancy is simply that many 'bare' lands are grazed during part of the year, but that this land use cannot be observed, only inferred, given its lack of visibility on summer imagery. If bare lands and rangelands are lumped together, the correspondence between estimates from remote sensing and production statistics is quite good.

Another interesting finding is the good correspondence between land cover/land use patterns and the major physical regions of Syria. The imagery used for this study allows drawing only limited, but useful, conclusions about the prevalence of land degradation and the current activity of degradation processes. In addition, it is not always easy to separate those forms of degradation that are entirely natural from those that are man-made. Three forms of land degradation processes could be identified or inferred from the imagery: (I) vegetation degradation, (ii) wind and water erosion, and (iii) salinization.

The current land cover/land use map has applications in land use planning and research related to the characterization and evolution of production systems and land degradation. The approach to land cover/land use mapping, based on manual interpretation of a hardcopy image product, while perfectly acceptable at the time to achieve a high-priority research goal in a short time under prevailing constraints of data products and budgets, will probably not be replicated in the future. With the cost of medium-resolution imagery dropping markedly over the last few years, and image analysis software becoming cheaper, more powerful and user-friendly, it is unavoidable that any new land cover/land use mapping will be based on image analysis rather than manual interpretation.

Given the rapid rate of change in the rural environments of Syria, an update on the land cover/land use situation is urgently needed for the period 2000-2005.

1. INTRODUCTION

This research report presents a study of land cover and land use in Syria as it existed during the period 1989/1990. Based on an interpretation of satellite-derived products (Landsat 5 TM hardcopy images) and field checking, it aims to provide to ICARDA and its research partners reliable baseline information which can be of value for monitoring changes, e.g. in the context of desertification of farming systems research.

Land cover and land use are related but different mapping themes.
de Bie et al. (1996) define land cover as *'the vegetation (natural or planted) or man-made constructions (buildings, etc.) which occur on the earth surface. Water, ice, bare rock, sand and similar surfaces also count as land cover'.* The same authors, by contrast, define land use, as *'a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources'.*
In essence, the objective of mapping land cover is to describe and locate natural or man-made resources, whereas land use mapping aims to identify the goals, products and benefits from these resources.

Mapping land use is essential for the upscaling and extrapolation of farming systems research. The problem is that land use cannot be observed directly: to identify land use, knowledge is needed about land user goals, operations, products and benefits derived from land use. On the other hand, land cover can be observed directly, either by field surveys or remote sensing or, ideally, a combination of both. For this reason in order to map land use a land cover foundation is needed.

In practice mapping land use is usually undertaken as a reinterpretation of land cover. For example, a single land cover class, such as forest may be used for timber production, watershed management, and recreational use, resulting into different land use classes. This is a case of a clear separation of the resource (cover) and goal/product (use).
In other cases the distinction between land use and land cover may be artificial and lead to inconsistency. For example, cropland (a land cover) can be composed of individual crop types such as irrigated or non-irrigated olive, fruit trees, grapes, citrus etc. Depending on the tools used, it may or may not be possible to observe these uses of land directly or not. In the first case they could be considered subgroups of land cover, in the second case they are land use categories. This explains why in many maps land use and land cover are not always separated and features are mapped as 'land use/land cover' categories.

The fact is that in our minds we are seldom able to clearly dissociate land cover from its possible uses, since there is always some degree of interpretation possible about the use(s) associated with a particular land cover. Scale is therefore a paramount factor in deciding where land cover ends and land use starts, as it determines to what degree land use operations can be distinguished from the land-based assets.

There are also cases where *land cover* is not directly visible but has to be inferred from information on land use. The steppe areas of Syria, for example, are used for extensive grazing of small ruminants. Because these areas are in a state of permanent overgrazing, it is not possible to see the land cover 'rangelands' on the imagery for most of the year. Its presence needs to be inferred from interpreting secondary data, such as topography, rainfall patterns and soils. Also areas covered by rainfed crops are not directly visible since outside the growing season the land is bare, but their presence is inferred from the field patterns. Field patterns indicate a land use and from land use the land cover can be inferred.

These considerations explain why this baseline study at national level uses a classification system that is based on a mixture of land cover and land use features (see section 2.2).

The structure of this report is simple. Section 2 presents the methodology for mapping land cover and land use in Syria. Section 3 explains the categories of the map legend. Section 4 summarizes the 1989/1990 patterns of land cover/land use in different parts of Syria and attempts to associate certain forms of land degradation, visible on the satellite image

products, with particular land use/land cover categories. The appendices include small-size maps as well as the full map legend with areas.

2. METHODOLOGY

2.1. Materials

The major source of information is the 'Syria Space Image Atlas' (GORS, 1996). The Atlas contains 108 pages of high-quality printed images, georeferenced through a grid, and based on a mosaic compiled from Landsat Thematic Mapper (TM) images. The prints are in pseudo-natural colors and the scale is at 1:200,000. The location of the imagery covering Syria is shown by path and row numbers in Fig.1. The dates of the imagery used are shown in Table 1.

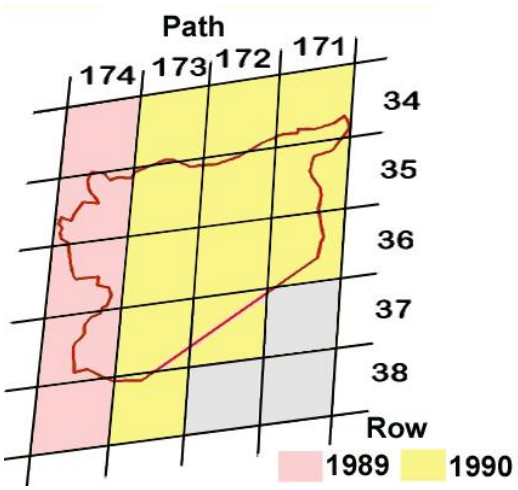


Figure 1. Landsat 5-TM coverage used

Table 1. Dates of imagery used (GORS, 1996)

Path-row	Date	Path-row	Date
171-34	17-8-90	173-34	8-9-90
171-35	17-8-90	173-35	8-9-90
171-36	17-8-90	173-36	8-9-90
171-37	26-6-84	173-37	8-9-90
		173-38	8-9-90
172-34	9-9-90	174-34	27-8-89
172-35	9-9-90	174-35	27-8-89
172-36	9-9-90	174-36	27-8-89
172-37	9-9-90	174-37	27-8-89
172-38	6-7-84	174-38	15-6-89

As Table 1 indicates, virtually the whole of Syria is covered by imagery within a 1-year time frame, 1989-1990. Two very small areas, in the northeast of the country, are covered by older imagery.

The imagery, with 30 m resolution, represents the late summer season (August and September). With the exception of the northern coastal strip, which represents the summer of 1989, for most of the area the summer of 1990 situation is visible. The imagery is therefore sufficiently coherent to be interpreted as a single set.

It is to be noted that the time of the imagery is outside the growing season. This implies that most areas used for extensive grazing show up as bare areas, and that the areas on the map identified as 'range' have been inferred from a combination of climatic, topographic and soils information. Similarly, areas under rainfed agriculture have been identified from their field pattern.

2.2. Classification

For this land cover/land use map a local and *a-posteriori* classification system has been selected. This is a system based on classifiers defined on the basis of an analysis of the collected data (de Bie et al., 1996). It contrasts with a standard or *a-priori* classification, such as the USGS land use/land cover classification scheme (Anderson et al., 1976) or the European Union Corine system (CEC, 1993), which are developed before any data collection takes place.

The main advantage of the a-posteriori classification is that the range of variation within the dataset can be much better addressed by a flexible typology. Also, the a-posteriori classification can at a later stage be converted into an a-priori classification without any loss of information at the mapping stage.

The classification scheme is a mixed one that incorporates principally elements of land cover, but also of land use. On the other hand, a classification based only on land cover would not make the most efficient use of the information provided by remote sensing and the analyst's knowledge about the area. A mixed classification therefore provides the greatest flexibility.

2.3. Compilation method

Map compilation was essentially a GIS exercise, based on visual interpretation of observed features rather than supervised classification using image analysis software and digital imagery. Classification units were drawn directly from the Atlas onto transparencies. The units and map sheet coordinates were subsequently digitized, the map sheets stitched together in the GIS software ARCINFO, and the boundaries joined across sheets.

The approach used has advantages and disadvantages as compared to automated classification methods of image analysis. The main advantages are speed and accuracy of interpretation. Visual interpretation, particularly by an experienced image interpreter familiar with the terrain, allows rapid and reliable identification of land use patterns. The advantage of the visual interpreter is that, in addition to the spectral characteristics, other important land attributes such as field patterns, can be considered in the classification. As a result of a more holistic interpretation, ground truthing of the classes established is easier and faster, thereby increasing speed and reliability of the classification.

The main disadvantages are interpreter bias and need for mapping units that are not homogeneous. Visual interpretation is always associated with some subjectivity and classification inconsistency. In addition, it allows only the identification of polygons that should be sufficiently large for mapping. Unavoidably, some of the mapping units thus defined through visual interpretation are therefore not homogeneous in terms of a single land use/land cover category. The trade-off is thus that in order to achieve a high map reliability, a relatively high number of classes needs to be defined that are mixtures of different land use/land cover classes.

2.4. Ground truthing

Two field trips of one week each were undertaken to validate the preliminary classification units, one to the area around the Euphrates river basin (Raqqa, Deir-ez-Zor, Qamishli, Hassakeh), the other one to the area south of Damascus (Hauran). For the other regions of the country the analysts were sufficiently acquainted with land cover and land use from previous field experience.

With the limitation that land use changes may have occurred since the time of the imagery, the ground truthing was particularly useful to understand how the unchanged patterns on the imagery looked at a much finer scale in the field, thus enabling a consistent interpretation across the country.

3. THE MAP LEGEND

The map legend can be subdivided into two major groupings:

- Homogeneous units
- Mixed units

Homogeneous units can be considered relatively pure (80-90%), e.g. the unit Bu can be considered to be composed for more than 80% of undifferentiated bare land.

Mixed units are complexes of homogeneous units. The relative importance of each homogeneous unit in the complex is indicated by its position in the unit label.
For example, the label Rg/Bu[1] indicates an area in which rangelands (Rg) compose most of the unit, but with an important proportion of undifferentiated bare land (Bu). The label Cw/Cs-l/Rs indicates an area in which the majority land cover is *rainfed winter/spring field crops (Cw)*, with an important proportion of *summer-irrigated crops on light-colored soils* (Cs-l) and with inclusions of natural vegetation in saline depressions (Rs).

For estimating the proportions of homogeneous units inside mixed units, one can use the following rough guide:

- >50% for the first unit in the label;
- 20-50% for the second unit in the label
- <20% for the third unit in the label

3.1. Map display

Label structure
Labels have been designed for mnemonic purposes (e.g. B for bare land, C for cultivation, F for forests etc.). Labels are short for homogeneous units (e.g. Cs-l), and long for mixed units (e.g., Cs-l/Bs). The homogeneous units inside mixed units are separated by the "/" character.

Map color scheme
Each homogeneous unit has its own color. Mixed units take over the color of the dominant homogeneous component with a superimposed pattern to mark that they are mixed.
For example, the homogeneous unit Cs-l has a green color on the map, whereas the mixed unit Cs-l/Bs has a green color with a superimposed cross-hatched pattern (Fig.2).

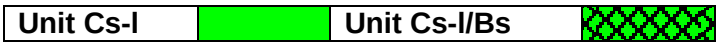


Figure 2. Example of a map color coding for homogeneous and mixed units

3.2. Homogeneous units

Tthe following major homogeneous categories can be distinguished:

- Bare areas with or without sparse cover
- Cultivated areas

[1] All labels are explained in sections 3.2. and 3.3. and the full map legend of Appendix 1.

- Forests and other wooded areas
- Rangelands
- Urbanized areas
- Water bodies

3.2.1. Water bodies

Within this category there are two homogeneous units:

Sweet water lakes and reservoirs, rivers (Wl)

This unit includes the Euphrates River, Lake Assad as well as some smaller dammed lakes. The unit can be recognized on imagery by its black (open water surface) or light green color (open water partially covered by algae or other floating vegetation).

Salt lakes, periodically inundated salt flats (Ws)

This unit includes saline areas that are either permanently or seasonally flooded. In very low rainfall areas, such as the SE of the country, this flooding does not necessarily occur every year. The unit can be recognized on imagery by a shape and texture that indicates depressions and a turquoise color that is indicative of salt-tolerant vegetation.

3.2.2. Bare areas with or without sparse cover

Bare areas show a surprising diversity, which is related to the underlying geological substratum, topography and denudation processes. Within this category nine homogeneous units have been differentiated:

Basaltic rock outcrops and rubble slopes (Bb)

Basaltic rock outcrops occur scattered throughout the country. They usually take the form of table mountains, with flat hilltops and boulder slopes, which rise over surrounding plains as a result of better resistance against geological erosion. An exception is the area south of Damascus, which is an extensive lava field with a gentle regional slope. Basaltic rock outcrops can be identified on the imagery by dark brown to blackish colors and strongly curved boundaries.

Carbonate-type rock outcrops and rubble slopes (Bc)

These areas include bare or poorly covered hills and mountains on different types of limestone. They are recognized on satellite imagery by pale colors combined with patterns that indicate an important relative relief between hilltops and valley positions, a moderate to close dissection by dendritic patterns of drainage lines, and hilltop or slope positions.

Undifferentiated highly dissected and eroded land (Be)

These areas include bare or poorly covered land with a stronger degree of dissection than the above category. The relative relief between hilltop and valley positions is lower, the spacing between drainage channels is closer and their orientation is more random. The erosion is due to the action of water and does not appear linked to human activities.

Plains with bare soil surface covered with flintstones (Bf)

These areas are confined to the south and southwest of Palmyra and are developed on outwash plains and lower footslopes enriched with flintstones as a result of the erosion of neighboring hills with siliceous deposits.

Plains with bare gypsum-enriched soil surface or gypsum outcrops (Bg)

These areas are fairly common in the east of the country in the Euphrates basin. They form plains and low hills, often eroded with a color pattern that is slightly more greenish than

the one of saline depressions. A further differentiating criterion is that these areas are generally located in upland positions.

Plains with bare lime-enriched soil surface covering calcareous sediments (Bl)

These areas are located in flat or gently sloping enclosed basins that show a typical bright white color on the imagery. According to the Geological Map of Syria (Technoexport, 1967) these areas are often underlain by calcareous deposits formed in small lakes during more pluvial periods of the Quaternary. There is no indication of vegetation cover.

Plains with bare soil surface partially covered with sand sheets(Bs)

Extensive bare areas occur in the east of the country, which have the characteristic appearance of plains with a thin cover of windblown sand. The thinness of the sand sheets is evidenced by the lack of full dune formation and the visibility of the underlying drainage network.

Shallow depressions of periodically inundated land (takyrs)(Bt)

These areas are located in clearly defined bare depressions, with on the imagery a typical pale color, that indicates a smooth flat surface. From the sparse vegetation cover, the low rainfall (< 100 mm/ yr) and landscape position, it can be assumed that these areas collect runoff from neighboring bare upland areas, but that flooding is infrequent, of low intensity and of very short duration.

Plains with undifferentiated bare soil surface (Bu)

These areas include plains with a bare soil surface that cannot be clearly classified into one of the above units.

3.2.3. Rangelands

Within this category there are two homogeneous mapping units:

Natural vegetation of saline depressions (Rs)

This unit includes higher parts of saline depressions that are less frequently flooded than unit Ws. The vegetation of these areas appears perennial and is likely to include salt-tolerant species. The unit can be recognized on imagery by a shape and texture that indicate the edges and slightly higher parts of depressions, and by a somewhat more greenish color than for unit Ws.

Sparse grasslands and shrublands of rocky hills and arid lands (Rg)

This unit covers the predominant grasslands and shrub areas used for extensive grazing. As the available imagery shows a late summer situation, when any grasses have either dried up or been consumed, there is no characteristic pattern related to vegetation. Instead the presence of range areas is inferred from the combination of landscape position, soils, rainfall pattern and absence of other land use. Range areas thus inferred are characterized by topographic positions intermediate between hilltops and depressions, lack of rocks or boulders, rainfall adequate to support range (> 150 mm/yr), and absence of field patterns. Sometimes the imagery shows greener patches that are also indicative of vegetation cover that is less sparse than in the B-units.

3.2.4. Forests and other wooded areas

Within this category two homogeneous mapping units are recognized:

Undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas (Fu)

This unit includes all forest areas, whether they are coniferous or broadleaf, evergreen or deciduous. At the scale of the study and the time of the imagery it is not possible to separate them. The imagery indicates that these areas have a dense canopy cover and are therefore in a relatively well preserved state and do not contain major impurities such as enclaves with

tree crops. Forest areas are mainly confined to the western escarpment bordering the Jebel Ansariya and the Ghab and to the Kassab area.

Scrubland and degraded forest, often interspersed with tree crops (Fd)

This unit includes forest areas characterized by scrub physiognomy as a result of frequent cutting and burning, and numerous inclusions of bare patches, agricultural areas, principally tree crops, and preserved forest patches. These areas cover a large proportion of the Jebel Ansariya.

3.2.5. Cultivated areas

Within this category six homogeneous mapping units are recognized. Some land use/land cover types are subdivided according to whether they occur on light-colored (suffix –l) or dark-colored soils (suffix –d). Although strictly speaking this is a study of land cover and not of soils, the addition of surface soil color information may be useful. This easily observable feature can point to management practices (e.g. higher residue incorporation, burning) or to different soil types, which could be associated with climatic conditions and hence different land uses. The darker-colored soils usually occur in higher-rainfall areas or on basaltic parent materials, whereas the lighter-colored soils mainly occur in lower-rainfall areas. A comparison with the soil map of Syria (Van de Steeg and De Pauw, 2000) indicates that the darker-colored soils tend to be more clayey, whereas the lighter-colored soils tend to have a higher silt content. Important land management properties, such as resistance to wind and water erosion, tend to be associated with these textural differences.

Horticultural crops (Ch)

This mapping unit may include tree crops, field and vegetable crops, which are grown on small plots receiving intensive inputs. These inputs include irrigation, optimal plant nutrition and protection, high labor input, and soil conservation structures such as stone terraces. By its very nature the unit shows tremendous diversity over small distances because it manipulates every terrain particularity for a specific purpose. The term refers therefore more to a high-input based management system rather than a specific category of crops. This unit in its pure form has a limited extent.

Tree crops (Ct)

In its pure form this mapping unit refers mostly to olive grove areas in the NW of the country, particularly certain parts of the Afrin valley, where the trees have a standard density. It can be recognized on the imagery by a dark green dotted pattern, which does not follow the traditional elongated field patterns, typical of field crops.

Mostly irrigated summer field crops, on dark-colored soils (Cs-d) or on light-colored soils (Cs-l)

Summer-irrigated crops show up light green on the imagery and can, in conjunction with the field pattern information, be easily delineated. From the color of the interspersed fallow areas it can be inferred whether they occur on either dark-colored soils (Cs-d) or on light-colored soils (Cs-l).

These mapping units refer to relatively homogeneous areas under field crops that are irrigated in summer. The proportion of fallow land is relatively low within these mapping units (< 20%), which distinguishes them from units where the proportion of irrigated crops is important but smaller, and which are therefore considered mixed units (e.g. Cw/Cs-d).

Mostly rainfed winter/spring field crops, on dark-colored soils (Cw-d) or on light-colored soils (Cw-l)

These mapping units refer to areas that are assumed to be under rainfed crops. They are identified from the characteristic field patterns, the lack of crop cover and the soil colors. While fairly homogeneous, they usually contain inclusions (<20%) of summer-irrigated crops.

For these areas the time of the imagery does not allow to differentiate between winter-sown or spring-sown crops, or to assess whether the latter have been irrigated in spring. However, given the fact that these areas, which occur mostly in the west and north of the country, match quite well the higher-rainfall zones (>250 mm/yr), it can be safely assumed that the crops grown are mostly rainfed, although supplemental irrigation can not be entirely excluded. Generally speaking, the unit Cw-d is associated with a higher rainfall regime than unit Cw-l, which is at the borderline of the range areas. The latter mapping unit also occurs in a few depression areas inside low rainfall areas (< 200 mm/yr).

3.2.6. Urbanized areas

Urbanized areas are separated into two mapping units:

Built-up areas and settlements (cities, villages)(Ub)
These are characterized by a typical gray granular pattern on the imagery.

Non-built-up areas (Un)
These include open structures related to human activities, such as quarries. Given the limited resolution of the imagery only very large non-built-up areas can be displayed on the map.

3.3. Mixed units

As explained earlier, mixed units are complex mapping units formed by homogeneous units. The first homogeneous unit in the label is the *dominant* one and gives the color to the complex mapping unit. The second label component is the *associated* land use/land cover, and the third label component refers to *inclusions*.
As these units are combinations of homogeneous units, the composition only is listed and for more details is referred to section 3.2.

3.3.1. Predominantly water bodies

Within this category only 1 mapping unit has been identified:

Ws/Bc
Dominant: salt lake or periodically inundated salt flats
Associated: carbonate-type rock outcrops and rubble slopes

3.3.2. Predominantly bare or sparsely covered land

Within this category 19 mapping units have been identified:

Bb/Cw-d/Cs-d
Dominant: basaltic rock outcrops and rubble slopes
Associated: rainfed winter/spring field crops
Inclusions: irrigated crops on dark-colored soils

Bb/Fd
Dominant: basaltic rock outcrops and rubble slopes
Associated: scrubland and other types of degenerate forest

Bc/Bs
Dominant: carbonate-type rock outcrops and rubble slopes
Associated: bare soil surface partially covered with sand sheets

Bc/Ct
Dominant: carbonate-type rock outcrops and rubble slopes

Associated: tree crops

Bc/Rg
Dominant: carbonate-type rock outcrops and rubble slopes
Associated: sparse grasslands and shrublands of rocky hills and arid lands

Be/Bs
Dominant: highly dissected and eroded land
Associated: bare soil surface, partially covered by sand sheets

Be/Cw-I/Cs-I
Dominant: highly dissected and eroded land
Associated: rainfed winter/spring field crops
Inclusions: irrigated crops on light-colored soils

Be/Rg
Dominant: highly dissected and eroded land
Associated: sparse grasslands and shrublands

Be/Rg/Bg
Dominant: highly dissected and eroded land
Associated: sparse grasslands and shrublands
Inclusions: bare gypsum-enriched soil surface or gypsum outcrops

Be/Rs
Dominant: highly dissected and eroded land
Associated: natural vegetation in saline depressions

Be/Ws
Dominant: highly dissected and eroded land
Associated: periodically inundated salt flats

Bg/Bs
Dominant: plains with predominantly bare gypsum-enriched soil surface or gypsum outcrops
Associated: sand sheets

Bg/Bt/Bs
Dominant: bare gypsum-enriched soil surface or gypsum outcrops
Associated: shallow depressions of periodically inundated land
Inclusions: scarce grassland and scrubland, and bare soil surface covered with sand sheets

Bg/Rg
Dominant: plains with bare gypsum-enriched soil surface or gypsum outcrops
Associated: sparse grasslands and shrublands of arid lands

Bl/Cw-I/Cs-I
Dominant: plains with bare lime-enriched soil surface covering calcareous sediments
Associated: rainfed winter/spring field crops
Inclusions: irrigated crops on light-colored soils

Bs/Bg
Dominant: plains with bare soil surface, partially covered with sand sheets
Associated: gypsum-enriched plains, or with gypsum outcrops

Bs/Bg/Rg

Dominant: plains with bare soil surface, partially covered with sand sheets
Associated: gypsum-enriched plains, or with gypsum outcrops
Inclusions: some sparse grasslands or scrublands

Bu/Be
Dominant: plains with undifferentiated bare soil surface
Associated: highly dissected and eroded land

Bu/Bs
Dominant: plains with bare soil surface
Associated: sand sheets

3.3.3. Predominantly rangelands

Within this category three mixed mapping units can be differentiated:

Rg/Bu
Dominant: sparse grass and shrub plains
Associated: undifferentiated bare soil

Rg/Cw-d
Dominant: sparse grasslands and shrublands of rocky hills and arid lands
Associated: rainfed winter/spring field crops
Inclusions: irrigated crops on dark-colored soils

Rg/Cw-l
Dominant: sparse grasslands and shrublands of rocky hills and arid lands
Associated: abandoned rainfed cropland, on light-colored soils

3.3.4. Predominantly forests and other wooded areas

Within this category only 1 mixed mapping units has been differentiated:

Fu/Fd
Dominant: undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas
Associated: scrubland and other types of degenerate forest, often with interspersed tree crops

3.3.5. Predominantly cultivated areas

Within this category 20 mixed mapping units have been differentiated:

Cs-l/Bs
Dominant: irrigated summer field crops, on light-colored soils
Associated: natural vegetation in saline depressions

Ct/Ch
Dominant: tree crops
Associated: horticultural crops

Ct/Cw/Cs-d
Dominant: tree crops
Associated: rainfed winter/spring and summer-irrigated field crops, on dark-colored soils

Ct/Cw-d

Dominant: tree crops
Associated: rainfed winter/spring field crops
Inclusions: irrigated crops, on dark-colored soils

Cw/Cs-d
Dominant: rainfed winter/spring field crops
Associated: summer-irrigated crops, on dark-colored soils

Cw/Bc/Cs-d
Dominant: rainfed winter/spring field crops
Associated: carbonate-type rock outcrops and rubble slopes
Inclusions: irrigated crops, on dark-colored soils

Cw/Bg/Cs-d/
Dominant: rainfed winter/spring field crops
Associated: bare gypsum-enriched soil surface or gypsum outcrops
Inclusions: irrigated crops, on dark-colored soils

Cw/Cs-d/Ct
Dominant: rainfed winter/spring field crops
Associated: irrigated summer crops on dark-colored soils
Inclusions: tree crops

Cw/Cs-l
Dominant: rainfed winter/spring field crops
Associated: summer-irrigated crops, on light-colored soils

Cw/Cs-l/Bl
Dominant: rainfed winter/spring field crops
Associated: summer-irrigated crops, on light-colored soils, and bare, lime-enriched soil surface covering calcareous sediments

Cw/Cs-l/Rs
Dominant: rainfed winter/spring field crops
Associated: summer-irrigated crops, on light-colored soils, and natural vegetation in saline depressions

Cw/Cs-ld
Dominant: rainfed winter/spring field crops
Associated: summer-irrigated crops, mainly on light-colored but also dark-colored soils

Cw-d/Bb
Dominant: rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils
Associated: basaltic rock outcrops and rubble slopes

Cw-d/Bl
Dominant: rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils
Associated: bare lime-enriched soil surface covering calcareous sediments

Cw-l/Be/Cs-l
Dominant: rainfed winter/spring field crops
Associated: highly dissected and eroded land
Inclusions: irrigated crops, on light-colored soils

Cw-l/Bg
Dominant: plains with predominantly rainfed winter/spring field crops
Associated: bare gypsum-enriched soil surface or gypsum outcrops
Inclusions: irrigated crops, on light-colored soils

Cw-l/Bl
Dominant: plains with predominantly rainfed winter/spring field crops
Associated: bare, lime-enriched soil surface covering calcareous sediments
Inclusions: irrigated crops, on light-colored soils

Cw-l/Bu
Dominant: plains with rainfed winter/spring field crops
Associated: bare soil surface
Inclusions: irrigated crops

Cw-l/Rg
Dominant: rainfed winter/spring field crops
Associated: sparse grasslands and shrublands
Inclusions: irrigated crops, on light-colored soils

Cw-ld
Dominant: rainfed winter/spring field crops mainly on light-colored, but also dark-colored soils
Inclusions: irrigated crops

4. THE BROAD PICTURE OF LAND COVER AND LAND USE IN SYRIA

4.1. General patterns of land cover and use

The detailed map of land cover/land use in Syria is shown in Appendix 2. A simplified map showing only the dominant types is provided in Fig. 3. Both maps show the complexity of land cover/land use patterns.

From the digitized land cover/land use map it was possible to calculate the surface areas of each land cover/use class. The areas, expressed in square kilometer, and as a percentage of Syria's total area, are given for each class in Appendix 1.
A summary of the areas is given in Table 2.

For the base year 1989/1990 about one third of Syria (about 34%) was cultivated, mostly under rainfed systems. Considering the semi-arid or arid conditions in the country, this is a very high proportion of agriculture to the total land area. Of the cultivated area, about 8,000 km^2 was irrigated. This is probably an underestimation, because the mixed units in which irrigated cropping occurs as a minority land use, have not been added. If, using the allocation key given in section 3.1., the areas of irrigated land use are estimated and included in the assessment, a total of about 11,500 km^2 of irrigated land can be identified.

Another interesting finding is the very limited extent of forested or wooded areas (about 3 %). Considering the importance of agriculture and bare land in areas where forestry is either feasible or desirable for watershed or landscape protection, this poor representation indicates that forestry is not a priority land use.

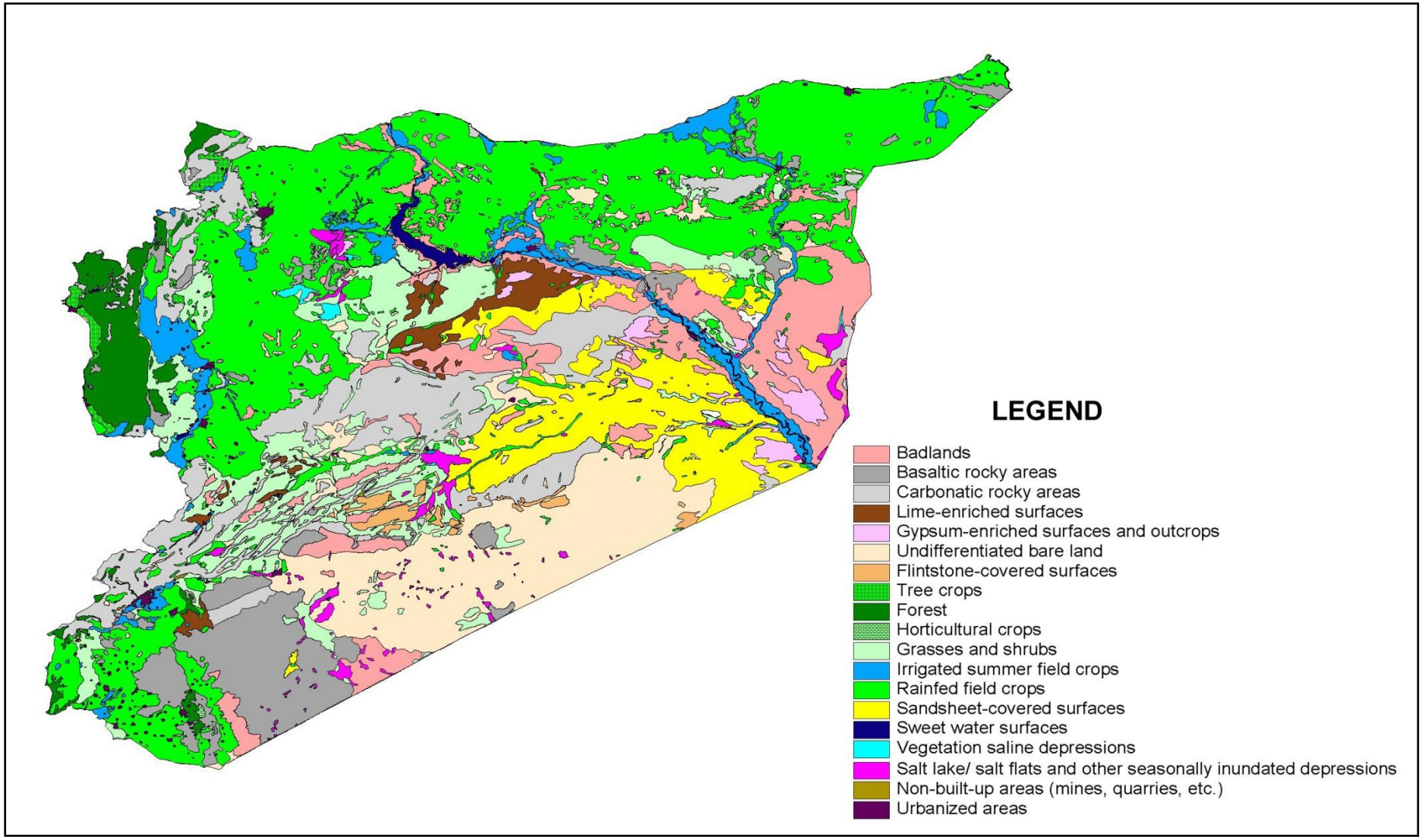


Figure 3. Simplified map of land cover and land use in Syria showing only the dominant types

Table 2. Areas for major land cover/land use categories

Category		**Homogeneous units**		**Mixed units**		***Totals***	
		%	no.	%	no.	*%*	*Total no.*
B	Bare areas with or without sparse cover	36.9	9	14.6	19	*51.5*	*28*
C	Cultivated areas	18.7	7	15.5	19	*34.2*	*26*
F	Forests and other wooded areas	3.2	2	0.0	1	*3.2*	*3*
R	Rangelands	7.5	2	1.9	3	*9.4*	*5*
U	Urbanized areas	0.5	2	0.0	0	*0.5*	*2*
W	Water bodies	1.1	2	0.1	1	*1.2*	*3*
Totals		*67.8*	*24*	*32.2*	*43*	*100.0*	*67*

Note:
%: percentage of Syria
no.: number of mapping units

The rangelands only occupy about 10% of the country. This is a major under-representation of the land that is being used for grazing. The main reason for this under-estimation is an issue of classification. Rangeland is a 'use', and on satellite images one can only see 'vegetation cover', which during summertime, when the images were taken, is virtually nil in most of the country. It therefore needs to be remembered that much of the land in the 'Bare Areas' classes is in fact grazed during some time of the year

Table 2 also confirms that, whereas there are fewer homogeneous mapping units, the visual interpretation allowed delineating homogeneous land cover/use categories in most (67%) of the country.

Table 3 confirms that there is a good match between the current assessment based on remote sensing and official statistics in the case of rainfed agriculture. In the case of the irrigated lands, the estimates obtained from remote sensing are nearly twice as high as those of the official statistics. The estimates derived from satellite imagery are considered more reliable because the spectral signature of irrigated areas is unmistakable in summer.

Table 3. Comparison of land cover areas with FAO statistics[2] (FAO, 1992)

Category	Remote sensing				Statistics	
	Homo-geneous	Mixed	Total	Bare + range	Total	Bare + Permanent pastures[3]
Bare areas with or without sparse cover[4]	68,244	27,111	95,355		41,740	
Rangelands	13,893	3,467	17,360	112,715	78,690	119,424
Cultivated areas	34,633	28,739	63,372		56,260	
1) Rainfed[5]	26,449	25,238	51,687		49,330	
2) Irrigated	8,184	3,501	11,685		6,930	
Forests and other wooded areas	5,845	70	5,914		7,230	
Urbanized areas	1,006	0	1,006			
Water bodies	1,967	206	2,173		1,260	
	125,587	*59,593*	*185,180*		*185,180*	

[2] The FAO statistical data refer to the year 1990, the same year as the satellite images.
[3] Estimated as Permanent Pastures (FAO) + Other land (FAO) – Built up areas (Remote sensing)
[4] In the case of FAO statistics, the statistical category 'other land', includes apart from 'bare land' also built-up (urbanized) areas.
[5] In the case of FAO statistics, *areas under rainfed agriculture* have been estimated as follows:
Arable + Permanently cropped land – irrigated land

Table 3 also indicates the difficulty of defining range areas as a land use category. The estimates of both bare areas and rangelands diverge tremendously. This is due to the fact that what is classified as 'bare', as a land cover category, can easily correspond with rangeland, as a land use category. The statistical land use categories 'barren' and 'rangeland' are differentiated on the basis of different indicators than remote sensing and are not explained in the statistical yearbooks. However, if bare lands and rangelands are lumped together, the correspondence between estimates from remote sensing and production statistics is quite good.

For the time being it has to be accepted that in the present study it is not possible to differentiate consistently rangelands from bare land and that the latter contain many areas that are being grazed during the rainy season. In order to identify rangelands reliably, imagery taken during early April would be most suitable.

4.2. Land cover and use in relation to physical regions

Land cover and use patterns are specific to the major physical regions of Syria. For the purpose of establishing broad land cover patterns the following physical regions have been differentiated:

- Coastal Plain (CP)
- Coastal Mountains (CM)
- Ghab (G)
- Hauran (H)
- Rocky Hills and Uplands (RH)
- Semi-arid Plains (SAP)
- Arid Interior (AI)
- Euphrates Basin (EB)

These regions are shown in Fig. 4 in black lines on top of the map of annual precipitation[6].

4.2.1. Coastal Plain (CP)

The coastal plain is a narrow strip of flat to gently undulating land west of the coastal mountains (Jebel Ansariye). It is a densely settled area mainly used for intensive agriculture. Olives, citrus and other fruit trees, vegetables, tobacco and, to a lesser extent, cereals are grown. The land cover pattern is therefore highly diverse. The main mapping units are Ct/Ch (tree and horticultural crops) and Cw-d (winter/spring sown field crops).

4.2.2. Coastal Mountains (CM)

The Jebel Ansariye is a large tilted mountain block, highly dissected by a parallel drainage system flowing westward towards the coastal plain. The mountains are sparsely settled and are still largely covered by forest areas. The main land cover is degraded forest interspersed with agriculture and tree crops planted on terraced hillsides (mapping unit Fd). The second most important cover is undisturbed forest (mapping unit Fu). Due to the rugged topography there is an important proportion of bare rocks (Bc).

4.2.3. Ghab (G)

The Ghab is the rift depression between the coastal mountains (CM) on the west and the limestone hills (RHa) on the east. It is a very flat plain, previously flooded by the Orontes River, subsequently drained and now a major irrigated area. Due to its good rainfall, the

[6] Source: ICARDA GIS Laboratory

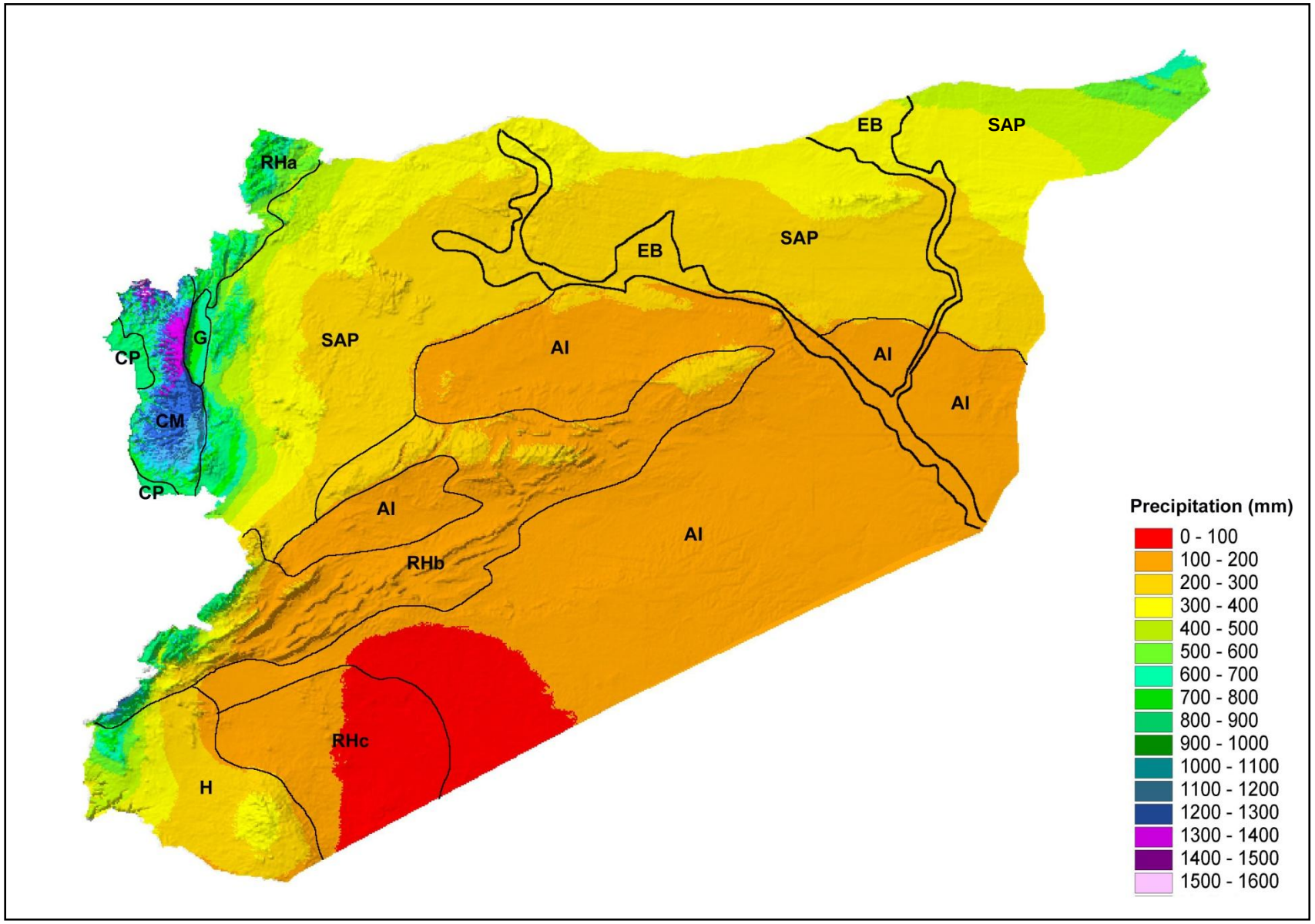


Figure 4. Physical regions of Syria

abundance of irrigation water and mild temperatures in winter, two crops are possible during the year, although generally only one crop will be grown on the same field in any one year.
The area has a very diversified and commercialized agriculture, mostly field crops (wheat, cotton, legumes, potatoes, tobacco, vegetables) but also olives and grapes. The main mapping units are in order of decreasing proportion Cs-d (irrigated summer crops) and Cw-d (rainfed winter/spring crops. The field pattern of the Ghab reflects the merger of a canal-based irrigation infrastructure with a traditional tenure pattern.

4.2.4. Hauran and Golan (H)

This region covers a highly settled fertile agricultural area on weathered volcanic, mostly basaltic deposits. Diverse and mostly rainfed crops are grown. The dominant mapping unit is Cw-d (rainfed winter/spring crops on dark soils), with inclusions of summer-irrigated crops (Cs-d) and bare basalt rock (Bb).

4.2.5. Rocky Hills and Uplands

Three major hill and upland areas occur in different parts of Syria. All are characterized by a predominance of bare or sparsely vegetated land.

RHa: Limestone hills of NW Syria

These are blocks of low karstic limestone hills, separated by flat valleys, and are situated in a higher rainfall zone (> 350 mm). Owing to the bare rock land they have a sparse shrub cover, or in isolated patches with thicker soil cover, plots of cereals or tree crops.
Destoning takes place in these places with soil collected from underneath the rocks being used to grow olive and fruit trees. Agriculture is highly concentrated in the intervening wide, flat valleys between the limestone hills, which are fully occupied by rainfed field crops, with olive and fruit trees on the more stony and shallow margins. There is an important proportion of irrigated field crops.

RHb: Palmyrenian mountain range

This area is an elongated complex of parallel hills and valleys, which crosses the country from Damascus to near the Euphrates. The area is much drier than region RHa and is predominantly rocky or stony (mapping unit Bc). The wide valleys may have a thicker soil cover and provide valuable range areas (mapping unit Rg). Occasionally winter/spring crops are grown in low-rainfall valleys, which can therefore be assumed to receive supplementary water from runoff harvesting (mapping unit Cw-l/Bl). With the exception of the Palmyra oasis, irrigation is not much practised in this area.

RHc: Lava field of SW Syria

This area covers a vast, recently deposited and unweathered lava field. It includes the Jebel Druze and numerous small volcanoes. With the exception of a few agricultural areas, situated on fault lines, where water is concentrated, the area is generally bare and devoid of any agricultural land use.

4.1.6. Semi-Arid Plains (SAP)

These areas include the gently undulating and flat plains of west and northern Syria, which have adequate rainfall for rainfed cultivation (350-200 mm). This is a highly settled part of Syria and most of the land is used for agriculture. Rainfed crops predominate, mostly on dark soils (mapping unit Cw-d). With the decline in rainfall from west to east and from north to south, soils tend to become lighter in color, which is clearly visible on the imagery and is one of the differentiating criteria for the mapping units. Irrigated agriculture is not dominant, but an important component of the agricultural land use. It is highly concentrated in a few areas, favored by good topography and easy availability of groundwater.

As rainfall decreases, rainfed agriculture becomes more risky, subject to drought, and in some areas rainfed agriculture is only possible in years of exceptional rainfall. An example is mapping unit Rg/Cw-l, which shows weak cultivation patterns. It corresponds with an

opportunistic cultivation in which the area cultivated was much expanded into the steppe areas in anticipation of a very wet year (1987-88). However, when the rains failed later in the season, agriculture was abandoned in favor of grazing (Debaine and Jaubert, 1998).

This area is the dynamic and fluctuating boundary between the cultivated and range areas, although since the introduction of land use regulations related to the 'steppe line', land use has become more static.

The field pattern in the west is mostly small-scale, indicating a predominantly traditional land tenure pattern, in which only limited land consolidation has taken place. In the north, land consolidation, resulting into big block farms has taken place to a much larger extent. These block farms are mostly rainfed.

4.1.7. Arid interior (AI)

These areas include mainly gently undulating and flat plains, which are predominantly bare, due to a low average annual precipitation (< 200 mm/yr). A wide belt of land curving from the center of Syria towards the southeast of the country, south of the Euphrates, is covered with a thin sand sheet (mapping unit Bs).

Saline depressions are common, as well as outcrops of gypsum rock or gypsum-enriched sediments. Other types of bare areas may occur in fairly complex combinations. Agricultural areas occur as inclusions only (e.g. mapping unit Cw-l), and then probably only during high-rainfall years. Some potential range areas may exist in valleys favored by water additions from runoff, or in isolated hills (e.g. mapping unit Rg).

4.1.8. Euphrates Basin (EB)

This area covers the Euphrates valley and the irrigation extension areas served by the Tabqa Dam. The Euphrates valley includes the floodplain and several terrace levels and is highly settled and intensively cultivated. Given the mild temperatures in winter and year-round availability of irrigation water two crops are possible per year. The valley and extension areas are dominated by summer-irrigated crops, mainly cotton. The field pattern in the Euphrates valley is predominantly small-scale, indicating smallholder agriculture. The field pattern in the irrigation extension areas is generally large-block-based, except where valley shape and size impose limits on the provision of irrigation water through canals.

4.2. Land degradation

The imagery used for this study allows drawing only limited conclusions about the prevalence of land degradation and the current activity of degradation processes. In addition, it is not always easy to separate those forms of degradation that are entirely natural from those that are man-made.

Three forms of land degradation processes can be distinguished:

- vegetation degradation
- wind and water erosion
- salinization

4.2.1. Vegetation degradation

The imagery shows very clear vegetation degradation in the coastal mountains. This is obvious from the intertwining of original forest vegetation and mosaics of agricultural areas mixed with degraded forms of the original forest vegetation.

Degradation of the rangelands in the drier semi-arid plains and arid interior can not be observed directly from imagery that represents a summer situation, but has to be inferred from other evidence. What is striking is the particular bareness of the soil surface in summer. For the very arid areas and rocky hills this is natural. However, in the higher rainfall areas or topographic lowlands one would expect the granular patterns typical of shrubs and other perennials. The absence of such patterns indicates that perennial vegetation has

disappeared almost entirely, except in some depression areas, where it may be linked with saline conditions. The conclusion is that whatever the winter/spring conditions for range, it is largely based on the presence of annuals. This in itself is a form of degradation caused by overgrazing.

4.2.2. Wind and water erosion

Wind erosion is evidenced by the presence of widespread sand sheets in the arid interior, particularly around the eastward extension of the Palmyrenian range, where it covers a combined maximal width of 80 km. This form of wind erosion can occur rapidly and is probably linked to the absence of perennials in the steppe.

Water erosion of a geological nature is obvious, particularly in the bare areas around the Euphrates valley (mapping unit Be), and is entirely natural even in the arid interior which is crisscrossed by large wadi systems and other seasonal drainage lines. Large areas affected by accelerated water erosion can be observed south and southwest of Jebel Bishri. Apparently an abrupt shift in land use took place here, with the establishment of large mechanized block at the cultivation-steppe margin for opportunistic rainfed cropping in the expectation of an exceptional rainfall year. The interpretation is that accelerated erosion took place after the farms were abandoned. This can be observed on the imagery from gully patterns that extend over the farm blocks. Debaine and Jaubert (1998) have observed the same land use changes in the area south of lake Jabboul, and attribute it to the lifting of Government restrictions to cultivation in the steppe in 1987.

4.2.3. Salinization

Salinization of a geological nature occurs in the depressions without external drainage that collect drainage water from the surrounding uplands. Several large depressions with saline conditions or even salt deposits occur in the semi-arid plains and arid interior, such as lake Jabbour, the depression south of the Palmyra oasis and other depressions near the Iraqi border.

Man-induced salinization can not observed directly on the imagery but inferred from anomalies in the land use pattern. Large areas in the Euphrates valley south of Deir ez Zor are bare while the canal infrastructure and field pattern typical of an intensive irrigation system, and shortage of suitable land can be clearly seen. The bare patches are too concentrated and too ragged at the edges to be fallow land. By elimination, confirmed by field observations, they most likely represent salinized land.

5. CONCLUSIONS

A national land cover/land use map offers a snapshot in time of the spatial distribution of vegetation-based resources and their uses. As such it has applications in land use planning and research related to the characterization and evolution of production systems and land degradation.

The particular patterns of land use and certain land cover features that are visible or can be interpreted from a map at different moments in time, offer important clues to the evolution of production systems in either sustainable or unsustainable ways. The outscaling of farming systems research, which by its very nature is site-specific and difficult to extrapolate, can only operate through an intermediate step of land cover/land use mapping.

The assessment of the state of the natural resource base as a component of the rural environment requires regular land cover/land use mapping. Without it, no serious research into desertification can get off the ground. The comparison of land cover/land use at different times is an essential step to allow interpretation of changes as either natural fluctuations in the resource base or the land use pattern, induced by e.g. climatic variability, or as human-induced long-term trends.

The potential value of a national land cover/land use map is enhanced by integration with other environmental, infrastructural and socioeconomic data sources related to climate, soil

and water resources, and population, in a GIS framework. An integrated environmental database contains many elements that would allow understanding important relationships between resource endowment, use and livelihood systems, and identify poverty 'hot spots'.

In the light of the above considerations and in the absence of a suitable product in the public domain, it was realized that the preparation of a land cover/land use map for Syria was a high-priority matter.

The current approach to land cover/land use mapping is based on manual interpretation of a hardcopy image product and was not an issue of choice, but rather one of lack of choice. Clearly, image analysis based on training areas, statistical modeling and limited ground truthing, is the preferred method, if a quality set of digital imagery, image analysis software, and skilled remote sensing analysts are available. At the time ICARDA had none of these, only a printed Atlas, skills to convert this into a GIS system, and ability to reconcile features observed on the images with those observed on the ground.

With the added benefit of color for feature differentiation and a proper geo-referencing in GIS, the current approach can be considered an improved form of aerial photography interpretation. Nevertheless, the comparison of land cover/land use estimates obtained from this simple approach with those from official statistics, demonstrates that the manual interpretation works quite well at the national level. In the hands of experienced interpreters, the approach is also useful in getting a feel for the main kinds of land degradation, their location and severity.

A major disadvantage of the manual interpretation remains the necessary use of classes based on mixed units, leading to a complex legend. Inherent to the approach, it is subject to observer bias and leads to a proliferation of non-systematic errors in the estimation of area proportions of the components in these mixed units.

The cost of medium-resolution imagery, such as Landsat 7 ETM, has dropped markedly over the last few years, image analysis software has become cheaper, more powerful and user-friendly, whereas hardcopy products are getting rarer and more expensive. With these technological trends it is unavoidable that any new land cover/land use mapping will be based on image analysis rather than manual interpretation.

As mentioned earlier, land cover/land use maps require to be updated at regular intervals. Depending on the rate of change in the rural environments, this should be done every five to ten years. For Syria significant changes have occurred since 1989/90 in land use and land use policy. Several new irrigation schemes have been inaugurated, new dams have been constructed and artificial lakes created. The creation of the 'steppe line' in 1995 and subsequent banning of cultivated in areas with precipitation less than 200 mm/yr may have had a significant impact on land use. The cultivation of tree crops, assisted by large-scale mechanized destoning operations in previous marginal lands, has expanded tremendously. An update is therefore urgently needed to assess the land cover/land use situation in Syria for the period 2000-2005.

REFERENCES

Anderson, J.R., E.E. Hardy, J.T. Roach and R.E. Witmer. 1976. A Land Use and Land Cover Classification System for use with remote sensor data. Geological Survey Professional Paper 964, 41 pp. On-line document: http://landcover.usgs.gov/pdf/anderson.pdf

CEC, 1993. CORINE Land Cover Technical Guide. European Union. Directorate-General Environment, Nuclear Safety and Civil Protection. Luxembourg.

Debaine F. and Jaubert R. 1998. Les marges aride de Syrie: la “frontière” des 200 mm. Planification agricole et occupation du territoire. Sécheresse 1998; 9(1): 43-50

de Bie C.A., Van Leeuwen J.A. and Zuiderma P.A. 1996. The Land Use Database. A knowledge-based software program for structured storage and retrieval of user-defined land use data sets. User’s Reference Manual. ITC Enschede

FAO 1991. FAO Yearbook. Production. Vol. 45, 1991. Food and Agriculture Organization of the United Nations, Rome 1992

GORS. 1996. Syria Space Image Atlas. General Organization of Remote Sensing, Prime Ministership, Damascus, 168 pp.

Technoexport, 1967. The Geology of Syria, Map 1: 500.000/1:200.000 and Explanatory notes. Department of geological and Mineral Research, Ministry of Industry, Syrian Arab Republic, Damascus

APPENDIX 1. LEGEND LAND COVER/LAND USE MAP OF SYRIA

1. HOMOGENEOUS UNITS

Legend symbol	Area (sq.km)	Area (% of Syria)	Description
	68,400	***36.9***	***Bare or sparsely covered land***
Bb	*12779*	*6.9*	Basaltic rock outcrops and rubble slopes
Bc	*19633*	*10.6*	Carbonate-type rock outcrops and rubble slopes
Be	*11778*	*6.3*	Undifferentiated highly dissected and eroded land
Bf	*1405*	*0.8*	Plains with bare soil surface covered with flintstones
Bg	*1398*	*0.8*	Plains with bare gypsum-enriched soil surface or gypsum outcrops
Bl	*1257*	*0.7*	Plains with bare lime-enriched soil surface covering calcareous sediments
Bs	*14137*	*7.6*	Plains with bare soil surface partially covered with sand sheets
Bt	*998*	*0.5*	Shallow depressions of periodically inundated land (takyrs)
Bu	*5015*	*2.7*	Plains with undifferentiated bare soil surface
	34,712	***18.7***	***Cultivated areas***
Ch	*58*	*0.0*	Horticultural crops
Cs-d	*3828*	*2.1*	Mostly irrigated summer field crops, on dark-colored soils
Cs-l	*4307*	*2.3*	Mostly irrigated summer field crops, on light-colored soils
Ct	*174*	*0.1*	Tree crops
Cw-d	*12265*	*6.6*	Mostly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils
Cw-l	*9642*	*5.2*	Mostly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils
Cw-ld	*4438*	*2.4*	Rainfed winter/spring field crops, with inclusions of irrigated crops, mainly on light-colored and an important proportion on dark-colored soils
	5,858	***3.2***	***Forests and other wooded areas***
Fd	*3783*	*2.0*	Scrubland and other types of degenerate forest, often with interspersed tree crops
Fu	*2075*	*1.1*	Undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas
	13,925	***7.5***	***Rangelands***
Rs	*405*	*0.2*	Natural vegetation of saline depressions
Rg	*13520*	*7.3*	Sparse grasslands and shrublands of rocky hills and arid lands
	1,008	***0.5***	***Urbanized areas***
Ub	*922*	*0.5*	Built-up areas and settlements (cities, villages)
Un	*86*	*0.0*	Non-built-up areas (mines, quarries, etc.)
	1,972	***1.1***	***Water bodies***
Wl	*954*	*0.5*	Sweet water lakes and reservoirs, rivers
Ws	*1018*	*0.5*	Salt lakes, periodically inundated salt flats

2. MIXED UNITS

Legend symbol	Area (sq.km)	Area (% of Syria)	Description
	27,173	***14.6***	***Predominantly bare or sparsely covered land***
Bb/Cw-d	*220*	*0.1*	Predominantly basaltic rock outcrops and rubble slopes, with an important proportion of rainfed winter/spring field crops and inclusions of irrigated crops, on dark-colored soils
Bb/Fd	*106*	*0.1*	Predominantly basaltic rock outcrops and rubble slopes, with an important proportion of scrubland and other types of degenerate forest
Bc/Bs	*640*	*0.3*	Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of plains with bare soil surface partially covered with sand sheets
Bc/Ct	*306*	*0.2*	Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of tree crops
Bc/Rg	*275*	*0.1*	Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of sparse grasslands and shrublands of rocky hills and arid lands
Be/Bs	*135*	*0.1*	Predominantly highly dissected and eroded land, with an important proportion of bare soil surface, partially covered by sand sheets
Be/Cw-l	*78*	*0.0*	Predominantly highly dissected and eroded land, with an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on light-colored soils
Be/Rg	*330*	*0.2*	Predominantly highly dissected and eroded land, with an important proportion of sparse grasslands and shrublands
Be/Rg/Bg	*4696*	*2.5*	Predominantly highly dissected and eroded land, with important proportions of sparse grasslands and shrublands, and bare gypsum-enriched soil surface or gypsum outcrops
Be/Rs	*63*	*0.0*	Predominantly highly dissected and eroded land, with an important proportion of natural vegetation in saline depressions
Be/Ws	*197*	*0.1*	Predominantly highly dissected and eroded land, with an important proportion of periodically inundated salt flats
Bg/Bs	*161*	*0.1*	Plains with predominantly bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of sand sheets
Bg/Bt/Bs	*383*	*0.2*	Plains with bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of shallow depressions of periodically inundated land and inclusions of scarce grassland and scrubland, and bare soil surface covered with sand sheets
Bg/Rg	*393*	*0.2*	Plains with bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of sparse grasslands and shrublands of arid lands

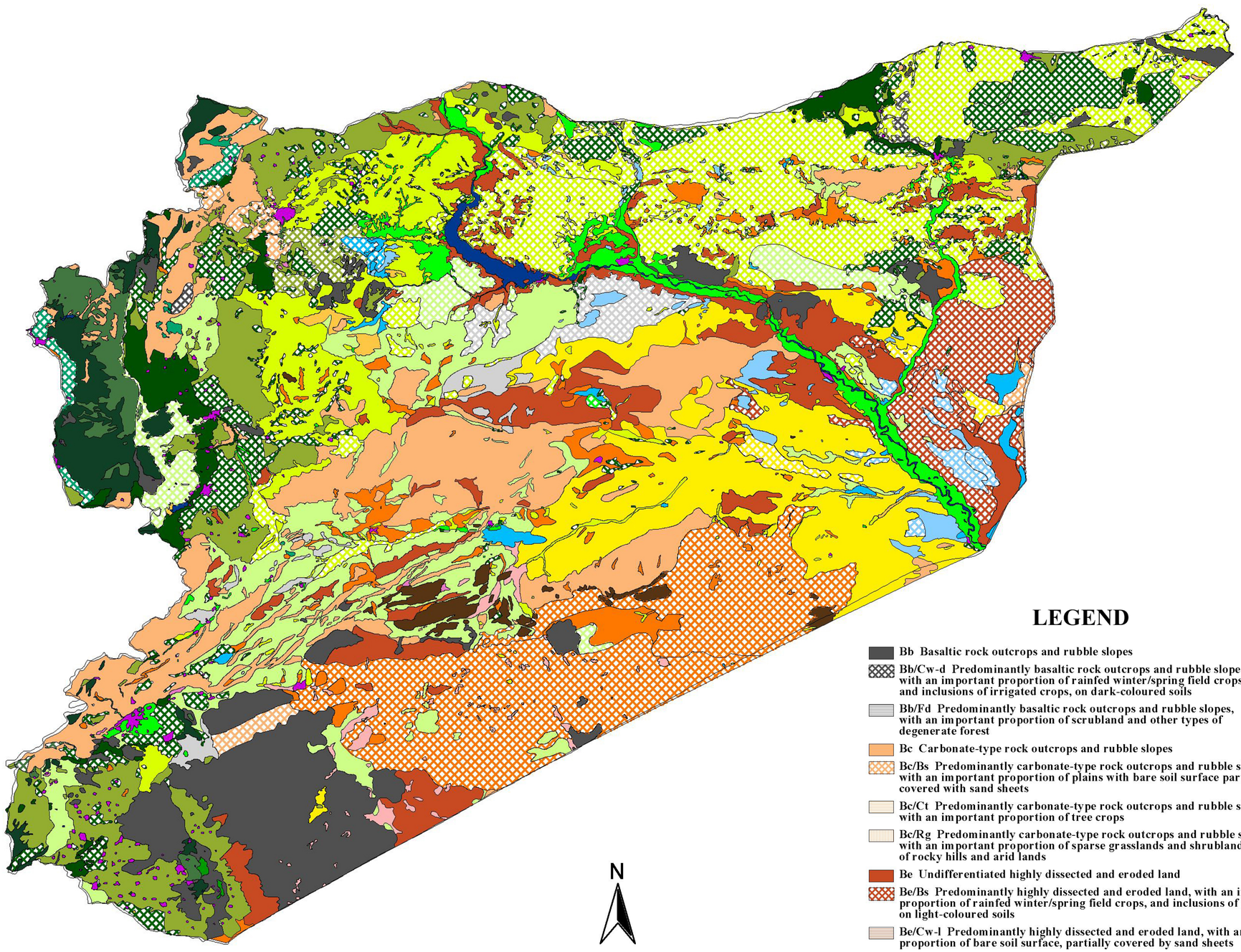
Bl/Cw-l	*1894*	*1.0*	Plains with bare lime-enriched soil surface covering calcareous sediments, and an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on light-colored soils
Bs/Bg	*155*	*0.1*	Plains with bare soil surface, partially covered with sand sheets, partially gypsum-enriched, or with gypsum outcrops
Bs/Bg/Rg	*578*	*0.3*	Plains with bare soil surface, partially covered with sand sheets, partially gypsum-enriched, or with gypsum outcrops and some sparse grasslands or scrublands
Bu/Be	*6168*	*3.3*	Plains with undifferentiated bare soil surface, with an important proportion of highly dissected and eroded land
Bu/Bs	*10395*	*5.6*	Predominantly plains with bare soil surface, in parts covered by sand sheets
	28,805	***15.5***	***Predominantly cultivated areas***
Cs-l/Bs	*49*	*0.0*	Predominantly irrigated summer field crops, on light-colored soils, with an important proportion of natural vegetation in saline depressions
Ct/Ch	*452*	*0.2*	Predominantly tree crops, with an important proportion of horticultural crops
Ct/Cw/Cs-d	*253*	*0.1*	Predominantly tree crops, with important proportions of rainfed winter/spring and summer-irrigated field crops, on dark-colored soils
Ct/Cw-d	*41*	*0.0*	Predominantly tree crops, with an important proportion of rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils
Cw/Cs-d	*4693*	*2.5*	Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on dark-colored soils
Cw/Cs-d/Bc	*526*	*0.3*	Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils, with an important proportion of carbonate-type rock outcrops and rubble slopes
Cw/Cs-d/Bg	*69*	*0.0*	Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils, with an important proportion of bare gypsum-enriched soil surface or gypsum outcrops
Cw/Cs-d/Ct	*138*	*0.1*	Predominantly rainfed winter/spring field crops, with important proportions of a) irrigated summer crops, and b) tree crops, on dark-colored soils
Cw/Cs-l	*4348*	*2.3*	Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-colored soils
Cw/Cs-l/Bl	*5*	*0.0*	Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-colored soils, and an important proportion of bare, lime-enriched soil surface covering calcareous sediments
Cw/Cs-l/Rs	*21*	*0.0*	Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-colored soils, and an important proportion of natural vegetation in saline depressions

Cw/Cs-ld	*1870*	*1.0*	Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, mainly on light-colored but also dark-colored soils
Cw-d/Bb	*919*	*0.5*	Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils, with an important proportion of basaltic rock outcrops and rubble slopes
Cw-d/Bl	*80*	*0.0*	Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-colored soils, with an important proportion of bare lime-enriched soil surface covering calcareous sediments
Cw-l/Be	*4640*	*2.5*	Rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils, with an important proportion of highly dissected and eroded land
Cw-l/Bg	*9405*	*5.1*	Plains with predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils and an important proportion of bare gypsum-enriched soil surface or gypsum outcrops
Cw-l/Bl	*597*	*0.3*	Plains with predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils, and an important proportion of bare, lime-enriched soil surface covering calcareous sediments
Cw-l/Bu	*490*	*0.3*	Plains with rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils, and an important proportion of bare soil surface
Cw-l/Rg	*209*	*0.1*	Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-colored soils, with an important proportion of sparse grasslands and shrublands
	70	***0.0***	***Predominantly forests and other wooded areas***
Fu/Fd	*70*	*0.0*	Predominantly undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas, with an important proportion of scrubland and other types of degenerate forest, often with interspersed tree crops
	3,475	***1.9***	***Predominantly rangelands***
Rg/Bu	*150*	*0.1*	Predominantly sparse grass and shrub plains, with an important proportion of undifferentiated bare soil
Rg/Cw-d	*1177*	*0.6*	Predominantly sparse grasslands and shrublands of rocky hills and arid lands, with an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on dark-colored soils
Rg/Cw-l	*2148*	*1.2*	Predominantly sparse grasslands and shrublands of rocky hills and arid lands, with an important proportion of abandoned rainfed cropland, on light-colored soils
	206	***0.1***	***Predominantly water bodies***
Ws/Bc	*206*	*0.1*	Predominantly salt lake or periodically inundated salt flats, with an important proportion of carbonate-type rock outcrops and rubble slopes

APPENDIX 2.

MAP OF LAND COVER AND LAND USE IN SYRIA
BASE YEAR 1989/1990

LAND COVER AND LAND USE IN SYRIA. BASE YEAR 1989/1990



N

25 0 25 50 75 100 125 Kilometers

Appendix 2 of Technical Report
"An overview of land cover and land use in Syria"
E. De Pauw, A. Oberle, M. Zöbisch (2004)

GIS handling by A. Oberle and A. Balikian

LEGEND

Bb Basaltic rock outcrops and rubble slopes

Bb/Cw-d Predominantly basaltic rock outcrops and rubble slopes, with an important proportion of rainfed winter/spring field crops and inclusions of irrigated crops, on dark-coloured soils

Bb/Fd Predominantly basaltic rock outcrops and rubble slopes, with an important proportion of scrubland and other types of degenerate forest

Bc Carbonate-type rock outcrops and rubble slopes

Bc/Bs Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of plains with bare soil surface partially covered with sand sheets

Bc/Ct Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of tree crops

Bc/Rg Predominantly carbonate-type rock outcrops and rubble slopes, with an important proportion of sparse grasslands and shrublands of rocky hills and arid lands

Be Undifferentiated highly dissected and eroded land

Be/Bs Predominantly highly dissected and eroded land, with an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on light-coloured soils

Be/Cw-l Predominantly highly dissected and eroded land, with an important proportion of bare soil surface, partially covered by sand sheets

Be/Rg Predominantly highly dissected and eroded land, with an important proportion of sparse grasslands and shrublands

Be/Rg/Bg Predominantly highly dissected and eroded land, with important proportions of sparse grasslands and shrublands, and bare gypsum-enriched soil surface or gypsum outcrops

Be/Rs Predominantly highly dissected and eroded land, with an important proportion of natural vegetation in saline depressions

Be/Ws Predominantly highly dissected and eroded land, with an important proportion of periodically inundated salt flats

Bf Plains with bare soil surface covered with flintstones

Bg Plains with bare gypsum-enriched soil surface or gypsum outcrops

Bg/Bs Plains with predominantly bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of sand sheets

Bg/Bt/Bs Plains with bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of shallow depressions of periodically inundated land and inclusions of scarce grassland and scrubland, and bare soil surface covered with sand sheets

Bg/Rg Plains with bare gypsum-enriched soil surface or gypsum outcrops, with an important proportion of sparse grasslands and shrublands of arid lands

Bl Plains with bare lime-enriched soil surface covering calcareous sediments

Bl/Cw-l Plains with bare lime-enriched soil surface covering calcareous sediments, and an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on light-coloured soils

Bs Plains with bare soil surface partially covered with sand sheets

Bs/Bg Plains with bare soil surface, partially covered with sand sheets, partially gypsum-enriched, or with gypsum outcrops

Bs/Bg/Rg Plains with bare soil surface, partially covered with sand sheets, partially gypsum-enriched, or with gypsum outcrops and some sparse grasslands or scrublands

Bt Shallow depressions of periodically inundated land (takyrs)

Bu Plains with undifferentiated bare soil surface

Bu/Be Plains with undifferentiated bare soil surface, with an important proportion of highly dissected and eroded land

Bu/Bs Predominantly plains with bare soil surface, in parts covered by sand sheets

Ch Horticultural crops

Cs-d Mostly irrigated summer field crops, on dark-coloured soils

Cs-l Mostly irrigated summer field crops, on light-coloured soils

Cs-l/Bs Predominantly irrigated summer field crops, on light-coloured soils, with an important proportion of natural vegetation in saline depressions

Ct Tree crops

Ct/Ch Predominantly tree crops, with an important proportion of horticultural crops

Ct/Cw-d Predominantly tree crops, with an important proportion of rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils

Ct/Cw/Cs-d Predominantly tree crops, with important proportions of rainfed winter/spring and summer-irrigated field crops, on dark-coloured soils

Cw-d Mostly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils

Cw-d/Bb Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils, with an important proportion of basaltic rock outcrops and rubble slopes

Cw-d/Bl Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils, with an important proportion of bare lime-enriched soil surface covering calcareous sediments

Cw-l Mostly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils

Cw-l/Be Rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils, with an important proportion of highly dissected and eroded land

Cw-l/Bg Plains with predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils and an important proportion of bare gypsum-enriched soil surface or gypsum outcrops

Cw-l/Bl Plains with predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils, and an important proportion of bare, lime-enriched soil surface covering calcareous sediments

Cw-l/Bu Plains with rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils, and an important proportion of bare soil surface

Cw-l/Rg Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on light-coloured soils, with an important proportion of sparse grasslands and shrublands

Cw-ld Rainfed winter/spring field crops, with inclusions of irrigated crops, mainly on light-coloured and an important proportion on dark-coloured soils

Cw/Cs-d Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on dark-coloured soils

Cw/Cs-d/Bc Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils, with an important proportion of carbonate-type rock outcrops and rubble slopes

Cw/Cs-d/Bg Predominantly rainfed winter/spring field crops, with inclusions of irrigated crops, on dark-coloured soils, with an important proportion of bare gypsum-enriched soil surface or gypsum outcrops

Cw/Cs-d/Ct Predominantly rainfed winter/spring field crops, with important proportions of a) irrigated summer crops, and b) tree crops, on dark-coloured soils

Cw/Cs-l Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-coloured soils

Cw/Cs-l/Bl Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-coloured soils, and an important proportion of bare, lime-enriched soil surface covering calcareous sediments

Cw/Cs-l/Rs Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, on light-coloured soils, and an important proportion of natural vegetation in saline depressions

Cw/Cs-ld Predominantly rainfed winter/spring field crops, with important proportion of summer-irrigated crops, mainly on light-coloured but also dark-coloured soils

Fd Scrubland and other types of degenerate forest, often with interspersed tree crops

Fu Undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas

Fu/Fd Predominantly undifferentiated coniferous and broadleaf, deciduous and evergreen, forest areas, with an important proportion of scrubland and other types of degenerate forest, often with interspersed tree crops

Rg Sparse grasslands and shrublands of rocky hills and arid lands

Rg/Bu Predominantly sparse grass and shrub plains, with an important proportion of undifferentiated bare soil

Rg/Cw-l Predominantly sparse grasslands and shrublands of rocky hills and arid lands, with an important proportion of abandoned rainfed cropland, on light-coloured soils

Rg/Cw-d Predominantly sparse grasslands and shrublands of rocky hills and arid lands, with an important proportion of rainfed winter/spring field crops, and inclusions of irrigated crops, on dark-coloured soils

Rs Natural vegetation of saline depressions

Ub Built-up areas and settlements (cities, villages)

Un Non-built-up areas (mines, quarries, etc.)

Wl Sweet water lakes and reservoirs, rivers

Ws Salt lakes, periodically inundated salt flats

Ws/Bc Predominantly salt lake or periodically inundated salt flats, with an important proportion of carbonate-type rock outcrops and rubble slopes