MONITORING OF VEGETATION AND ALEDO CHANGES IN THE YARMULKE BASIN FROM REMOTE SENSING DATA

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DEDICATION

This thesis is dedicated to my husband who has been a great source of motivation and inspiration. Also, to my parents who have supported me all the way since the beginning of my studies. Finally, it is dedicated to all those who believe in the richness of learning.

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LIST OF ABBREVIATIONS OR SYMBOLS

1	**ANOVA**	Analysis of variance
2	**Asl**	Above Sea Level
3	**ASTER**	Advanced Space Borne Thermal Emission and Reflection Radiometer
4	**AVHRR**	Advanced Very High Resolution Radiometer
5	**Bsl**	Below Sea Level
6	**BRDF**	Bidirectional Reflectance Distribution Function
7	**DN**	Digital Number
8	**ESRI**	Environmental System Research Institute
9	**ETM+**	Enhanced thematic mapper Plus
10	**FAO**	Food and Agriculture Organization
11	**GIMMS**	Global Inventory Monitoring and Modeling Studies
12	**GIS**	Geographical Information System
13	**GPS**	Global Positioning System
14	**Ha**	Hectare
15	**HDF**	Hierarchical Data Format
16	**ISODATA**	Iterative Self-Organizing Data Analysis.
17	**Kg**	Kilogram
18	**Km**	Kilometer
19	**Lu/c**	Land use/cover
20	**M**	Meter
21	**MAA**	Mixed Agricultural Areas
22	**MCM**	Million Cubic Meter
23	**Mm**	Millimeter
24	**MOA**	Ministry of Agriculture
25	**MODIS**	Moderate-Resolution Imaging Spectroradiometer
26	**MOE**	Ministry of Environment
27	**NASA**	National Aeronautics and Space Administration
28	**NBAR**	Nadir BRDF-adjusted reflectance
29	**NDVI**	Normalized Difference Vegetation Index
30	**NIR**	Near Infra Red
31	**NOAA**	National Oceanic and Atmospheric Administration
32	**NSAP**	National Strategy and Action Plan
33	**NSMLUP**	National Soil Map and Land Use Project
34	**UNEP**	United Nation Environmental Program
35	**USC**	Unsupervised Classification
36	**UTM**	Universal Transverse Mercator
37	**VI**	Vegetation Indices
38	**WIST**	Warehouse Inventory Search Tool
39	**Y**	Year

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MONITORING OF VEGETATION AND ALBEDO CHANGES IN THE YARMOUK BASIN FROM REMOTE SENSING DATA

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ABSTRACT

This research, undertaken in Yarmouk basin, aimed at using remote sensing techniques with GIS tools to assess vegetation index and surface reflectance (albedo) as remotely sensed indicators of land degradation among the different land use/cover classes.

The methodology included the downloading and processing of remote sensing data from Moderate-Resolution Imaging Spectroradiometer (MODIS) by Geographical Information System (GIS) and image processing software to prepare land use/cover map and analyze both Normalized Difference Vegetation Index (NDVI) and surface reflectance (Albedo) for the different land use/cover.

Both NDVI and albedo were analyzed using time series data of 2000-2006 to detect monthly and annual variations. Analysis of temporal changes of NDVI and albedo was carried out to derive trends and to identify vegetations cycles. To determine if the degradation is by natural processes or by human actions, the relationship between NDVI and rainfall was investigated. In order to find if there was any effect of rain on the NDVI values and to detect any kind of degradation in the vegetation during the dry months as well as to find if there is any effect of inter-annual rainfall variability on NDVI, the year was divided into periods of rainy months (January, February, March, April, May, October, November and December) and dry months (June, July, August and September). The NDVI values of rainy months were compared with cumulative rainfall. On the other hand, NDVI values of the dry months were analyzed to study the behavior of vegetation in the absence of rain during 2000-2006.

Digital classification of Landsat ETM+ imagery produced six distinct spectral classes of landuse/cover: wheat and mixed agricultural areas, open rangeland; urban; barley; protected rangeland; and irrigated areas. The unsupervised classification of NDVI and albedo images could isolate wheat and mixed agricultural areas, open rangeland, and barley classes, which were spectrally distinct.

There was a strong response between cumulative rainfall and NDVI during rainy months for most of classes in which NDVI-rainfall relationship for semi arid areas (mean annual rainfall 300–500 mm) was stronger than arid areas (mean annual rainfall <100 mm).

Results showed an obvious decrease in NDVI from 2003 to 2006, which was related to climatic conditions like drought. Albedo of many classes increased from 2003 to 2006, which means that the uncovered soil area increased because of vegetation cover

reduction. Changing in urban areas was hard to detect by Albedo or NDVI at the moderate spatial data resolution (1 km). The statistical analysis showed significant differences ($p<0.05$) for most of monthly and yearly NDVI and albedo values between different land use/cover classes during the analysis period.

The NDVI can provide a useful indicator of vegetation variability on seasonal and inter-annual time-scales. The inter-annual variability of NDVI could show meaningful relationships with inter-annual climate variability.

1. Introduction

Land degradation in arid, semi-arid, and dry sub-humid areas is resulting from a series of natural, anthropogenic processes lead to gradual environmental deterioration of the vegetation cover, adverse changes in soil physical properties, and loss of the land's biological or economic productivity; a result leads to desertification as cited by the United Nations Environment Programme (UNEP, 1984).

Jordan is one of the countries in which most of its arid and semi-arid areas are suffering from land degradation. The Ministry of Environment (MOE, 2006) indicated that Jordan's land is at the threat of high rate of degradation. The process of land degradation has been accelerated by unsupervised management and improper land use practices such as overgrazing, overcultivation, and plowing of marginal soils and woodland removal in the high rainfall zones.

Jordan adopted a new, integrated approach emphasizing action to promote sustainable development at the community level. As a result, the country launched its National Strategy and Action Plan to combat desertification (NSAP) in June 2006. Within NSAP, programes and projects were initiated in the short term and in the long term. Among the most important programes are the desertification database on extent and rate of desertification.

Adequate response to early signs of ongoing land degradation and to monitor land cover modifications associated with land degradation or rehabilitation is often prevented by the lack of knowledge about the causes triggering these processes or their specific location. Much information exists on environmental problems, but it is easy to become overloaded with data and to miss key messages. In that sense, indicators have the advantage of being simplified, synthetic information on the state and tendency of complex processes like land degradation and desertification (Rubio and Bochet, 1998).

The complexity of land degradation processes has so far precluded the development of comprehensive methods of monitoring, so it was necessary to involve the use of indicators, which usually describe one or more aspects of land degradation and provide data on threshold levels, status, and evolution of relevant physical, chemical, biological, and anthropogenic processes. However, there is a clear distinction between the indicators that are useful to have and those, which are practical to obtain (Warren and Khogali, 1992).

A provisional methodology for assessment and mapping of land degradation and desertification consisting of several indicators that were developed by the Food and Agriculture Organization (FAO, 1984) and by the UNEP (UNEP, 1984) in which many studies attempted to map all indicators using field methods and concluded that most of the indicators proposed by UNEP could be only used at the local scale; because the costs at the regional scale would be prohibitive and the process of data collection is time-consuming.

The most common indicators used to highlight the areas with the greatest degradation susceptibility are vegetation cover and soil which may help in defining areas that are suffering from degradation. On the other hand, remote sensing-derived indicators that are related to vegetation and soil will provide alternatives to data collection and ground surveys that consumes time and money. In addition, they are considered as an efficient way to map and monitor the desertification processes over large areas (Grunblatt et al., 1992).

The remote sensing data archives would allow both spatial and temporal trends in degradation to be determined and gradually build up a time series of data that would allow the analysis of these temporal trends. Alternatively, use of online archives would allow examination of inter-annual variability of these factors (Symeonakis and Drake, 2004).

One of the remote sensing successful instruments is the (MODIS) on board Terra Platform. The sensor of MODIS was among several sensors that were launched on board Terra program. The program was designed and implemented by National Aeronautics and Space Administration (NASA) and was aiming to provide an earth observation resource for terrestrial environment. The data of MODIS is available through the internet, free for use and downloads from the web (https://wist.echo.nasa.gov), in addition to its high quality of radiometric properties and calibration. The MODIS instruments represent improved measurements of surface vegetation conditions and soil characteristics (Tucker et al., 2005). The data can be downloaded through "WIST" gateway. Alogorithms and theoretical background is also available for all data types of MODIS products. Therefore, this research aims to assess dynamic changes of vegetation and surface reflectance (albedo) derived from MODIS images for the Yarmouk basin in Jordan, as possible indicators for monitoring desertification.

Specific objectives of the research are:

1. To assess the temporal changes of vegetation index and albedo within different land use types.

2. To assess the response of vegetation index and albedo to rainfall for the available time series of MODIS.

2. Literature Review:

With the increase in the complexity of human impacts on the environment, there is a need to improve monitoring and evaluation methodologies 'with a view to more efficient environmental management strategies'. It is unlikely that there is one single index or variable, which can represent the complex process of land degradation and desertification (Symeonakis and Drake, 2004).

Indicators generally simplify reality to make complex processes quantifiable so that the information obtained can be communicated. The identification of valid indicators ensures the most effective use of limited data provided by monitoring systems (Kosmas et al., 1999).

Indicators can be used as easy synthetic information in remote sensing and (GIS) to determine spatial extension and geographic distribution of degraded areas. In addition indicators should be reliable, scientifically valid, preferentially quantitative (can be assessed quantitatively with numbers rather than qualitatively and subjectively), easy and cost-effective to measure, collect, assay and calculate, be able to assess the present status and trends and be interpretable (Rubio and Bochet, 1998).

To provide a starting point, some indicators have been selected because they result from all land degradation processes like changes in vegetation cover and soil erosion. It would be relatively practical to establish monitoring systems based on using indicators, which are dynamic at time-scales longer than a year, and online archives that would allow the analysis of temporal trends and examination of inter and intra-annual variability of these factors for many years. Furthermore, it is evident that long-term observations from space provide a practical way of implementing a regional monitoring system (Symeonakis and Drake, 2004).

Satellite remote sensing techniques have been widely used to monitor dryland degradation (Geerken and Ilaiwi 2004) because its data is the only source of relatively long-term (10± 15 years) views of the earth's surface and are therefore used extensively for observing the abundance, distribution and evolution of the vegetation cover, which can be considered as an indicator of the land degradation (Camacho-de coca et al., 2004). This Data is available from the Normalized Difference Vegetation Index (NDVI) derived from a variety of satellite sensors and all the data needed to implement the monitoring system are readily available on the internet in near-real time (Weiss et al., 2001).

Although many satellite sensors options are now available, practical considerations (i.e. data and processing costs, free distribution, the inherent tradeoff between spatial and temporal resolution, and the influence of cloud cover), favor platforms that provide frequent images that are systematically processed into products useful for the assessment of vegetation. Two sensors among those that currently meet these criteria are the National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) and NASA's MODIS (Willem et al., 2006).

The NDVI derived from the AVHRR satellites emerge as one of the most active tools for monitoring vegetation. Since the early 1980s, the NOAA AVHRR satellites have provided data vital to a range of land applications (Fensholt and Sandholt, 2005).

The NDVI is defined as follows: NDVI= $(\rho_1 - \rho_2) / (\rho_1 + \rho_2)$ where, ρ_1 and ρ_2 are the reflectances in the near infrared and the red bands, respectively. The reflectance of chlorophyll pigments is about 20% in the red and 60% in the near infrared (NIR). Such a contrast between the responses of both bands allows quantifying the energy absorbed by chlorophyll pigments thus studying the different vegetative surfaces of the Earth (Tucker 1979).

The NDVI was estimated with the use of AVHRR satellite sensor and data was extracted from a continental database generated by the NASA Global Inventory Monitoring and Modeling Studies (GIMMS) group (Los et al., 1994). The AVHRR NDVI data have been successfully utilized to monitor regional to global scale vegetation patterns in arid and semi-arid lands (Weiss et al., 2001), also it has been widely used to estimate vegetation production and conditions (Wessels et al., 2006).

In Jordan, vegetation conditions were studied at the pixel level (1 km) using the NDVI derived directly from NOAA AVHRR imagery. This required the calculation of NDVI statistical distribution at the 1 km-spatial resolution from a time series of data (Al- Bakri and Taylor, 2003).

Earlier attempts to define vegetation zones in Jordan were conducted using many kinds of data such as sparse vegetation field surveys and lately using remote sensing techniques such as the use of AVHRR NDVI indices in which the spatial resolution of these studies at best was 1 km^2 which might be good enough for the homogeneous eastern part of Jordan but it is not enough for heterogeneous and fragmented north-western part of the country (Al-Bakri and Suleiman, 2004). However, these studies provided the first countrywide description of the vegetation patterns and response within the primary vegetation zones.

Some disadvantages of the AVHRR sensor were revealed regarding the design when formulating NDVI because this sensor was not originally designed to monitor vegetation (Trishchenko et al., 2002) Built on this knowledge, a new and improved generation of earth observing data has emerged, including the polar orbiting MODIS sensor aboard the (NASA) TERRA and AQUA platforms. These sensors hold promise for environmental monitoring in general and estimation of vegetation indices in particular, as they offer radiometric and spatial resolution superior to that of the AVHRR sensor (Huete et al., 2002).

The data derived from MODIS are more accurate than the AVHRR data in capturing both the seasonal dynamics and the overall level of vegetation intensity. The MODIS sensors represent the next generation of sensors with substantial improvements in spatial resolution, number of spectral channels, choices of bandwidths, radiometric calibration and a much-enhanced set of derived products
(Justice and Townshend, 2002).

On 18 December 1999, the MODIS instrument was launched on the Terra platform with a varied spatial resolution (250-1000m) according to the application with a near daily global coverage. This sensor provides a new and improved capability for terrestrial satellite remote sensing aimed at meeting the needs of global change research, particularly analysis of land-cover and land-use changes. The first true color composite image made from the MODIS data which was acquired on 10 September 2000 had covered a large portion of the Middle East, including Egypt (Western and Eastern

Deserts and the Sinai Peninsula), Jordan, Lebanon, as well as parts of Saudi Arabia, Iraq, and Syria (Gutman et al., 2002).

Since that date until now, the MODIS images were available on the web with a scheduled program that will continue to provide data in the future. The MODIS NDVI data from the Terra platform represent improvements in the ability to monitor land photosynthetic capacity (Tucker et al., 2005), on every 16 days basis, and these data are being regularly used because they provide high spatial resolution, enhanced atmospheric corrections and precise geo-registration (Willem et al., 2006).

The data represents a major advance in vegetation monitoring in which an analyst may choose from a number of different MODIS inputs, including one or more single-date images or some form of repeatedly composited data, such as monthly maximum NDVI composites. The spatial detail available from MODIS 250 and 500m bands is finer and closer to the scale at which major anthropogenic change events occur than that of heritage daily acquisition instruments, such as the AVHRR (Hansen et al., 2005).

The land surface reflectance product is another database that generates many of the standard MODIS land products, including the Bidirectional Reflectance Distribution Function BRDF/albedo (Vermote et al., 2005). This source of data has a direct relationship with soil properties including texture and organic matter where the Soil albedo varies with soil saturation and soil color. The surface reflectance data production name MODIS/TERRA Nadir BRDF-Adjusted Reflectance 16-DAY L3 Global 1 km SIN Grid Product (MOD43B4 NBAR) was chosen to be used in China to analyze the feature of albedo before use in land surface models. Results indicated that albedo exhibited clear interannual variation with large variation in Northern China with different features for different land covers (Gao et al., 2006).

Surface albedo is a measure of the proportion of total incoming solar radiation reflected by the earth's surface. It determines the amount of solar energy absorbed by the earth's surface that drives surface hydrological and biochemical processes, influences productivity of the terrestrial and aquatic ecosystems, and affects the atmospheric circulation. Multispectral surface albedo and its variability are important for global climate model development, atmospheric radiation applications, environmental monitoring, and climate change studies (Wang et al., 2007).

According to Jin, et al. (2003) the MODIS albedo with a 1-km resolution can capture considerable spatial variability of surface reflectivity. The 16-day temporal resolution of the MODIS albedo product also provides a great opportunity to monitor and identify human-induced albedo change.

Tsvetsinskaya, et al. (2002) used the MODIS albedo to study soil surface properties in the Arabian Peninsula. Results showed considerable spatial variability and correlation between MODIS albedo, soil, and geological characteristics of the study area. Samain et al. (2007) indicated that variability in MODIS albedo was mainly caused by soil surface wetness.

The above studies and further ones indicated that MODIS NDVI and albedo have the potential of monitoring vegetations and soil, respectively. However, detailed analysis of these products in relation to land region is required. Therefore, this study is considered as the first attempt to use and utilize MODIS data for monitoring soil and vegetation in Yarmouk basin area. Obviously, most of the studies and research utilized and analyzed the time series of NDVI and albedo and there statistical distribution and changes with time as indicators of land degradation. In this study, both products will be analyzed with respect to time and their changes during the last 7 years.

3. Methodology

3.1 Study Area

Yarmouk River Basin is a shared basin between Jordan and Syria. About 70% of its catchment's area falls inside Syria. This study is concerned about Jordan side of the basin (Figure 3.1) which contains many important cities like Ramtha and Irbid at north, Mafraq at the east and Ajloun, Jarash at southwest of the basin. The highest elevation point in Jordan side is located at Rass Muneif 1150 m above sea level (asl) while the lowest one is about 200 m below sea level (bsl) in Jordan Valley. Yarmouk River Basin is considered as an important basin in Jordan. It is highly recharged by rainfall and having good water quality. It is the main supplier of domestic and irrigation water for Irbid, northern Jordan Valley, and Amman.

3.1.1 Location and Climate

The total area of the basin is about 6790 km^2. The area of the basin within the Jordanian borders is around 1697.5 $km^{2.}$ The basin lies in the extreme north west of Jordan. The basin is bounded on the west by the Northern Rift Side Basin and on the south by Zarqa-Dhulelil Basin. The highest altitude in the basin is in the Syrian part (1800m asl), while the lowest altitude is in the Jordanian side (Jordan Valley, 200 m bsl). Yarmouk River Basin belongs to the semi-arid climate of the Mediterranean. It is divided into four bioclimatic Mediterranean zones (MOE, 2006):

1. Dry sub-humid Mediterranean, warm and cool: restricted to a very small area in Ajloun and Ras Muneef.
2. Semi-arid Mediterranean, warm: includes Irbid.
3. Arid Mediterranean, cool: areas of Mafraq
4. Arid Mediterranean, very warm: includes Ramtha.

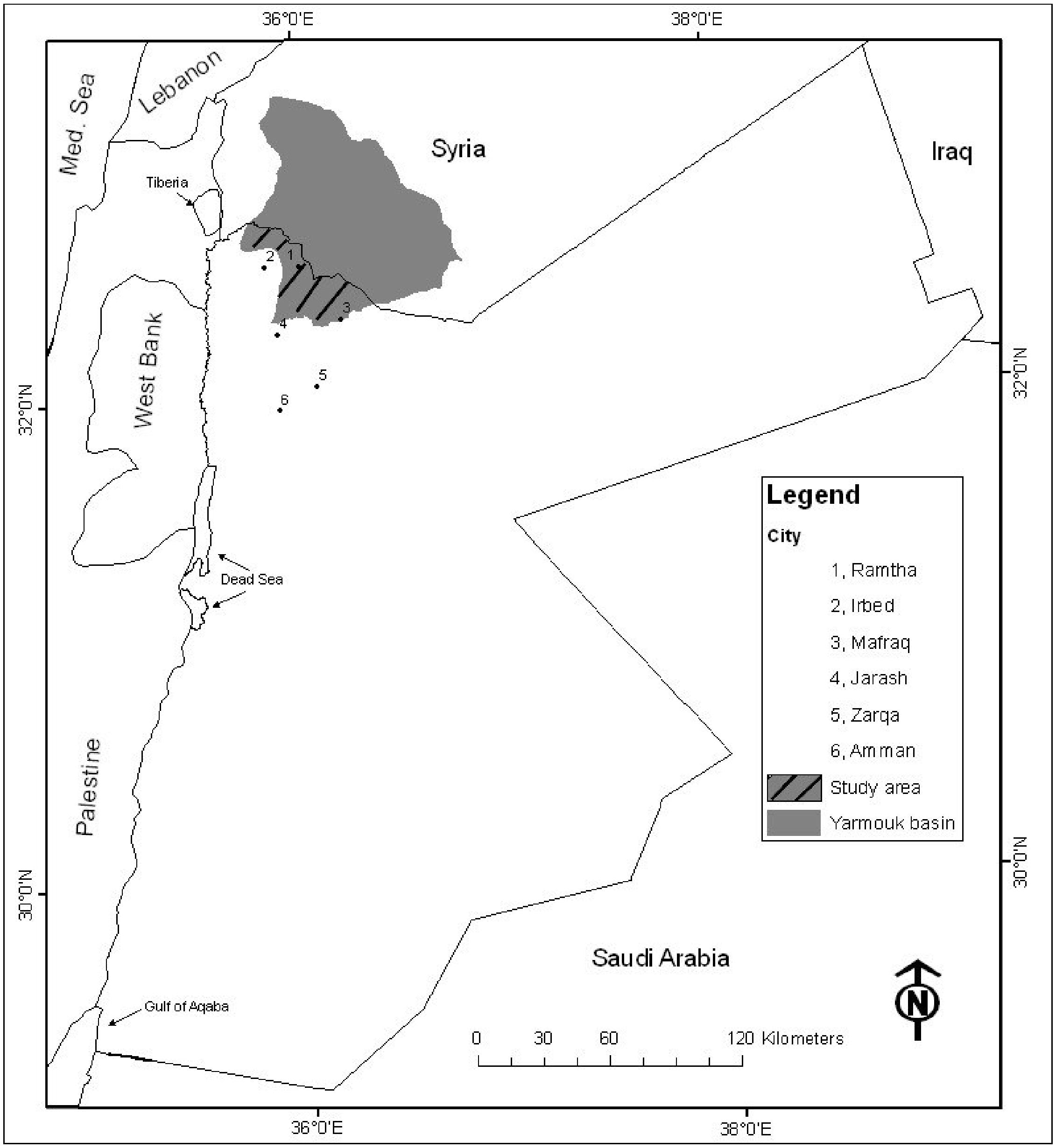


Figure 3.1: Location of the study area within Yarmouk basin.

Yarmouk basin is recharged in the mountain areas north of Jordan and south of Syria with relatively high rainfall intensities. The water year starts from October until May where the rainfall distribution in Yarmouk River Basin ranges from 900 mm at Quneitra, (Syrian side), going down to 150 mm near Mafraq. The maximum mean annual rainfall distribution, in Jordan side reaches 700 mm in wet years while the annual rainfall ranges between 150 mm in the east to 500 mm in the west. Rainfall increases with increasing elevation from the Jordan Valley (200–350 mm) to the mountains of Jerash (550– 650 mm) but decreases with the eastward movement from the mountain tops down to the fertile flat areas of Irbid in the east (400–450 mm) and decreasing much lower toward the eastern Badia (50–100 mm). The annual open surface evaporation in the basin ranges from 1400 to 2200 mm/year. The average temperature ranges from 22 to 31 C° in the summer and from 8.3 to 14.5 C° in winter. The prevailing wind directions mainly towards northwest in summer while it becomes towards southwest in winter with speed ranges from 5 to 15 km/hr (MOE, 2006).

3.1.2 Geology and Soil Types.

This basin is characterized by moderate to low relief developed on differently eroded, northeastwards and northward dipping, Upper Cretaceous and Tertiary limestone, marls, shales and dolomites. In many places, the Cretaceous and Tertiary beds are overlain by Quaternary gravels and terrace deposits. The basin drained by the northward flowing tributaries of the Yarmouk River (Swarieh and Sahawneh, 1998).

A thick-brown-color- top soil (red clay) covers a large parts of the Yarmouk River Basin, starting from Nu'aymeh Town, south of Irbid, extending towards northwest. Its depth changes from 2 to 10 m. The top soil of Quaternary age consists of silts, clays dense sand, chert, basalt pebbles, boulders, silt, and clay with limestone. In Yarmouk River area, a latertic crust of about 60m thick is found over basalt northwest of Magarin station.

The alluvial deposits of the Yarmouk River consist of rounded and sub-rounded sandy gravel, chalk, and chert. This region contains a wide range of soil types, reflecting the variety of physical characteristics in the area. In the western half of the basin mainly in Ajloun Highlands Dissected Plateau and parts of the Northern Highlands limestone region the dominant soil subgroup is typic and lithic xerochrepts with low content of carbonates. Calcixerollic, entic chromoxererts, lithic and typic xerochrepts subgroups are occurring in the eastern half of the basin particularly in the eastern parts of the Northern Highlands Dissected Limestone region. Also, these subgroups are found on the shallow eroded areas of the steeper slopes, the hilltops and upper slopes from which most of the residual soils have been eroded (MOA, 1995).

Some parts of The Northern Jordan Basalt Plateau, which is found in the eastern part of the basin, contain xerocheptic calciorthids and lithic xerochrepts soil subgroups. Lithic xerochrepts and xerothents together comprise 30 % of the region with shallow stony clays and silty clay with reddish and brown colored soils. Vertisols occur on the undulating plateau and in some of the wadi bottom alluvium. Haploxerolls with their moderate to high organic matter content occupy about 4 % of the region.

Rock outcrops are a common feature of the landscape of this region. Therefore, lithic subgroups and rock together occupy about 60 % of the region. Detailed description of soil is found in the soil maps produced by the Ministry of Agriculture (MOA, 1995).

3.1.3 Hydrology and Hydrogeology

The basin and the side wadis like wadi Arab, wadi Ziglab, wadi Yabes and wadi Kufranja have more than 50% of the surface water in Jordan and form the main supplier for the King Abdullah Canal. The total annual average rainfall volume in Yarmouk River Basin is calculated to be about 2872 Million Cubic Meter per a Year , during the period 1962-1983, generating average runoff of about 186.7 MCM/Y which corresponds to runoff coefficient of 6.0%. The average total base flow recorded at the outlet of Yarmouk River of the same period is 222.2 MCM/Y. The Yarmouk River discharge, especially its base flow, depends on the water year situation (dry or wet) and on the upstream abstraction in Syria which has been increased after 1984. There are two flood and flow rate stations in the basin (at Yarmouk River): the first is Adassyeh station measures the river flow rate in addition to the flow from King Abdulla channel. The second station is Magarin measures the Yarmouk River flow only. The highest flow rate recorded by the station is 40.6 MCM on March and the lowest one is 10.9 MCM during July (Swarieh and Sahawneh, 1998)

3.1.4 Land Use/Cover

Land use/cover (LU/C) reflects climate, topography, the availability of moisture supply, water resources, and soils. The main land use/cover types in the study area are:

3.1.4.1 Open Rangeland

Open rangeland includes non-cultivated areas in the high and low rainfall zones. However, most of this land is located in the arid zone, which provides important grazing and browse. The highest productive open rangelands are located within the 100-250 mm rainfall (steep grasslands and brush). In this zone, barley is cultivated for hay as rainfall is rarely adequate to produce a reasonable crop (100-500 kg/ha) and failure or, at best, limited vegetative growth is common.

3.1.4.2 Rainfed Agriculture

Areas in the northern and western highlands of the basin support good rainfed agriculture because of the amount of rainfall and climatic conditions. Therefore, the rainfed agricultural zone is lying within the xeric soil moisture regime in areas where rainfall exceeds 250 mm, according to the National Soil Map and Land Use Project (NSMLUP); there are two main subdivisions within the rainfed sector, namely fruit trees and field crops. Tree crops dominate the hilly and steeply sloping lands of the western parts of the basin. Wheat and Mixed Agricultural Areas (MAA) is the major crop on the undulating lands of the major plains of Irbid and it is sometimes grown on inappropriately steep slopes in some places. Forests stands of *Pinus halepensis* (wild Pine), *Quercus calliprinos* (ever-green Oak), Quercus *ithaburensis* (deciduous Oak), and *Juniperus phoenica* (Phoenician Juniper) represent natural vegetation which are mainly found in the high rainfall zone of Ajloun, Irbid and Jarash within the dry sub humid part of the basin and some are found in the semi arid part at the center of the basin (MOE, 2006).

3.1.4.3 Irrigated Agriculture

Important irrigated agriculture is taking place in the arid zone at the basalt plateau soils in the eastern part of the basin particularly in Mafraq governorate where summer crops, orchards, fruit trees and olive groves, are irrigated. However, most of this part provides important grazing and browse. In these areas, the utilization groundwater resources were expanded rapidly into the steppe zone, often for the production of fruit crops.

3.1.4.4 Urban Areas

Urban areas in Yarmouk Basin are mainly concentrated in productive lands of high rainfall zones such as Irbid, Ajlun, Jarash, and Ramtha. To the contrary, the lowest population density in Mafraq Governorate causes low rate of urbanization, and this demographic imbalance is found in areas characterized by aridity.

3.1.4.5 Protected Rangeland

Most of arid and semi-arid zones of the Mediterranean are rangelands, characterized by low vegetation productivity (Abu-Zanat et al., 2004). In the study area, these zones are found in the eastern part of the basin. The protected rangeland is represented by Surra reserve where the annual rainfall is less than 200 mm. The Surra reserve is located in northwest of Jordan at 36 10`E and longitude 32 24`N. In this study, Mafraq airport was considered as protected rangeland i.e. land cover rather than land use.

The reserve is typical steppe rangeland with a mean annual rainfall of 220 mm (a 20-year mean). Most of rainfall occurs in winter between December and March. Elevation ranges from 670 m to 690 m with a south-north slope. Soils of lithic xeric torriorthents, xerochrept calciorthids, and camborthids dominate the reserve. Dominate vegetation include *Stipa* spp., *Avena* spp., *Poa* spp., *Bromus* spp., *Hordeum* spp., *Aegilopes*, *Artemisia herba alba*, *Achillea Fragrantisimia* and *Salsola vermiculata.* In the year 2000. substantial numbers of *Atriplex halimus* and *A. nummularia* seedlings were planted in the reserve to increase biomass production (Al-Bakri and Abu-Zanat, 2007)

3.2 Study Approach

In order to achieve the objectives of the research, specific methodologies based on the integration of satellite remote sensing, GIS and field visits were implemented. These methodologies were applied as following:

1. Acquisition of data, by downloading the satellite images from the web, which included the registration and logging on the MODIS website through the Warehouse Inventory Search Tool (WIST) at the website: (https://wist.echo.nasa.gov) and gathering information about the annual rainfall from Jordan Meteorological Department (www.JMD.gov.jo) in the study area to compile it with the results of image processing.
2. Processing of MODIS data and high-resolution satellite imagery of Landsat Enhanced Thematic Mapper plus (ETM+) and Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER) data, by using image processing software. This stage included importing, stacking, reprojection, subsetting, applying a spatial model, and classifying both NDVI and albedo images. The data of NDVI was compiled with image files containing different bands; each has the NDVI of every 16 days- period. The albedo images, based on Strahler, et al. (1999) were processed in similar way to NDVI from 2000 until 2006.
3. Analysis of temporal trends and examination of inter and intra-annual.
4. Detecting yearly, monthly, and seasonal NDVI responses with rainfall in the study area.
5. On screen digitizing of images was carried out to derive land use/cover of the study area using ArcView 3.2a software (ESRI, 1998).
6. Statistical analyses of monthly and yearly NDVI and albedo values.

7. Ground survey to verify image interpretation and the output land use/cover map.

The research approach is summarized in Figure 3.2. The following sections include detailed description of the approach.

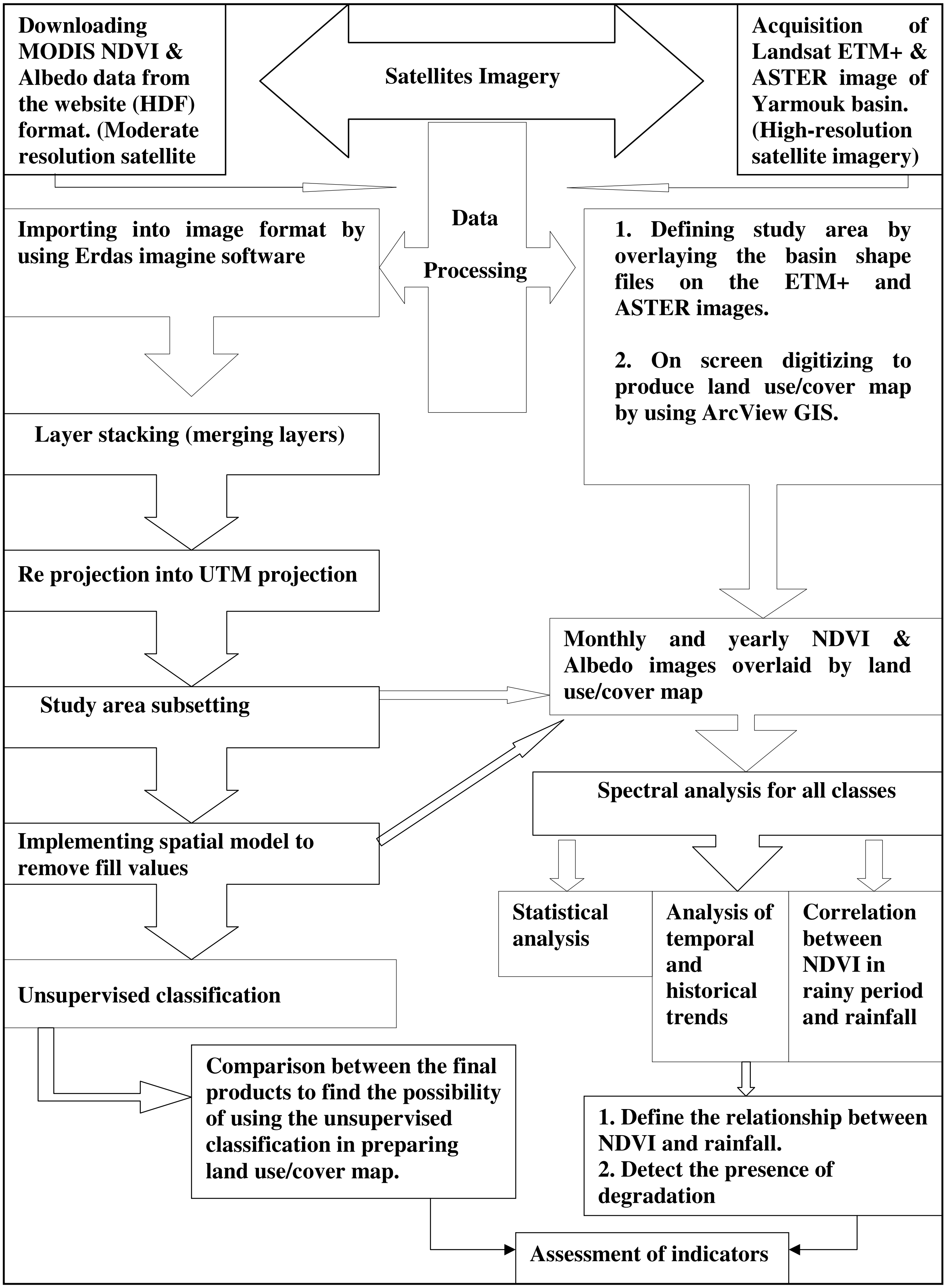


Figure 3.2: Schematic diagram of the research methodology.

3.2.1 Downloading of Data

The NDVI derived from MODIS is calculated, as the difference between the near-infrared and red reflectance values normalized with their sum, it the most commonly used index in vegetation and ecological studies. MODIS Vegetation Indices products use, as input, MODIS Terra surface reflectance's MOD09 corrected for molecular scattering, ozone absorption, and aerosols. One of the vegetation indices (VI) algorithms that are produced globally for land is the NDVI, and it is referred to as the "continuity index" to the existing NOAA-AVHRR derived NDVI. The MODIS NDVI designed to provide consistent spatial and temporal comparisons of vegetation conditions. These "MOD13A2" data are provided every 16 days at 1-kilometer spatial resolution as a girdded level-3 product in the Sinusoidal projection.

Surface albedo is a measure of the proportion of total incoming solar radiation reflected by the earth's surface. It determines the amount of solar energy absorbed by the earth's surface that drives surface hydrological and biochemical processes, influences productivity of the terrestrial and aquatic ecosystems, and affects the atmospheric circulation. Every 16 days, the MODIS BRDF/Albedo Product MOD43B algorithm relies on multidate, atmospherically corrected, cloud-cleared data, and a semiempirical kernel-driven bidirectional reflectance model to determine a global set of parameters describing the BRDF of the land surface. These one kilometer gridded parameters are then used to determine directional hemispherical reflectance ("black-sky albedo"), bihemispherical reflectance ("white-sky albedo"), and Nadir BRDF-adjusted reflectance (NBAR) for seven narrow spectral bands and (in the case of albedo) three broad bands. The MODIS reflectance product is one in a series of MOD43B products. The MOD43B4 product provides the NBAR adjusted reflectance value at the mean solar zenith angle of a 16-day period. These MOD43B4 data are provided every 16 days as a level-3 gridded product in the Sinusoidal projection. The stage of data downloading included the registration and logging on the MODIS website (https://wist.echo.nasa.gov), this stage included the following:

1. Registration to become an authorized user.
2. Identification of data type after first logging on.
3. Download of the MODIS Terra data of MOD13A2 and MOD43B4 types for the period 2000 to 2006.

3.2.2 Processing of Data.

3.2.2.1 Processing of High Resolution Satellite Imagery (Landsat ETM+ and ASTER Images).

This stage includes:

3.2.2.1.1 Mapping of Existing Land Use/Cover

This step was carried out by using an on-screen digitizing procedure to produce land use/cover map. The classification scheme (Table 3.1) included six land use/cover classes. Digitizing technique followed in this research was to use both Landsat ETM+ and ASTER images overlaid by the study area shape file as a background image for on screen digitizing using ArcView GIS software (ESRI, 1996). The whole image of Yarmouk basin was not available so it was necessary to use two parts of different satellite images to have full image of the study area.

Table 3.1 Land use/cover classification scheme used in the study.

Class Type	Description
Urban Areas	Continuous and discontinuous urban areas, areas occupied by dwellings, and buildings used by administrative/public utilities, including their connected areas (associated lands, approach road network, parking lots).
Irrigated Areas	Permanently irrigated lands; crops irrigated permanently or periodically, most of the crops that cannot be cultivated without an artificial water supply.
Open Rangelands	Open spaces with little or no vegetation, bare rock and soils, cliffs, rock outcrops, exposed rocks and limestone. Sparsely vegetated areas; Heavily grazed open shrub and herbaceous rangeland.
Protected Rangelands	Surra grazing reserve and Mafraq airport.
Wheat and Mixed Agricultural Areas. (Heterogeneous agricultural areas)	Non- irrigated arable lands, Rainfed wheat in the high rainfall areas and Areas of annual crops associated with permanent crops on the same parcel, annual crops, and orchards.
Barley	Non- irrigated barley in the low rainfall areas.

Digitizing was carried out to generate polygons by enclosing areas (classes) such as urban areas, agricultural lands, and soil types, with specific boundaries. Field survey was performed throughout the study area with the aid of Global Positioning System (GPS) equipment. Measuring the accuracy of the resulted land use/cover map required ground observations on a sample of points. Therefore, verification of the draft map was performed during field visit to the study area. The validation aims to:

1. Assess the identified land use/cover map and their interpretation.
2. Identify portions that require major modification in the land use/cover map.
3. Identify and correct the mis-classified land use polygons.
4. Aid in the interpretation of remotely sensed data and in explaining the results.

Ground survey included Irbid, Jarash, Mafraq and Surra reserve. The updated land use map was verified in its final form.

The output map included 6 land use/cover classes (Figure 3.3). The map was converted to grid format (raster) to calculate the percent of each class.

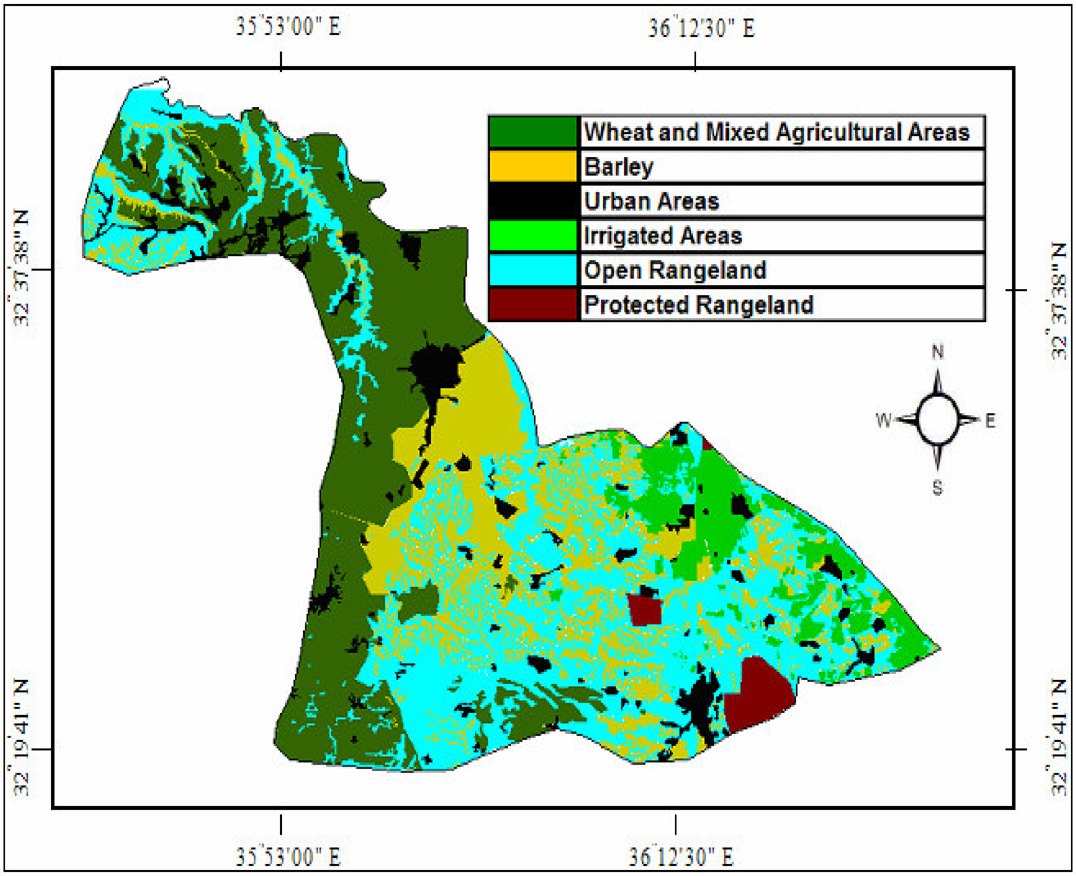


Figure 3.3: Land use/cover map of the study area.

3.2.2.2 Processing of MODIS Images.

The downloaded images of MODIS were in HDF (Hierarchical Data Format) which required importing into a standard image format. Each image represented a composite of maximum value of NDVI or albedo for 16 days period. For each year, 23 images were downloaded, imported and stacked. The image processing software (Erdas Imagine 8.7) was used for stacking the images. The layers of the imported images in each year were stacked into one image with multiple layers (23 bands). Examples on false color composites of NDVI and albedo images are shown in Figures (3.4) and (3.5), respectively.

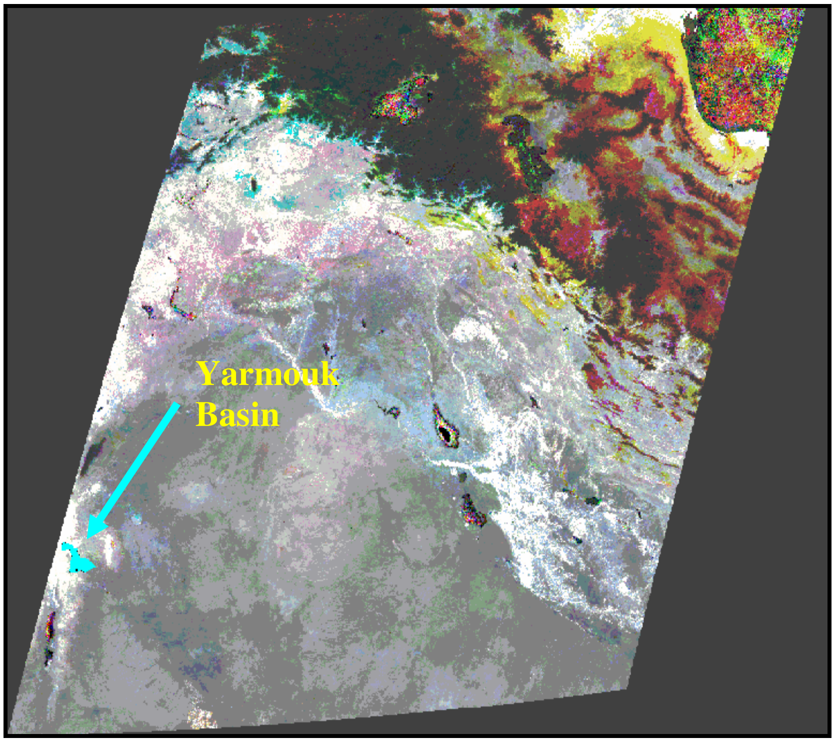


Figure 3.4: False color composite of 3 images of NDVI for 2001.

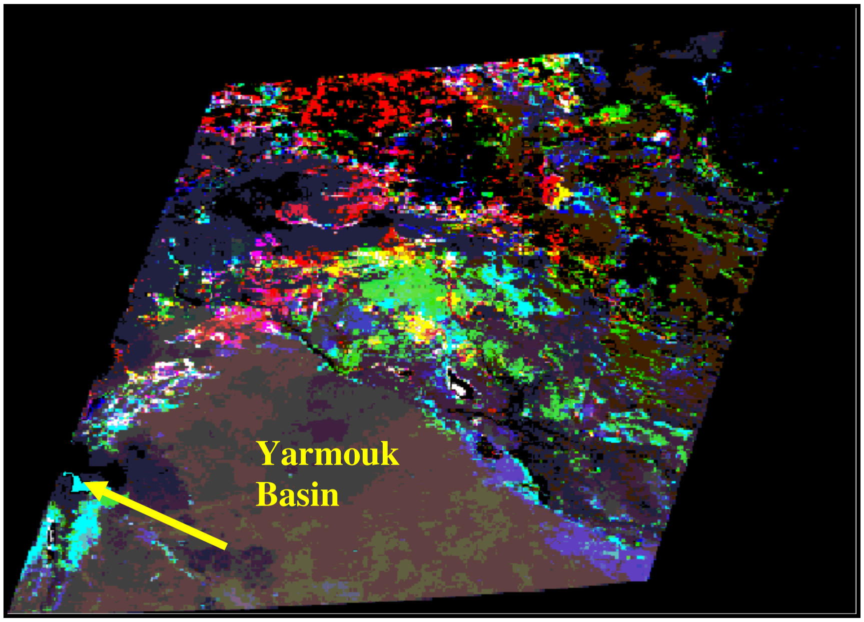


Figure 3.5: False color composite for three images of albedo for year 2001.

The images, originally in sinusoidal projection, were reprojected to Universal Transverse Mercator (UTM), Zone 36. The new geographic coordination's were needed to enable processing of data for NDVI images and for Albedo images.

MODIS images cover an area of 2330 km by 2330 km and extend outside Yarmouk basin. Therefore, images were clipped to study area to exclude the extraneous data outside the study area. In addition, this step increased the speed of processing due to the small data size. In order to subset the study area from the images, vector file of the basin boundary was exported from Arc Info as "shape files" and then imported into ERDAS software to subset (clip) NDVI and Albedo images.

After subsetting the study area, the fill value (for clouds or missing data) in both NDVI and Albedo images was removed by using a conditional model within the image processing software. Mean images for each year were also generated using the modeling capabilities of the software.

3.2.2.2.1 Unsupervised Classification

Digital classification was carried out on the stacked images using Iterative Self-Organizing Data Analysis (ISODATA) algorithm an unsupervised classification was carried out to categorize all pixels in NDVI and Albedo's digital images into different classes or clusters. This was carried out to compare the images with the land use/cover map resulted from digitizing the Landsat and ASTER images. ISODATA clustering method divided pixels into classes according to their spectral and statistical (mean, standard deviation) similarities. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration. The ISODATA utility repeats the clustering of the image until either a maximum number of iterations, which is the maximum number of times that the ISODATA utility reclusters the data until the percentage of unchanged pixel assignments had been reached between two iterations This threshold prevents the ISODATA utility from running indefinitely or from potentially being stuck in a cycle without reaching the convergence threshold number of 0.95 that means 95% or more of the pixels remain in the same cluster between one iteration and the next. In other words, as soon as 5% or fewer of the pixels change clusters between iterations, the utility stops processing.

3.2.3 Extraction of NDVI and Albedo Profiles.

Spectral profiles were extracted to study the annual and the monthly variations of NDVI and Albedo data during 7 years. This was carried out by overlaying land use/cover map onto the NDVI and albedo images and extracting the digital data for the corresponding location within the land use/cover class. An example is shown in Figure (3.6). The reflectance, Digital Number (DN), of each band within one (spatial) pixel was plotted (Figure 3.7) and transformed to statistical values. The same procedure was followed for all classes. At the end of this step, the values of NDVI and Albedo in the profiles were extracted for each class during 12 months of each year and during (2000-2006) for further analysis and interpretation. For each land use/cover class, three to eight profiles were extracted, except for protected rangeland were two profiles were extracted.

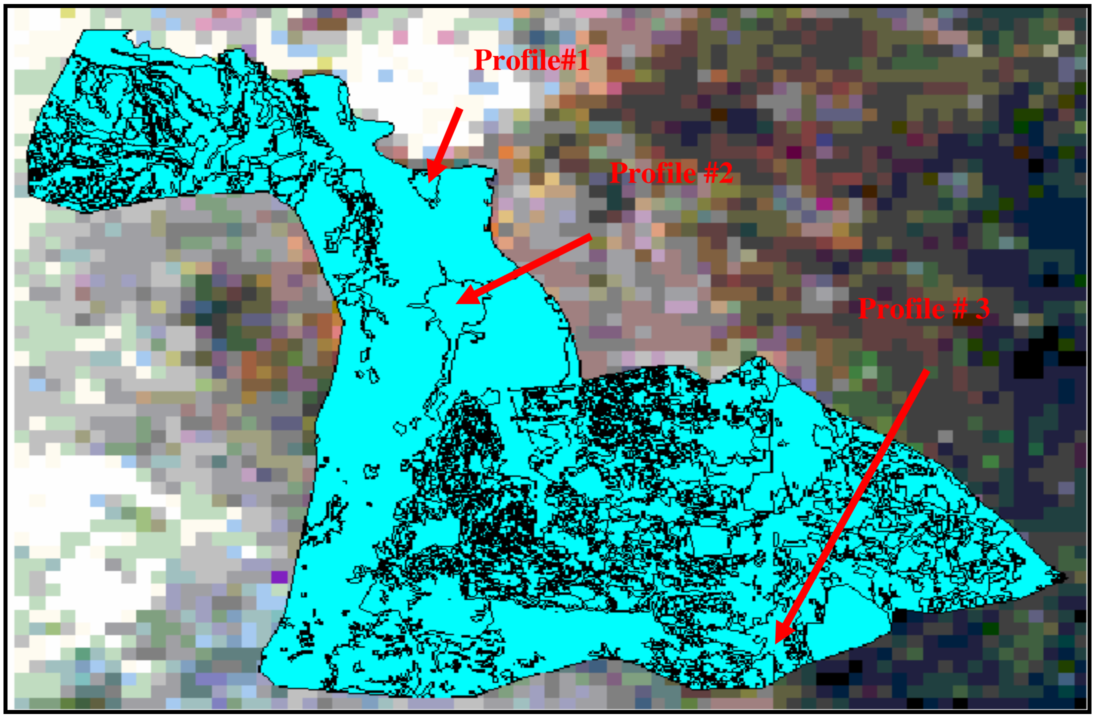


Figure 3.6: Land use/cover map overlaid over the NDVI image of 2004 with three profile points over some urban areas.

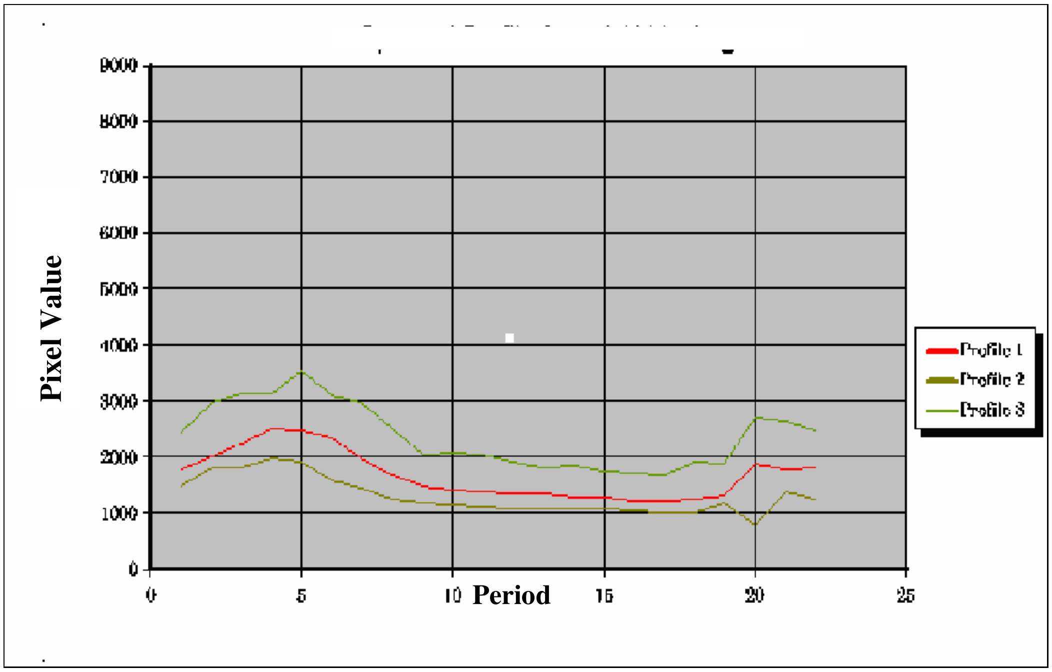


Figure 3.7: Spectral profile for three profiles of urban areas in the NDVI image of 2004.

The spectral profiles included the following:

- Mean Yearly NDVI and Albedo profile values of all classes during (2000-2006).

- Mean monthly NDVI and Albedo profile values for each class during (2000-2006).

3.2.4. Analysis of Temporal Changes of NDVI and Albedo.

Average monthly NDVI and Albedo profile values were extracted and used for plotting their time-series. The mean NDVI was estimated for each sixteen-day and for each month (by taking the average of the tow readings) during the single year. This was carried out to find the monthly behavior of both NDVI and Albedo. The same process was performed on each class during (2000-2006) to derive NDVI trends and for the identification of vegetation cycles and albedo changes. An example is shown in Figure (3.8).

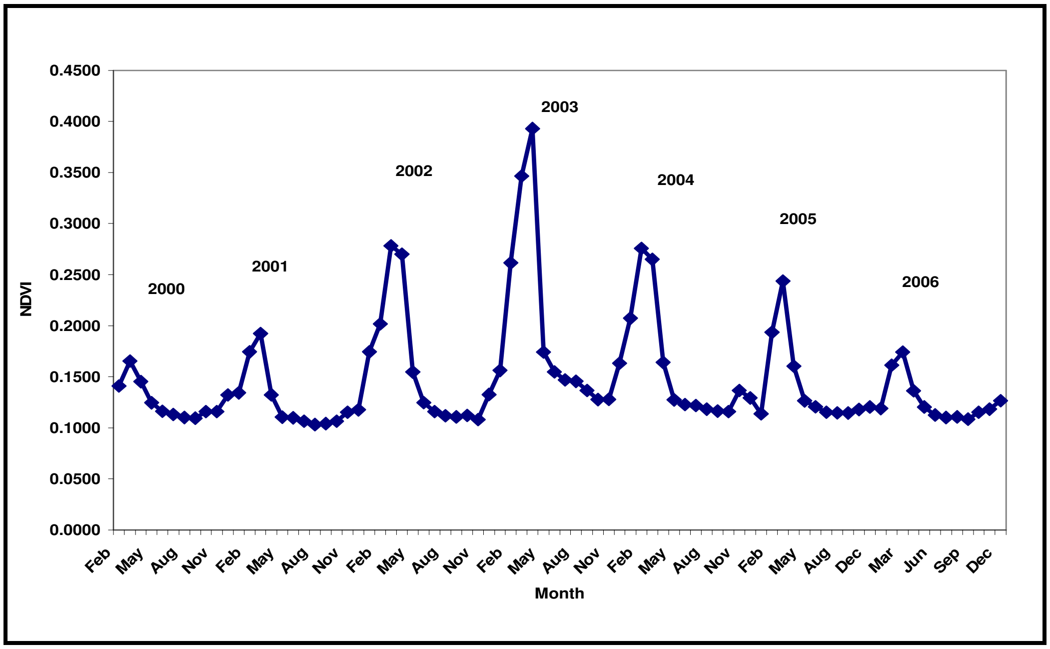


Figure 3.8: Monthly NDVI profile for barley during 2000-2006.

3.2.5. The Response of NDVI to Rainfall.

The response of NDVI to rainfall was analyzed using MODIS images and rainfall data from Irbid and Mafraq weather stations. Barley, irrigated areas, open rangeland, protected rangeland and urban were distributed in Mafraq and correlated with rainfall for Mafraq station. On other hand, wheat/MAA, urban and open rangeland classes were correlated with rainfall in Irbid station and there were some small areas of open rangeland, barley and irrigated areas in Irbid. Therefore, these classes were correlated with rainfall in Irbid station. The correlations were between cumulative and monthly rainfall with yearly, monthly and seasonal NDVI. In order to find if there was any effect of rain on the NDVI values and to detect changes in vegetation index during the dry months as well as to find if there is any effect of inter-annual rainfall variability on NDVI, the year was divided into periods of rainy months (January, February, March, April, May, October, November and December) and dry months (June, July, August and September). The NDVI values of rainy months were compared with cumulative rainfall;

on the other hand, NDVI values of the dry months were analyzed to study the behavior of vegetation in the absence of rain during (2000-2006).

The following relationships were examined:

- Mean monthly NDVI for each class during dry months (2000-2006).
- Mean monthly NDVI for each class during rainy months (2000-2006).
- Annual NDVI for each class vs. cumulative rainfall in both Irbid and Mafraq stations (2000-2006).
- Mean monthly NDVI for all classes vs. monthly rainfall in Irbid and Mafraq station during (2000-2006).
- Mean monthly NDVI for each class during rainy months vs. cumulative rainfall in both Irbid and Mafraq stations (2000-2006).

3.2.6. Statistical Analysis

1. Analysis of Variance (ANOVA): Single Factor

This step was performed using a simple analysis of variance on data for two or more samples. The analysis provided a test of the hypothesis that each sample was drawn from the same underlying probability distribution against the alternative hypothesis that underlying probability distributions were not the same for all samples.

This analysis was performed on:

- Monthly NDVI and Albedo profile values for each class during (2000-2006) to detect if there were differences between months for NDVI and Albedo in each year and to find if these differences were significant or not.

- Yearly NDVI and Albedo profile values during (2000-2006) to find if there were differences between years for NDVI and Albedo and if these differences were significant or not.

2. Z-test

Two-sample z-test for means with known variances was used to test the null hypothesis that there was no difference between two population (land use/cover) means against either one-sided or two-sided alternative hypotheses. This analysis was performed on NDVI and Albedo monthly profile values between every two classes for each year during (2000-2006) to find if the MODIS can separate between two classes during months and years for NDVI and Albedo.

4. Results

4.1. Land Use/Cover of the Study Area.

Land use/cover map of the study area is shown in Figure (4.1).

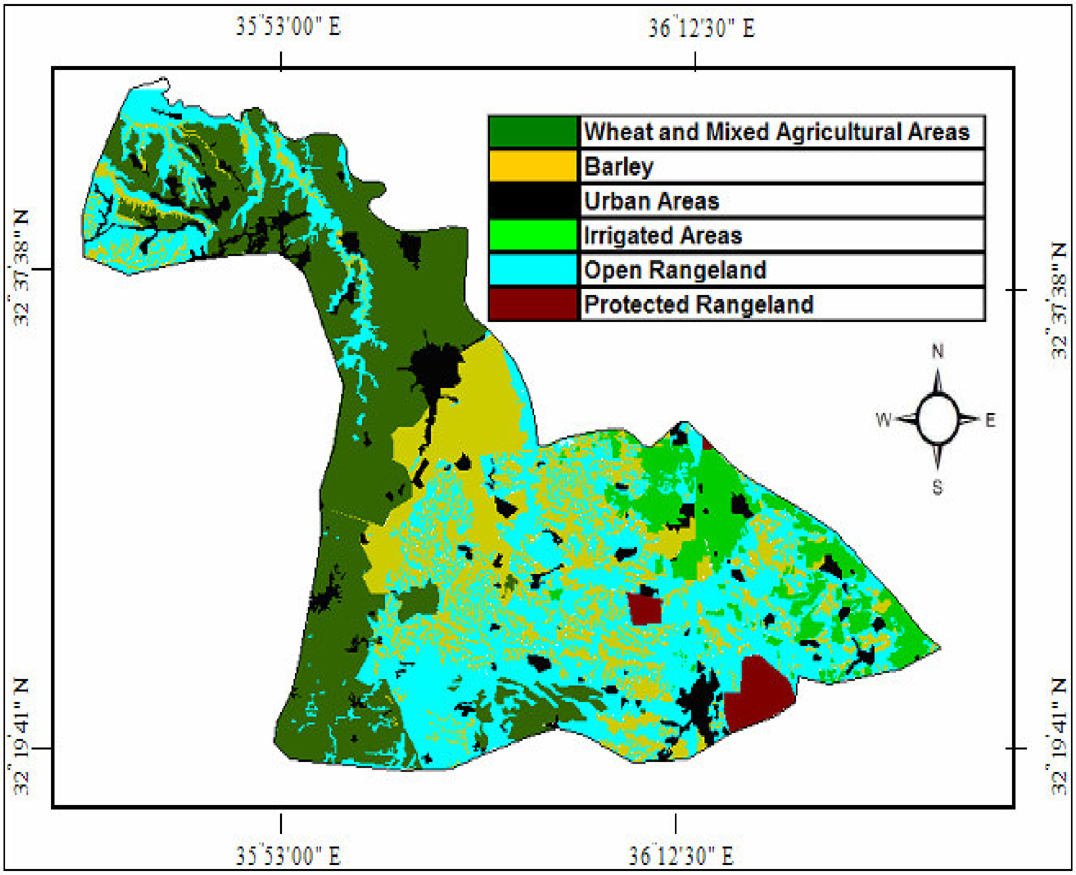


Figure 4.1: Land use/cover map of the study area.

Analysis of this map (Figure 4.2) showed that open rangeland class had the highest percentage in the study area followed by wheat/MAA and barley. On the other hand, urban areas had the same percentage (7%) as irrigated areas. Finally, the lowest class percentage was for protected rangeland (2%).

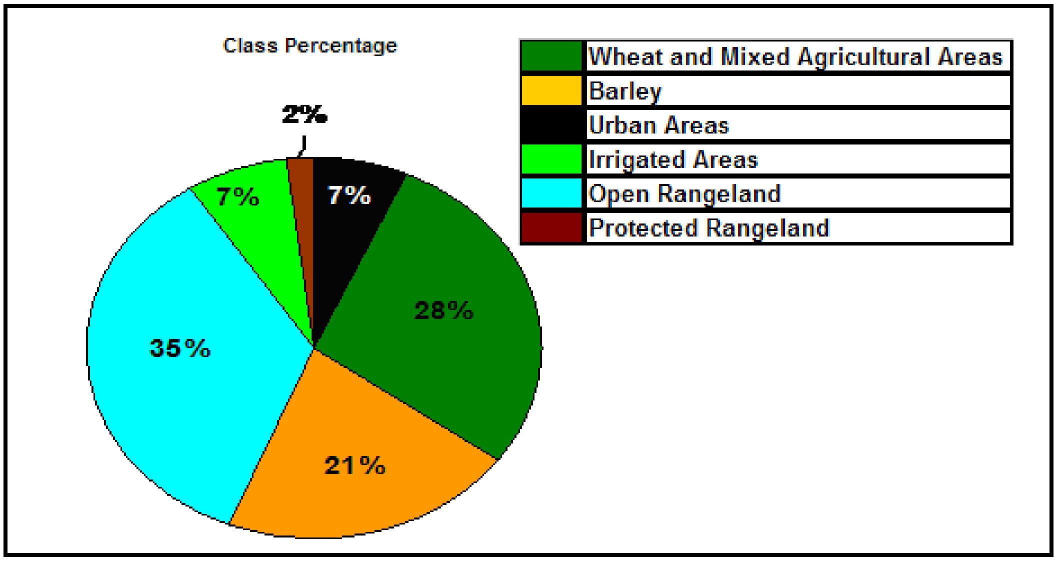


Figure 4.2: Class percentage of land use/cover map.

4.2 Unsupervised classification of MODIS data.

MODIS NDVI and Albedo images, initially classified using the ISODATA algorithm, showed that the area had ten spectral classes. Results of USC are shown in Figures 4.3 and 4.4 respectively.

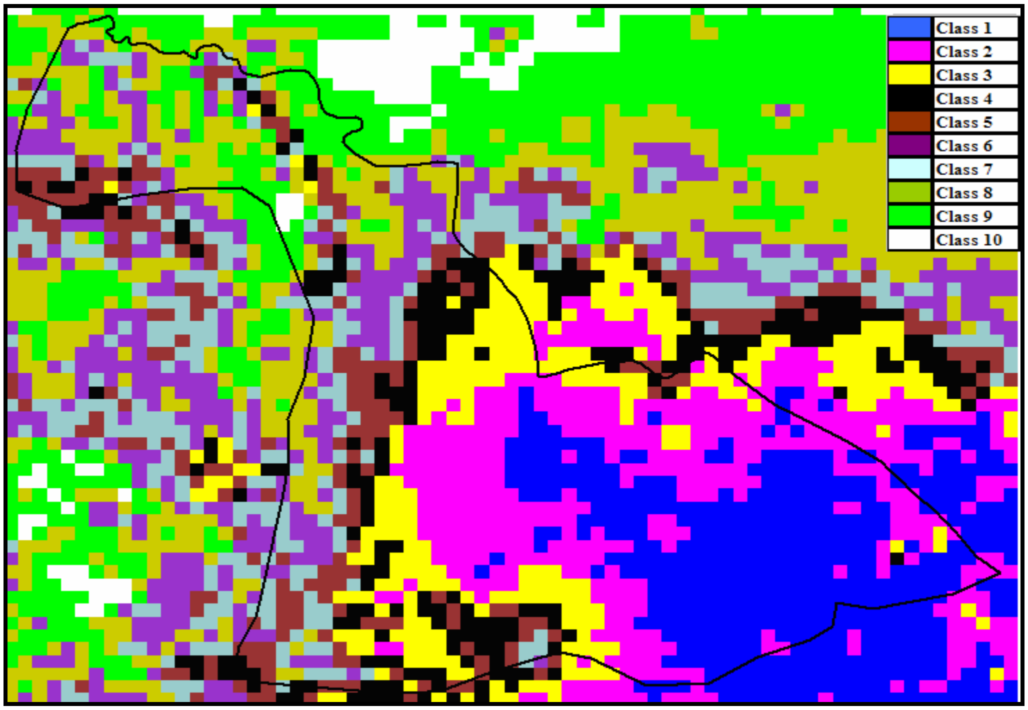


Figure 4.3: Albedo image after USC with ten classes.

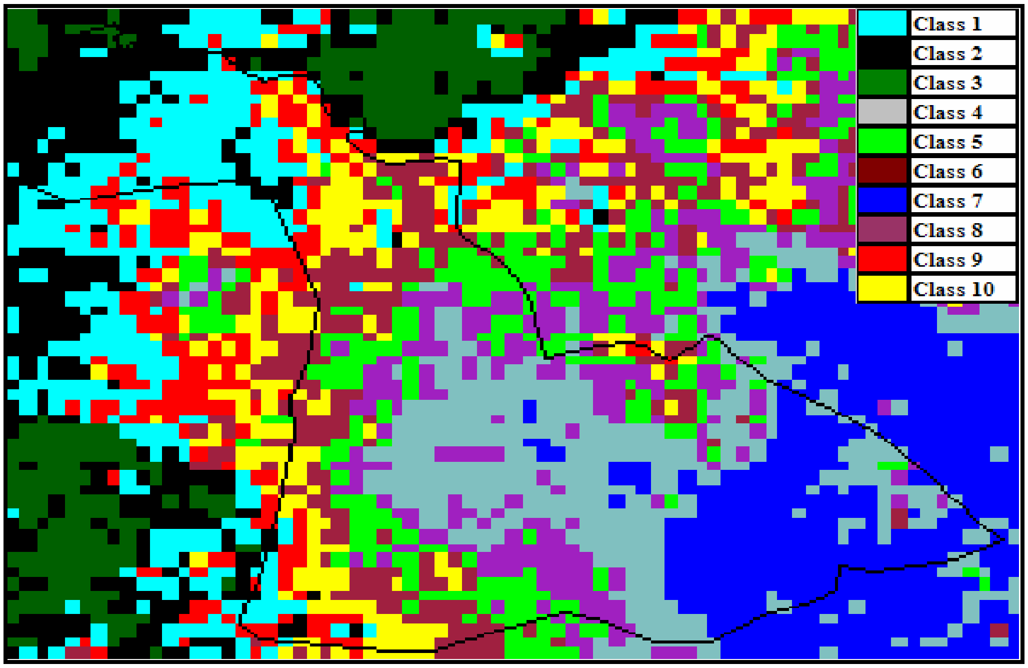


Figure 4.4: NDVI image after USC with ten classes.

Visual inspection of classes (clusters) indicated that only three distinct spectral classes with land use/cover meaning could be generated from the digital classification. The ten classes resulted from the USC were regrouped into three major classes as shown in Figures (4.5, 4.6) for NDVI and Albedo, respectively.

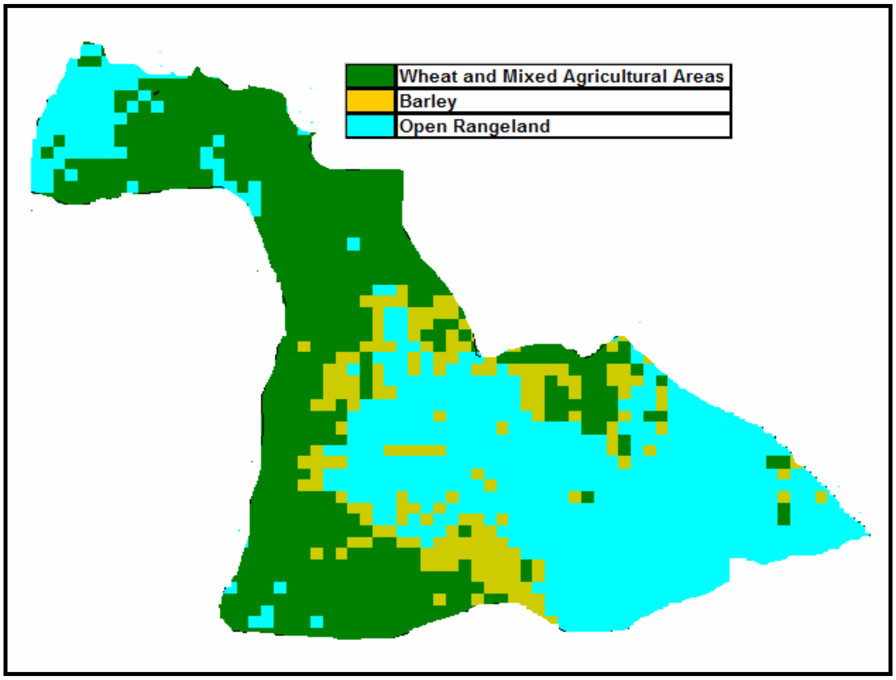


Figure 4.5: NDVI ISODATA image after regrouping classes to three.

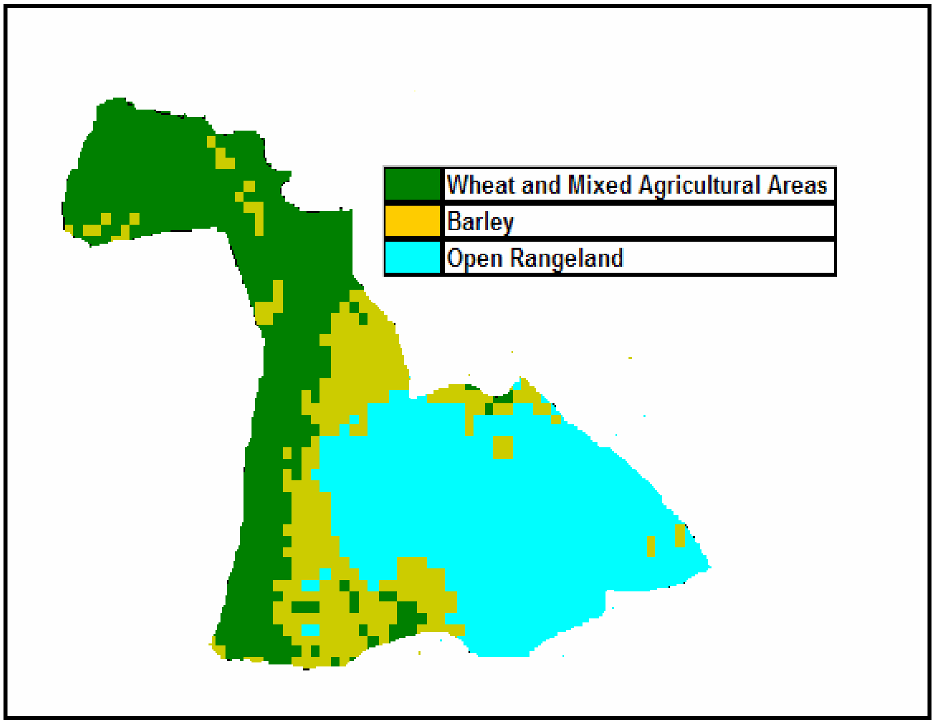


Figure 4.6: Albedo ISODATA image after regrouping classes to three.

Both figures showed three distinct classes of wheat/MAA, barley, and open rangeland. On the other hand, protected rangeland and urban areas were not distinguished, while irrigated areas preserved the same location in land use/cover map, although the color was similar to wheat/MAA class in the NDVI image. At the contrary, Albedo image did not isolate irrigated areas from other classes. Figure (4.6) showed that Albedo image did not separate open rangeland from wheat/MAA at the north west of the study area, while NDVI was able to separate both classes.

4.3 Analysis of NDVI and Albedo

-Mean yearly NDVI results:

The spectral profile for annual NDVI is shown in Figures (4.7), in which every class was well separated from other classes. The main values of each profile during the 7-years for all the classes are summarized in (Table 4.1).

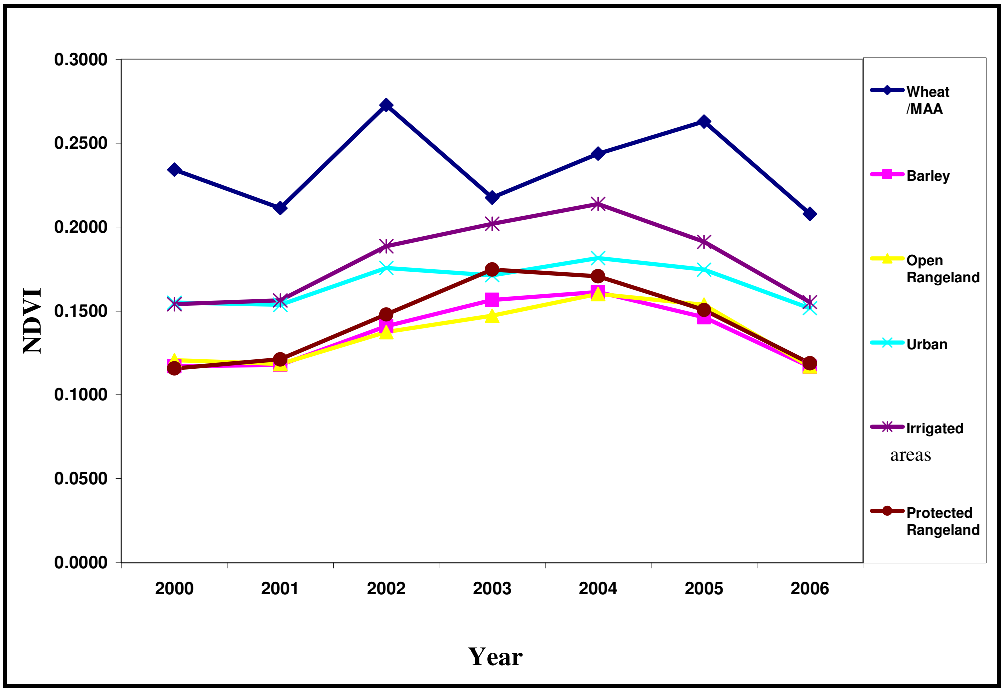


Figure 4.7: Mean yearly NDVI during 2000-2006 for all land use/cover classes.

The NDVI time-series for each land use/cover showed intra-annual variability from 2000 to 2006 for all classes. Open rangeland, barley and irrigated areas exhibited NDVI time-series that increased from 2000 until 2004 and decreased afterward. Protected rangeland had showed an increase until 2003 when it started to decrease after that year. Both Wheat/MAA and urban classes showed increases in 2002, 2004, 2005, and little to no NDVI change in the remaining years.

Table 4.1: Yearly NDVI profile values for all classes during 2000-2006.

Year	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5	Profile 6	Profile 7	Profile 8	Mean*	NDVI**
Urban										
2000	1519	1038	2092						1550	0.1550
2001	1484	996	2130						1537	0.1537
2002	1627	1083	2559						1756	0.1756
2003	1664	1236	2237						1712	0.1712
2004	1680	1219	2547						1815	0.1815
2005	1578	1114	2544						1746	0.1746
2006	1468	994	2085						1516	0.1516
Barley										
2000	1339	1029	1147						1171	0.1171
2001	1332	1075	1127						1178	0.1178
2002	1564	1190	1476						1410	0.1410
2003	1533	1565	1600						1566	0.1566
2004	1739	1467	1631						1612	0.1612
2005	1558	1416	1411						1462	0.1462
2006	1320	1061	1121						1167	0.1167
Irrigated areas										
2000	1441	2110	1233	1374					1539	0.1539
2001	1582	1887	1341	1442					1563	0.1563
2002	1602	2464	1592	1886					1886	0.1886
2003	2283	2136	1565	2095					2020	0.2020
2004	1860	2431	1906	2355					2138	0.2138
2005	1840	2197	1614	1996					1912	0.1912
2006	1602	1845	1341	1422					1553	0.1553
Protected Rangeland										
2000	1040	1277							1158	0.1158
2001	1171	1254							1212	0.1212
2002	1345	1612							1479	0.1479
2003	1613	1881							1747	0.1747
2004	1505	1908							1707	0.1707
2005	1267	1746							1506	0.1506
2006	1132	1245							1188	0.1188
Open Rangeland										
2000	1175	1155	1054	902	1117	1839			1207	0.1207
2001	1251	1113	958	862	1030	1886			1183	0.1183
2002	1454	1288	1047	957	1239	2264			1375	0.1375
2003	1635	1533	1171	999	1442	2051			1472	0.1472
2004	1758	1791	1239	1006	1447	2363			1601	0.1601
2005	1575	1584	1195	1248	1326	2291			1537	0.1537
2006	1246	1097	947	856	1010	1856			1169	0.1169
Wheat/MA										
2000	2521	2416	2538	2243	2186	2881	2094	1857	2342	0.2342
2001	2235	2258	2252	1894	2031	2546	1946	1751	2114	0.2114
2002	3082	3084	2976	2369	2728	3083	2214	2281	2727	0.2727
2003	2145	2223	2583	2136	1973	2619	2047	1678	2176	0.2176
2004	2442	2453	2763	2370	2229	2912	2369	1967	2438	0.2438
2005	2630	2776	2674	2468	2646	3059	2481	2302	2629	0.2629
2006	2187	2223	2199	1866	1998	2513	1930	1714	2079	0.2079

***: The mean of all NDVI profile values.**
**** : NDVI value /10000**

Table (4.2) showed the maximum mean yearly NDVI value for wheat/MAA class, which is 0.273 at 2002; on the other hand, the minimum value was for protected rangeland 0.116 at 2000. The maximum NDVI profile value is 0.308 at 2002 for wheat/MAA class and the minimum value is 0.086 at 2006 for open rangeland class. Values of yearly NDVI profiles are higher than average annual NDVI because averaging had smoothed and lowered these values.

Table 4.2: Maximum and minimum mean yearly NDVI for the selected profile and for the whole class.

Class	Year	Maximum yearly profile value	Year	Maximum mean yearly NDVI	Year	Minimum yearly profile value	Year	Minimum mean yearly NDVI
Protected Rangeland	2004	0.191	2003	0.175	2000	0.104	2000	0.116
Wheat/MAA	2002	0.308	2002	0.273	2003	0.168	2006	0.208
Open Rangeland	2004	0.236	2004	0.160	2006	0.086	2006	0.117
Irrigated areas	2002	0.246	2004	0.214	2000	0.123	2000	0.154
Barley	2004	0.174	2004	0.161	2000	0.103	2006	0.117
Urban	2002	0.256	2004	0.182	2006	0.099	2006	0.152

Results of ANOVA analysis (Appendix 4) for yearly NDVI values showed significant differences between yearly NDVI for open rangeland, urban, irrigated and wheat/MAA classes.

-Mean yearly Albedo results:

The spectral profile for annual Albedo is shown in Figures (4.8), in which good separation was observed among classes. The values of each profile during the 7- years for all the classes are shown in Table (4.3).

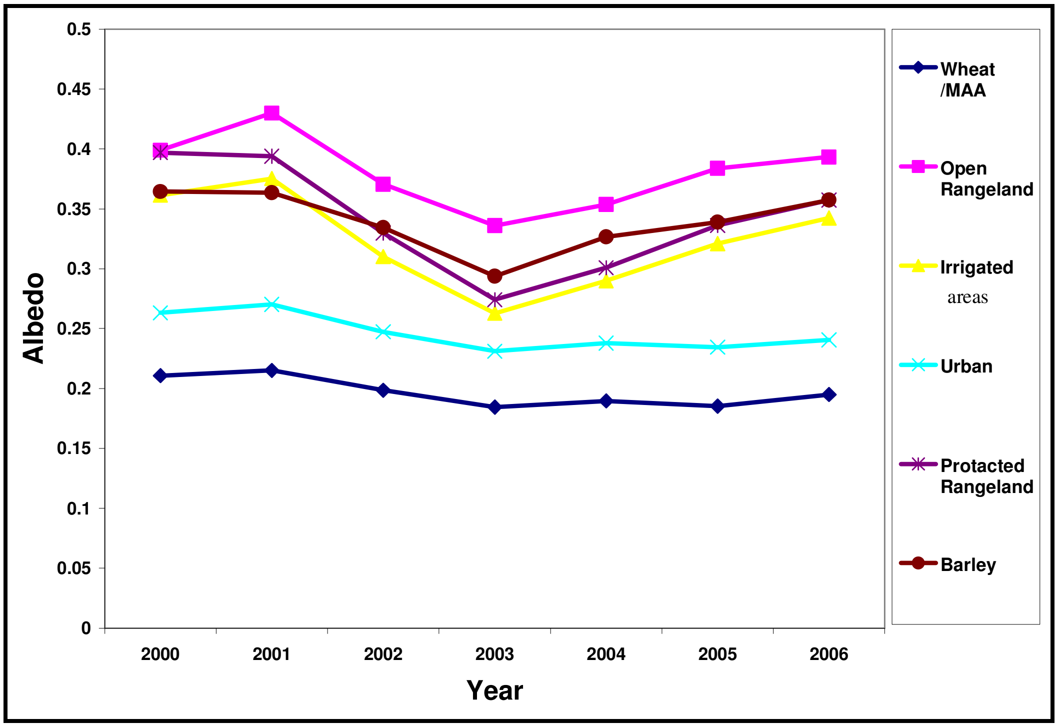


Figure 4.8: Mean yearly Albedo during (2000-2006) for all LU/C classes.

The albedo time-series showed little intra-annual variability from 2000 to 2006 for some LU/C classes like urban and wheat/MAA. On the other hand, the remaining classes showed some variations in the behavior of albedo. The albedo for open rangeland, barley, protected rangeland and irrigated areas increased after 2003.

Table 4.3: Yearly albedo profile values for all classes during 2000-2006.

Year	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5	Profile 6	Profile 7	Profile 8	Mean*	Albedo**
Urban										
2000	2573	2805	2517						2632	0.2632
2001	2730	2803	2575						2703	0.2703
2002	2532	2614	2271						2473	0.2473
2003	2326	2444	2165						2311	0.2311
2004	2380	2555	2200						2378	0.2378
2005	2318	2526	2193						2346	0.2346
2006	2409	2596	2212						2406	0.2406
Barley										
2000	3638	3548	3748						3644	0.3644
2001	3707	3471	3729						3636	0.3636
2002	3374	3221	3439						3345	0.3345
2003	3117	2827	2874						2939	0.2939
2004	3377	3119	3305						3267	0.3267
2005	3568	3208	3395						3390	0.3390
2006	3645	3380	3696						3574	0.3574
Irrigated Areas)										
2000	3173	3611	3776	3892					3613	0.3613
2001	3413	4253	3640	3706					3753	0.3753
2002	2675	3311	3310	3108					3101	0.3101
2003	2355	2675	3134	2354					2630	0.2630
2004	2738	3171	3114	2574					2899	0.2899
2005	3076	3424	3301	3035					3209	0.3209
2006	3288	3701	3376	3327					3423	0.3423
Protected rangeland										
2000	3945	3993							3969	0.3969
2001	4080	3796							3938	0.3938
2002	3406	3192							3299	0.3299
2003	3048	2434							2741	0.2741
2004	3230	2788							3009	0.3009
2005	3533	3190							3361	0.3361
2006	3723	3420							3572	0.3572
Open Rangeland										
2000	4350	4043	3872	3883	3944	3840			3989	0.3989
2001	4487	4582	4087	4275	4431	3933			4299	0.4299
2002	3913	3899	3605	3532	3654	3627			3705	0.3705
2003	4141	3723	3281	3016	2993	3005			3360	0.3360
2004	4178	3704	3457	3284	3365	3224			3535	0.3535
2005	4134	3999	3771	3894	3811	3416			3837	0.3837
2006	3994	4116	4034	3796	3944	3713			3933	0.3933
Wheat/MAA										
2000	1917	1815	1459	2042	2287	2352	2195	2802	2108	0.2108
2001	2109	1813	1469	2109	2305	2458	2210	2740	2152	0.2152
2002	1957	1731	1356	1951	2145	2171	2055	2526	1986	0.1986
2003	1741	1630	1359	1847	1980	1958	1958	2284	1845	0.1845
2004	1738	1638	1340	1850	2102	1989	2026	2494	1897	0.1897
2005	1707	1600	1323	1806	1992	1992	1939	2456	1852	0.1852
2006	1753	1628	1334	1998	2208	2106	2059	2521	1951	0.1951

*: The mean of all Albedo profile values.
** : Albedo value /10000

Table (4.4) showed that the maximum mean yearly albedo value for open rangeland class reached a relatively high value 0.43 in 2001. On the other hand, the minimum value 0.185 is for wheat/MAA in year 2003. The maximum albedo profile value was 0.46 at 2001 for open rangeland class and the minimum value is 0.13 at 2005 for wheat/MAA class. Values of yearly albedo profiles were higher than the average annual NDVI values because the averaging had smoothed and lowered these values.

Table 4.4: Maximum and minimum mean yearly albedo and profile value.

Class	Year	Maximum yearly profile value	Year	Maximum mean yearly albedo	Year	Minimum yearly profile value	Year	Minimum mean yearly albedo
Protected rangeland	2001	0.408	2000	0.397	2003	0.243	2003	0.274
Wheat /MAA	2000	0.280	2001	0.215	2005	0.132	2003	0.185
Open Rangeland	2001	0.458	2001	0.430	2003	0.299	2003	0.336
Irrigated	2001	0.425	2001	0.375	2003	0.235	2003	0.263
Barley	2000	0.375	2000	0.364	2003	0.283	2003	0.294
Urban	2000	0.281	2001	0.270	2003	0.217	2003	0.231

Results of ANOVA analysis (Appendix 4) for yearly albedo values showed no significant differences in yearly albedo were observed for open rangeland, urban and wheat/MAA.

-Mean monthly NDVI results:

Analysis of spectral profile was performed on (16-days) images in which there were two readings for each month. The mean monthly profile for each class is shown in Figure (4.9). The NDVI values tended to follow a uniform order across communities, related directly to vegetation dynamic and greening periods. All classes exhibited a unimodal-growing season, on average, with one peak in late winter and springtime that is between

March and April. Despite the high NDVI values during the spring, the time between May and November exhibited lower and stable NDVI values with little to no fluctuations. The figure showed that all classes had high NDVI values at 2003 with exception of wheat/MAA, which had the highest value in 2002. On the other hand, in 2001 all classes had the lowest values almost at all months. Results of the highest and lowest profile values before averaging are shown in Table (4.5).

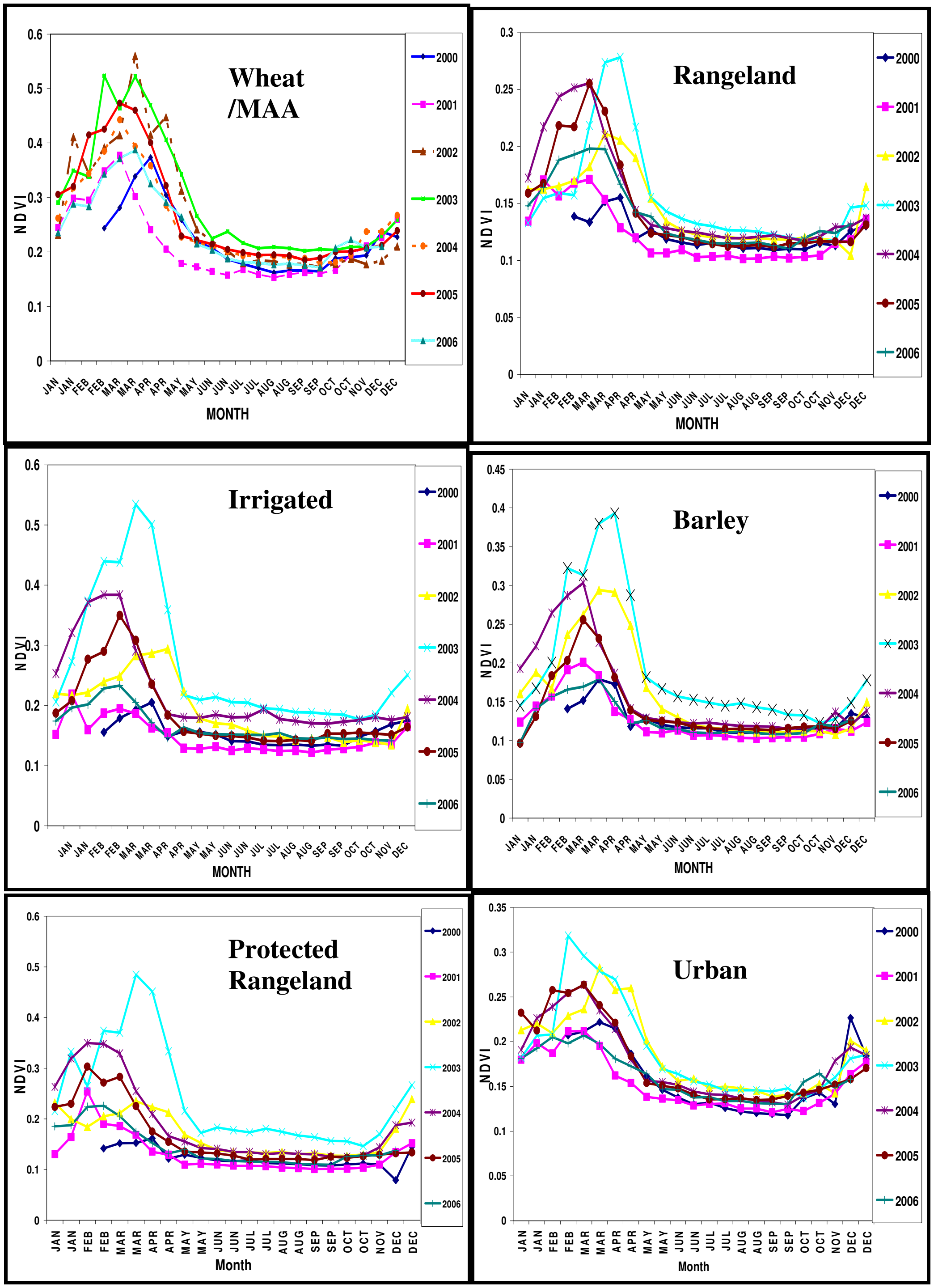


Figure 4.9: Mean values of 16-day NDVI for the profiles of LU/C classes during 2000-2006.

Table 4.5: Maximum and minimum 16-day NDVI for profiles and LU/C classes.

Class	Year	Month	Maximum monthly profile value/16 day	Minimum monthly profile value/16 day	Year	Month
Protected rangeland	2003	March	0.630	0.096	2001	September
Wheat/MAA	2002	March	0.925	0.119	2004	November
Open Rangeland	2002	March	0.402	0.020	2003	February
Irrigated	2003	March	0.662	0.099	2000	February
Barley	2003	March	0.432	0.004	2006	January
Urban	2002	March	0.437	0.072	2000	December

As shown in Table (4.5), the highest profile value of NDVI was 0.925 for wheat/MAA class during March/2002 while the lowest value was obtained for barley and open rangeland, which was around 0.004 during December/2006. In general, NDVI profile value for the 16-day images ranged between 0.004 to 0.925 and showed obvious monthly variations. The average of two readings within each month resulted in smoothing the NDVI curves. An example is shown in Figure (4.10) for protected rangeland in year 2000. Summary of the average monthly values of NDVI for all classes is shown in Table (4.6). The raw data of 16-day NDVI is shown in Appendix 1.

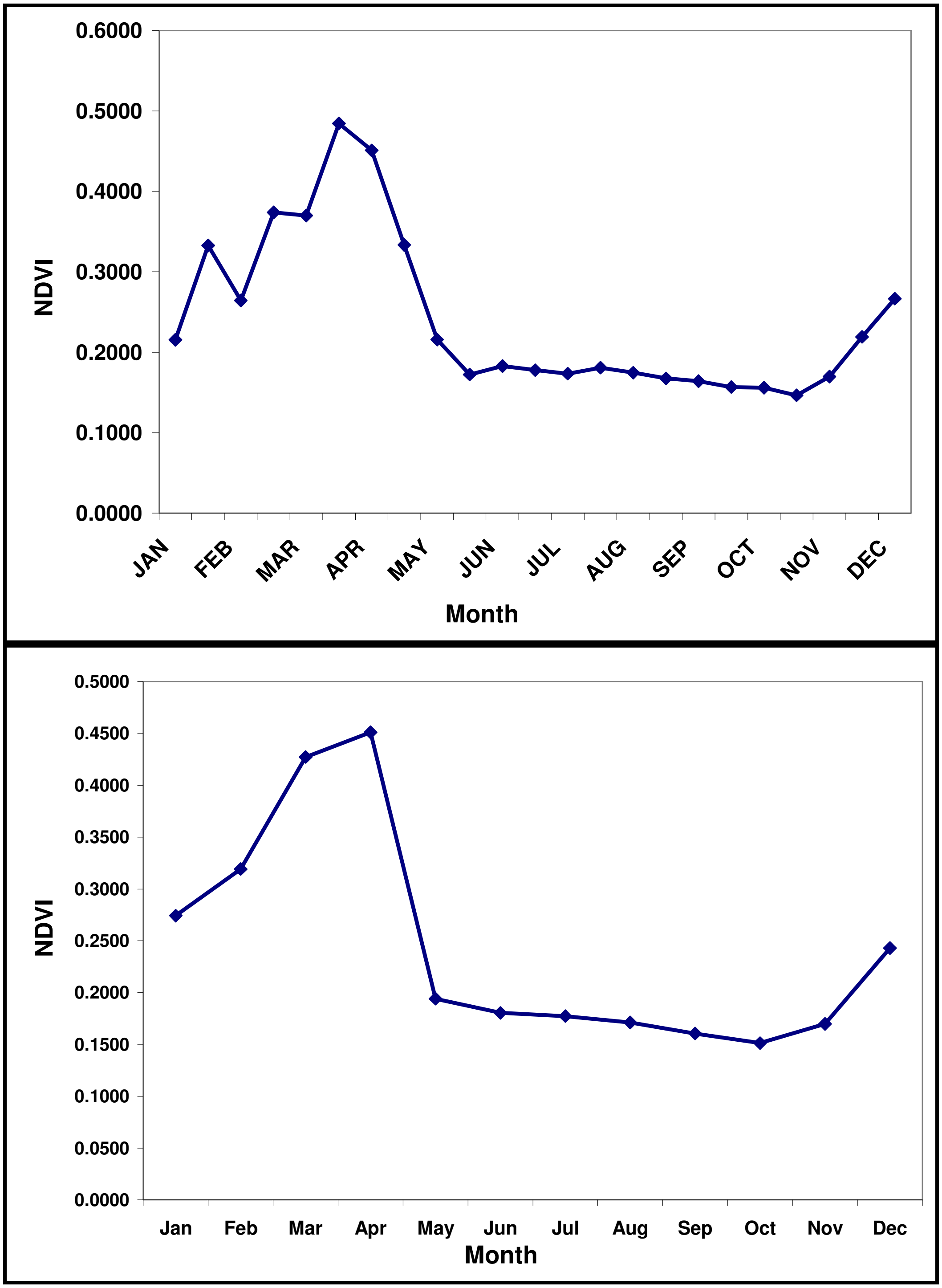


Figure 4.10: Mean NDVI values for protected rangeland using 16-day values (Top) and monthly NDVI values (Bottom) for year 2003.

Table 4.6: Mean monthly NDVI for all classes during 2000-2006

Year	Month	Protected Rangeland	Wheat /MAA	Open Rangeland	Irrigated	Barley	Urban
2000	February	0.142	0.229	0.139	0.156	0.141	0.207
	March	0.153	0.333	0.143	0.186	0.165	0.217
	April	0.142	0.380	0.137	0.177	0.145	0.201
	May	0.127	0.241	0.123	0.157	0.125	0.154
	June	0.117	0.185	0.115	0.146	0.116	0.134
	July	0.116	0.161	0.115	0.138	0.113	0.129
	August	0.112	0.150	0.111	0.135	0.110	0.121
	September	0.108	0.151	0.110	0.134	0.109	0.118
	October	0.111	0.184	0.113	0.141	0.116	0.140
	November	0.111	0.197	0.113	0.157	0.116	0.131
	December	0.112	0.232	0.128	0.172	0.132	0.205
2001	January	0.148	0.253	0.153	0.185	0.134	0.189
	February	0.222	0.326	0.162	0.174	0.174	0.199
	March	0.177	0.335	0.163	0.191	0.192	0.204
	April	0.133	0.219	0.124	0.158	0.132	0.158
	May	0.111	0.162	0.107	0.129	0.111	0.137
	June	0.109	0.144	0.106	0.128	0.110	0.132
	July	0.107	0.150	0.104	0.128	0.107	0.131
	August	0.104	0.143	0.102	0.125	0.103	0.125
	September	0.102	0.151	0.103	0.124	0.104	0.123
	October	0.103	0.179	0.104	0.130	0.107	0.127
	November	0.110	0.229	0.115	0.138	0.115	0.142
	December	0.143	0.204	0.127	0.150	0.118	0.171
2002	January	0.216	0.340	0.163	0.218	0.174	0.217
	February	0.195	0.336	0.168	0.231	0.202	0.219
	March	0.224	0.471	0.197	0.266	0.278	0.260
	April	0.218	0.424	0.198	0.291	0.270	0.259
	May	0.161	0.253	0.145	0.201	0.155	0.187
	June	0.137	0.179	0.125	0.170	0.125	0.158
	July	0.134	0.159	0.121	0.154	0.116	0.149
	August	0.133	0.154	0.119	0.145	0.112	0.147
	September	0.130	0.151	0.119	0.146	0.111	0.140
	October	0.129	0.162	0.120	0.141	0.112	0.148
	November	0.135	0.155	0.118	0.139	0.108	0.142
	December	0.210	0.175	0.135	0.165	0.133	0.196
2003	January	0.274	0.265	0.144	0.240	0.156	0.195
	February	0.319	0.369	0.158	0.407	0.262	0.263
	March	0.427	0.405	0.246	0.486	0.347	0.287
	April	0.451	0.486	0.278	0.501	0.393	0.270
	May	0.194	0.323	0.149	0.213	0.174	0.183
	June	0.181	0.217	0.135	0.210	0.155	0.160
	July	0.177	0.196	0.129	0.200	0.147	0.149
	August	0.171	0.184	0.126	0.191	0.146	0.146
	September	0.161	0.177	0.121	0.187	0.137	0.146
	October	0.151	0.171	0.117	0.181	0.128	0.200
	November	0.170	0.177	0.118	0.184	0.128	0.160
	December	0.243	0.199	0.147	0.236	0.163	0.183

Table 4.6: continued

Year	Month	Protected	Wheat /MAA	Open Rangeland	Irrigated	Barley	Urban
2004	January	0.2913	0.2453	0.1948	0.2872	0.2074	0.2086
	February	0.3487	0.3350	0.2477	0.3775	0.2757	0.2467
	March	0.2922	0.4321	0.2328	0.3372	0.2650	0.2491
	April	0.1879	0.3480	0.1605	0.2113	0.1640	0.1970
	May	0.1491	0.2018	0.1298	0.1798	0.1274	0.1556
	June	0.1383	0.1761	0.1254	0.1824	0.1228	0.1481
	July	0.1329	0.1666	0.1209	0.1872	0.1219	0.1409
	August	0.1327	0.1633	0.1197	0.1775	0.1184	0.1369
	September	0.1279	0.1570	0.1208	0.1701	0.1164	0.1309
	October	0.1268	0.1612	0.1192	0.1744	0.1160	0.1428
	November	0.1440	0.1803	0.1293	0.1802	0.1366	0.1785
	December	0.1904	0.2078	0.1338	0.1784	0.1294	0.1892
2005	January	0.2269	0.2550	0.1634	0.1977	0.1138	0.2224
	February	0.2876	0.3979	0.2178	0.2833	0.1935	0.2559
	March	0.2542	0.4915	0.2431	0.3289	0.2436	0.2523
	April	0.1651	0.3940	0.1628	0.2096	0.1604	0.2026
	May	0.1357	0.2113	0.1240	0.1566	0.1265	0.1539
	June	0.1300	0.1855	0.1186	0.1497	0.1206	0.1444
	July	0.1205	0.1724	0.1135	0.1443	0.1153	0.1357
	August	0.1212	0.1687	0.1131	0.1418	0.1147	0.1358
	September	0.1221	0.1621	0.1136	0.1470	0.1146	0.1374
	October	0.1251	0.1762	0.1161	0.1540	0.1180	0.1447
	December	0.1333	0.2035	0.1239	0.1578	0.1203	0.1643
2006	January	0.1867	0.2188	0.1559	0.1854	0.1190	0.1870
	February	0.2250	0.2708	0.1906	0.2149	0.1612	0.2016
	March	0.1905	0.3405	0.1732	0.2192	0.1741	0.2022
	April	0.1428	0.2876	0.1548	0.1591	0.1363	0.1766
	May	0.1308	0.2197	0.1312	0.1590	0.1204	0.1555
	June	0.1192	0.1752	0.1193	0.1520	0.1126	0.1420
	July	0.1156	0.1588	0.1151	0.1511	0.1100	0.1358
	August	0.1131	0.1555	0.1155	0.1499	0.1106	0.1328
	September	0.1102	0.1522	0.1117	0.1459	0.1084	0.1306
	October	0.1271	0.1830	0.1229	0.1446	0.1153	0.1598
	November	0.1279	0.1760	0.1242	0.1425	0.1183	0.1493
	December	0.1382	0.1969	0.1321	0.1411	0.1265	0.1577

Figure (4.11) shows the mean monthly profile curves before and after averaging for protected rangeland during 2000-2006. Generally, the year 2003 showed high NDVI values that extended to April. Oppositely, year 2000 showed the lowest NDVI values among years.

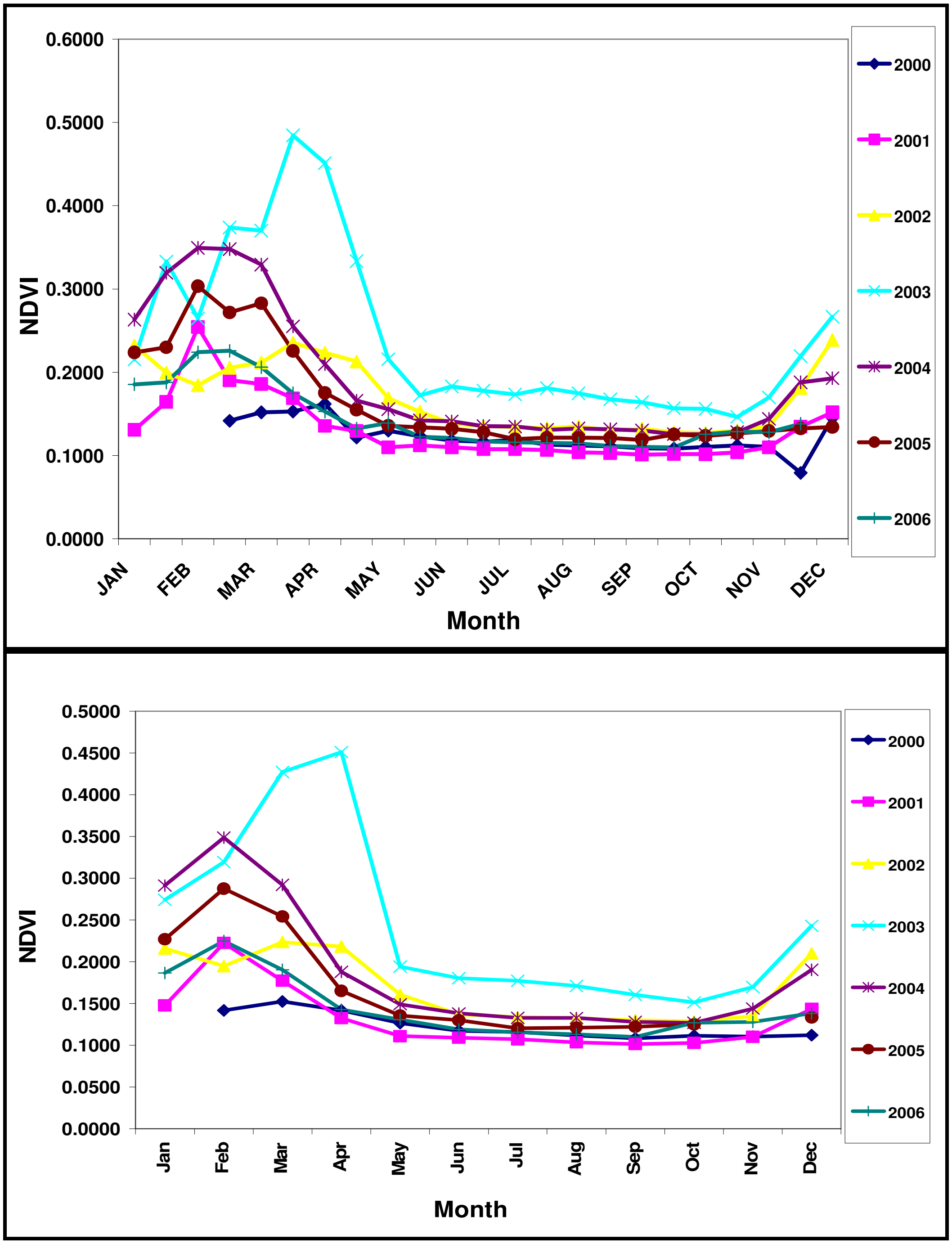


Figure 4.11: Mean NDVI values for protected rangeland using 16-day values (Top) and monthly NDVI values (Bottom) during 2000-2006.

Results of ANOVA analysis (Appendix 4) for monthly NDVI values showed significant differences ($p>0.05$) between months for the different profiles in each year for protected rangeland, urban and open rangeland, while there were significant differences between monthly NDVI values for irrigated areas except in 2005. Spectral profiles of barley showed significant differences among 2000, 2002, and 2006. The differences between months during 2000, 2001, and 2006 for wheat/MAA were also significant.

Using Z-test (Appendix 5), significant differences between (16-day) monthly NDVI values were observed among the different classes in some years, but not necessarily all years (Table 4.7)

Table 4.7: Summary of years of significant differences in monthly NDVI among classes.

Class	Year
Barley+ Open Rangeland	2000, 2001,2002, 2004, 2005
Barley+ Protected rangeland	2000, 2001, 2002
Urban+ Protected rangeland	2000, 2002, 2004, 2005, 2006
Urban+ Irrigated areas	2001, 2002, 2005, 2006
Urban+ Barley	2003, 2004, 2005
Urban+ Open Rangeland	2005
Open Rangeland + Protected rangeland	2000, 2001, 2005
Irrigated areas+ Protected rangeland	2002, 2003, 2005
Irrigated areas+ Wheat/MAA	2003

-Mean monthly albedo results:

Unlike vegetation, albedo tended to be higher during the summer months when soil was bare and vegetation was absent. Albedo values tended to follow a uniform order across different classes Figure (4.12). All classes had a unimodal curves, on average, with one peak between May and August. The time of early and late winter exhibited lower and stable albedo values with little to no fluctuations. Obviously, the behavior of albedo was opposite to NDVI as all classes had high albedo values in at 2001 and low albedo values in 2003. Results of the highest and lowest profile values before averaging are shown in Table (4.8). Raw data is shown in appendix 2.

Table 4.8: Maximum and minimum albedo for the 16-day readings for all profiles of LU/C classes.

Class	Year	Month	Maximum monthly profile value 16-day	Minimum monthly profile value 16-day	Year	Month
Protected rangeland	2001	June	0.481	0.135	2006	January
Wheat/MAA	2000	June	0.306	0.054	2006	April
Open Rangeland	2003	June	0.518	0.072	2003	February
Irrigated	2001	June	0.496	0.074	2000	December
Barley	2001	June	0.444	0.134	2005	February
Urban	2001	June	0.440	0.122	2002	December

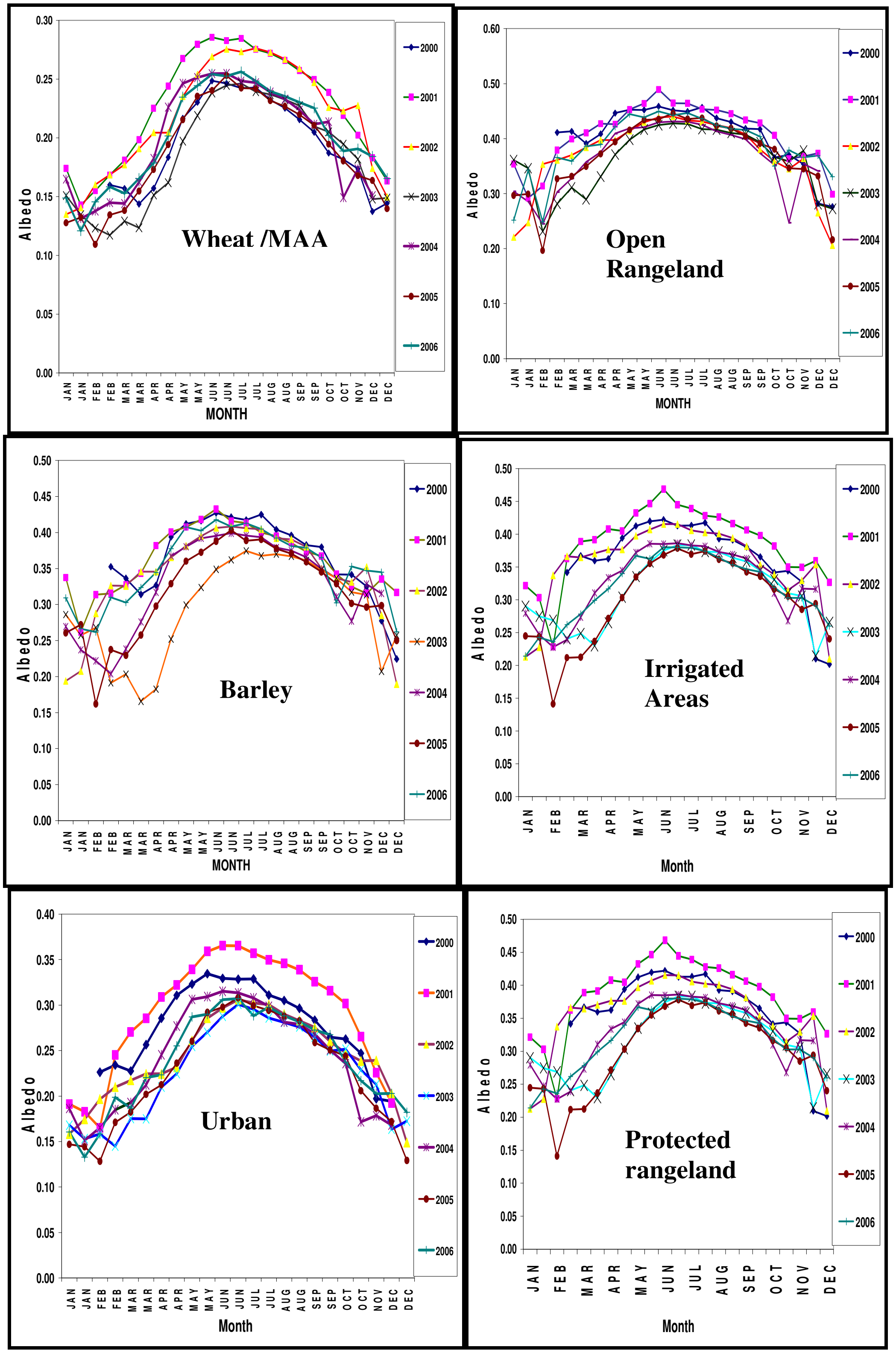
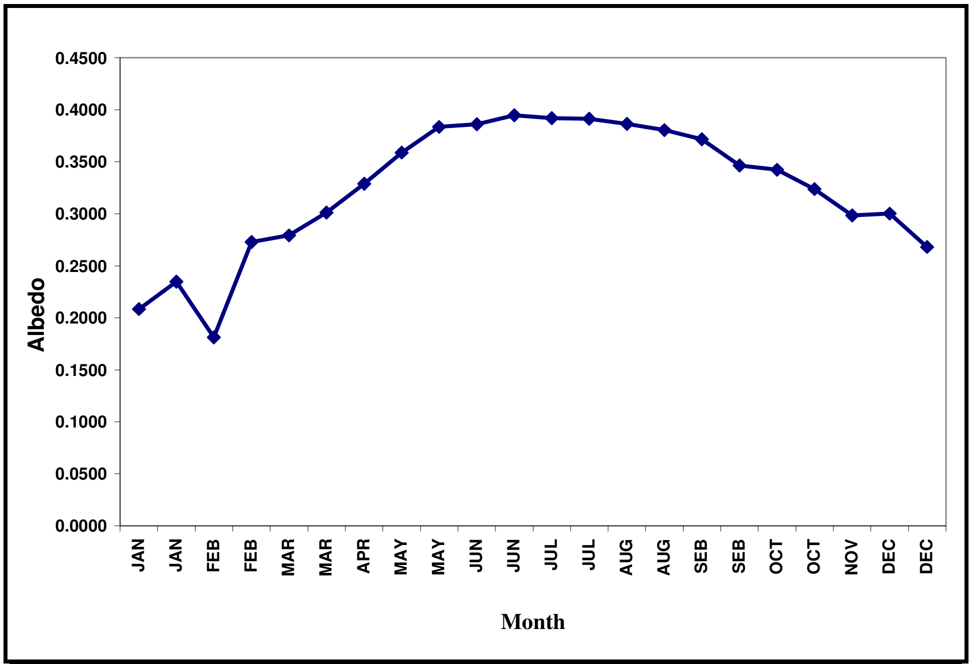


Figure 4.12: Mean monthly profile values of albedo for all classes during 2000-2006.

As shown in Table (4.8), the highest pro file value is 0.52 for open rangeland class during June/2003 and the lowest value for wheat/MAA and mixed agricultural areas (MAA), which is around 0.05 during April/2006. In general, albedo profile value for 16-day images ranged between (0.05 to 0.50). As same as NDVI, It was easy to study the monthly variation by taking one reading for each month; therefore, the average of two readings was estimated, and this step made the spectral profile curves smoother than the 16-days readings. As an example (Figure 4.13) and (Table 4.9) showed the spectral profile curves and values for mean monthly albedo of protected rangeland during 2005 before and after averaging while (Table 4.10) showed monthly albedo profile values for 16-day basis and for the rest of classes all 16-day tables are in Appendix (2).



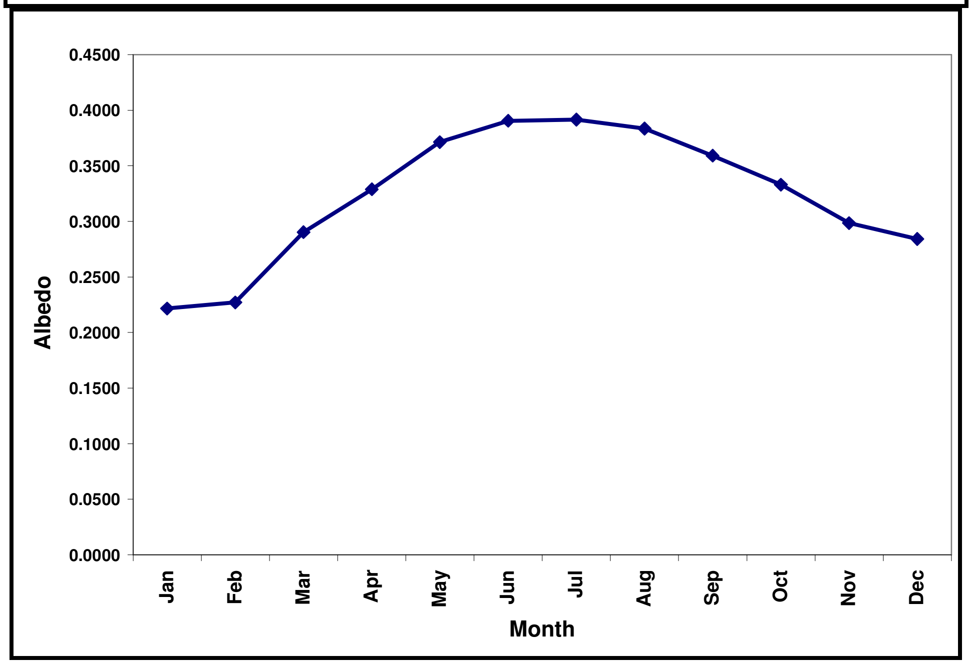


Figure 4.13: Mean albedo values for protected rangeland using 16-day values (Top) and monthly albedo values (Bottom) for year 2005.

Table 4.9: Mean monthly albedo for all classes during 2000-2006.

Year	Month	Wheat /MAA	Barley	Protected Rangeland	Open Rangeland	Urban	Irrigated
2000	February	0.153	0.353	0.378	0.411	0.226	0.342
	March	0.146	0.325	0.373	0.402	0.231	0.363
	April	0.168	0.360	0.376	0.427	0.271	0.378
	May	0.224	0.414	0.437	0.452	0.317	0.416
	June	0.255	0.424	0.445	0.455	0.332	0.418
	July	0.247	0.421	0.447	0.453	0.329	0.415
	August	0.232	0.400	0.428	0.434	0.308	0.392
	September	0.217	0.381	0.414	0.418	0.290	0.373
	October	0.182	0.342	0.368	0.368	0.264	0.343
	November	0.178	0.325	0.356	0.354	0.247	0.327
	December	0.134	0.251	0.291	0.279	0.196	0.206
2001	January	0.132	0.300	0.293	0.323	0.187	0.312
	February	0.137	0.315	0.315	0.347	0.205	0.296
	March	0.162	0.336	0.358	0.405	0.278	0.390
	April	0.208	0.391	0.401	0.427	0.316	0.406
	May	0.237	0.413	0.430	0.458	0.349	0.439
	June	0.245	0.424	0.455	0.477	0.365	0.457
	July	0.234	0.407	0.437	0.459	0.354	0.433
	August	0.223	0.390	0.428	0.449	0.342	0.421
	September	0.209	0.370	0.416	0.431	0.321	0.402
	October	0.185	0.334	0.369	0.385	0.284	0.366
	November	0.164	0.316	0.361	0.368	0.226	0.349
	December	0.143	0.326	0.291	0.336	0.193	0.343
2002	January	0.120	0.201	0.214	0.234	0.167	0.220
	February	0.135	0.307	0.303	0.357	0.203	0.352
	March	0.135	0.326	0.337	0.370	0.217	0.365
	April	0.148	0.365	0.354	0.398	0.232	0.376
	May	0.190	0.388	0.374	0.422	0.273	0.402
	June	0.228	0.407	0.391	0.440	0.302	0.415
	July	0.233	0.405	0.392	0.432	0.302	0.404
	August	0.223	0.391	0.382	0.422	0.287	0.397
	September	0.212	0.365	0.355	0.394	0.268	0.367
	October	0.194	0.334	0.327	0.352	0.243	0.326
	November	0.188	0.352	0.317	0.364	0.239	0.330
	December	0.155	0.237	0.171	0.235	0.176	0.282
2003	January	0.137	0.272	0.271	0.354	0.161	0.283
	February	0.122	0.230	0.188	0.257	0.152	0.255
	March	0.129	0.184	0.214	0.300	0.175	0.239
	April	0.152	0.217	0.245	0.351	0.217	0.284
	May	0.195	0.312	0.302	0.407	0.263	0.346
	June	0.229	0.356	0.327	0.426	0.294	0.379
	July	0.231	0.371	0.327	0.422	0.291	0.378
	August	0.221	0.368	0.319	0.413	0.279	0.368
	September	0.209	0.355	0.311	0.401	0.257	0.351
	October	0.194	0.327	0.289	0.363	0.240	0.320
	November	0.176	0.314	0.287	0.378	0.213	0.306
	December	0.140	0.232	0.187	0.277	0.168	0.240

Table (4.9): continued

Year	Month	Wheat /MAA	Barley	Protected Rangeland	Open Rangeland	Urban	Irrigated
2004	January	0.136	0.253	0.198	0.295	0.169	0.263
	February	0.126	0.213	0.225	0.274	0.175	0.233
	March	0.130	0.257	0.268	0.343	0.203	0.292
	April	0.174	0.342	0.319	0.392	0.261	0.339
	May	0.229	0.386	0.346	0.420	0.308	0.379
	June	0.237	0.397	0.361	0.431	0.314	0.385
	July	0.224	0.395	0.364	0.428	0.303	0.382
	August	0.211	0.377	0.350	0.410	0.280	0.371
	September	0.197	0.358	0.341	0.386	0.260	0.354
	October	0.173	0.294	0.252	0.300	0.204	0.289
	November	0.151	0.328	0.277	0.355	0.178	0.317
	December	0.137	0.315	0.236	0.341	0.168	0.316
2005	January	0.128	0.266	0.222	0.298	0.146	0.244
	February	0.114	0.200	0.227	0.262	0.150	0.176
	March	0.125	0.244	0.290	0.341	0.192	0.225
	April	0.143	0.298	0.329	0.372	0.212	0.272
	May	0.209	0.366	0.371	0.425	0.276	0.345
	June	0.239	0.396	0.391	0.441	0.303	0.373
	July	0.235	0.390	0.392	0.437	0.297	0.372
	August	0.221	0.374	0.384	0.421	0.285	0.359
	September	0.205	0.352	0.359	0.398	0.255	0.339
	October	0.179	0.315	0.333	0.364	0.225	0.311
	November	0.155	0.296	0.299	0.345	0.187	0.285
	December	0.140	0.274	0.284	0.274	0.151	0.267
2006	January	0.107	0.288	0.238	0.297	0.147	0.228
	February	0.122	0.286	0.265	0.307	0.179	0.249
	March	0.132	0.313	0.330	0.373	0.204	0.289
	April	0.153	0.361	0.369	0.406	0.239	0.328
	May	0.209	0.405	0.402	0.442	0.289	0.365
	June	0.225	0.413	0.418	0.446	0.307	0.380
	July	0.218	0.409	0.421	0.442	0.293	0.377
	August	0.202	0.387	0.405	0.422	0.285	0.359
	September	0.193	0.372	0.398	0.410	0.270	0.345
	October	0.161	0.328	0.346	0.365	0.227	0.311
	November	0.156	0.347	0.343	0.366	0.203	0.303
	December	0.141	0.304	0.301	0.350	0.193	0.275

Results of ANOVA analysis (Appendix 4) for monthly albedo values showed significant differences in monthly values of albedo for wheat/MAA and irrigated areas during all years. Protected rangeland and barley showed no significant differences ($p<0.05$) between monthly albedo during most of the years except 2003 and 2004 for protected areas and 2001 and 2005 for barley.

Using Z-test (Appendix 5), significant differences between most of monthly albedo values were observed among some classes as shown in Table (4. 10).

Table 4.10: Summary of years with significant differences in monthly albedo among classes.

Class	Year
Barley +Irrigated	2000, 2001,2002, 2003, 2004, 2005
Barley+ Protected Rangeland	2001, 2002, 2005, 2006
Open Rangeland +Protected rangeland	2000
Irrigated+ Protected rangeland	2001

4.4 Time Series of NDVI and Albedo

The following sections will include the analysis of temporal changes of NDVI and albedo for different land use/cover classes during 2000-2006. One of the reasons of conducting this analysis was to find if there were trends and cycles in vegetation and land use/cover classes during 2000-2006.

4.4.1 Time Series of NDVI.

Time-series of the different LU/C generally showed uniform behavior through the growing season. All LU/C showed increases in NDVI from March into May, followed by uniform decrease. The NDVI would increase during the next growing season following the same cycle. Generally, wheat/MAA had the highest NDVI values, followed by irrigated areas. Open rangeland and barley showed the lowest NDVI values, while the remaining classes showed variably ordered NDVI values. Figure (4.14) reflects the local maxima in the period March–May and local minima in the period June-November. The former minimum coincides with the beginning of the growing season and the latter minimum is at the end of the growing season.

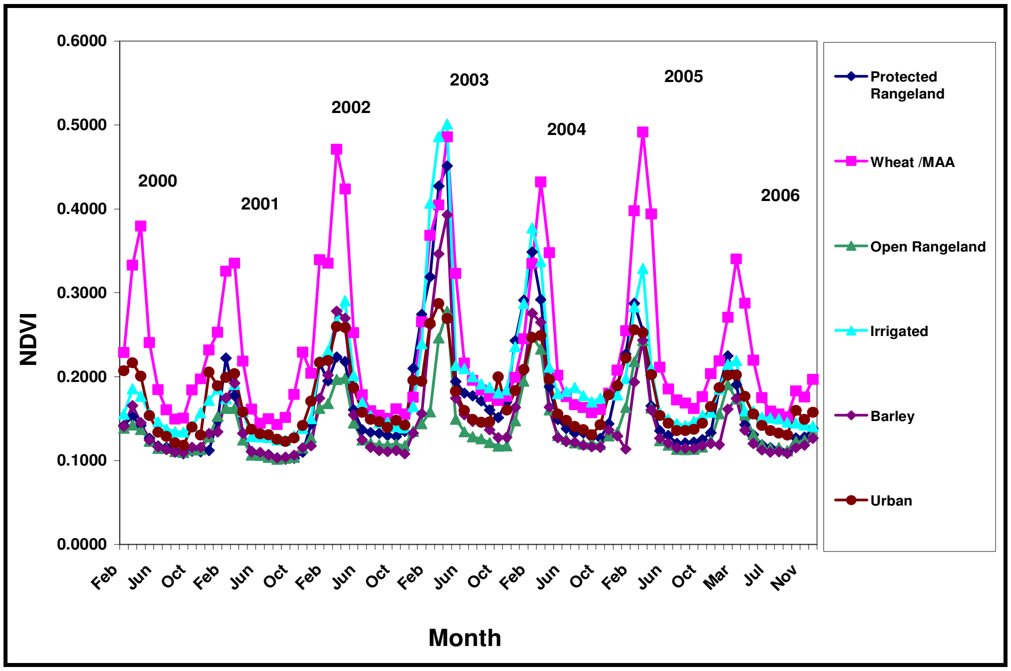


Figure 4.14: Average monthly NDVI values for all classes during 2000-2006.

In general, all of the classes except wheat/MAA showed gradual increase in the NDVI values from 2000 until 2003. After that, the NDVI values started to decrease until 2006. On the other hand, wheat/MAA showed some fluctuations in the temporal trend during the analysis period (Figures 4.15 and 4.16).

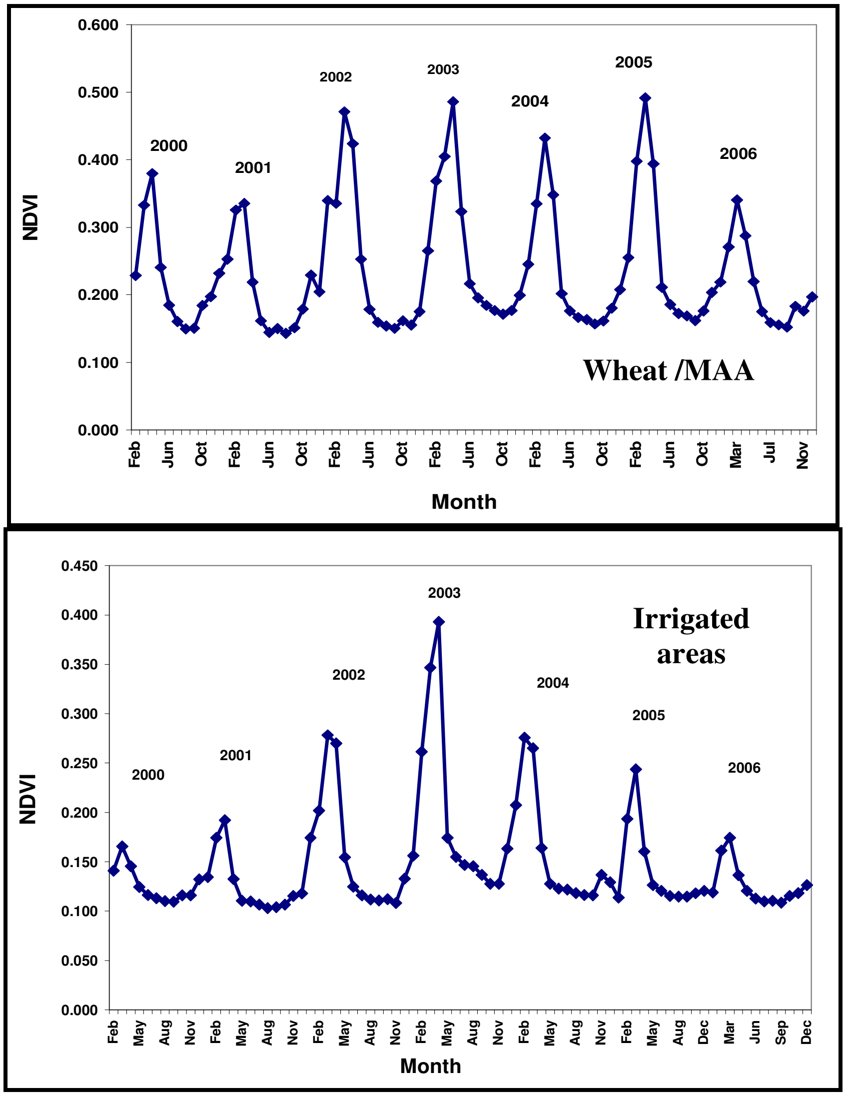


Figure 4.15: Mean monthly NDVI for wheat/MAA, irrigated areas, barley during 2000-2006. **Barley**

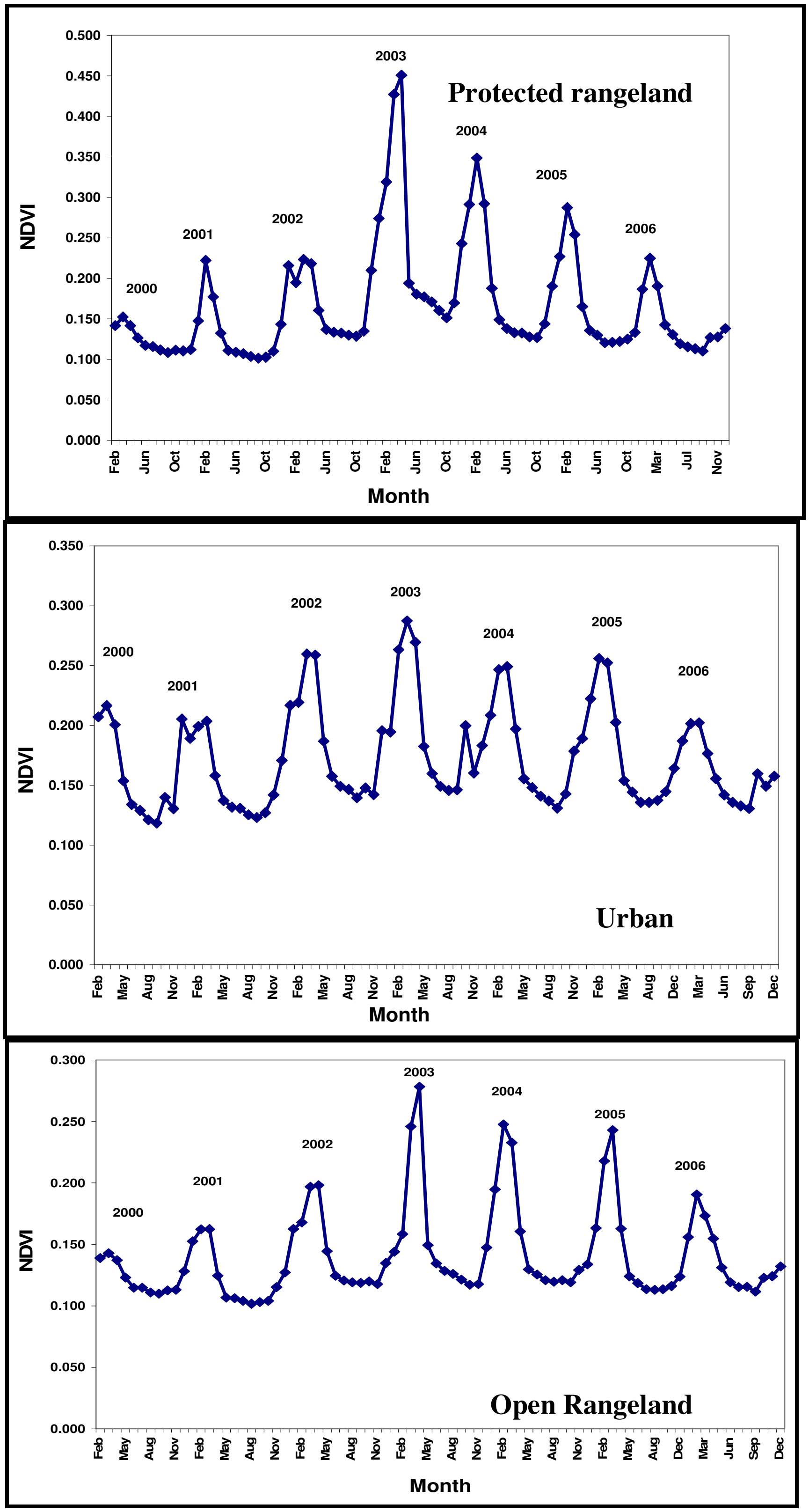


Figure 4.16: Mean monthly NDVI for protected rangeland, urban areas and open rangeland during 2000-2006.

Results of the maximum and minimum mean monthly NDVI values for profiles and for LU/C, classes are presented in Table (4.11). The maximum mean monthly values occurred between March and April, while profile values of 16-day NDVI occurred in March. In general, the 16-day NDVI was higher than the monthly NDVI values. Minimum mean monthly NDVI values showed no particular pattern in the time of occurrence in which the values were found in all years except 2002 and 2005 and in early to late winter. However, all minimum mean monthly NDVI values occurred during 2000 and 2001 in August and September. As mentioned before, averaging of NDVI smoothed the values and masked some trends and high values.

(Table 4.11): Maximum and minimum mean monthly NDVI and 16-day NDVI for the profiles and for all LU/C classes during 2000-2006.

	16-day values				Average monthly values			
Class	**Minimum**	**Year/Month**	**Maximum**	**Year/Month**	**Minimum**	**Year/Month**	**Maximum**	**Year/Month**
Protected Rangeland	**0.096**	**2001/September**	**0.630**	**2003/March**	**0.102**	**2001/September**	**0.451**	**2003/April**
Wheat /MAA	**0.119**	**2004/November**	**0.925**	**2002/March**	**0.143**	**2001/August**	**0.492**	**2005/March**
Open Rangeland	**0.020**	**2003/February**	**0.402**	**2002/March**	**0.102**	**2001/August**	**0.279**	**2003/April**
Irrigated areas	**0.099**	**2000/February**	**0.662**	**2003/March**	**0.124**	**2001/September**	**0.501**	**2003/April**
Barley	**0.004**	**2006/January**	**0.432**	**2003/March**	**0.103**	**2001/August**	**0.393**	**2003/April**
Urban	**0.072**	**2000/December**	**0.437**	**2002/March**	**0.118**	**2000/September**	**0.287**	**2003/March**

Results of the maximum and minimum monthly profile NDVI Table (4.12) showed similar values to mean monthly profiles in which the maximum values for both occurred between March and April and the minimum values showed no particular pattern in the time of occurrence in which the values were found in all years except 2002 and 2005 and in early to late winter.

Table (4.12): Maximum and minimum monthly NDVI profile values for all LU/C classes during 2000-2006.

Monthly Profile Values				
Class	**Maximum**	**Year/Month**	**Minimum**	**Year/Month**
Protected Rangeland	**0.097**	**2003/April**	**0.586**	**2001/September**
Wheat/MAA	**0.119**	**2002/March**	**0.661**	**2004/November**
Open Rangeland	**0.068**	**2003April**	**0.398**	**2003/February**
Irrigated areas	**0.099**	**2003/April**	**0.624**	**2000/February**
Barley	**0.060**	**2003/April**	**0.422**	**2006/January**
Urban	**0.077**	**2003/March**	**0.390**	**2004/November**

4.4.2 Time Series of Albedo

1. The 7-years average albedo showed uniform behavior through the summer. All LU/C classes showed increases in albedo from May to August because of the absence of vegetation cover through this time of year, followed by decrease afterwards due to the increase of vegetation cover during late winter and spring. Results showed that open rangeland had the highest albedo values, followed by barley. Wheat/MAA had the lowest albedo values, nevertheless the remaining LU/C classes showed varied albedo. The local maxima in the period May-August and local minima in the period November-February are shown in Figure (4.17). The former minimum coincided with the beginning of summer and the latter minimum was at the end of summer. The behavior of albedo could be explained as when NDVI values increased that means increasing in vegetation and so decreasing area of uncovered soil leading to low albedo values during growing season.

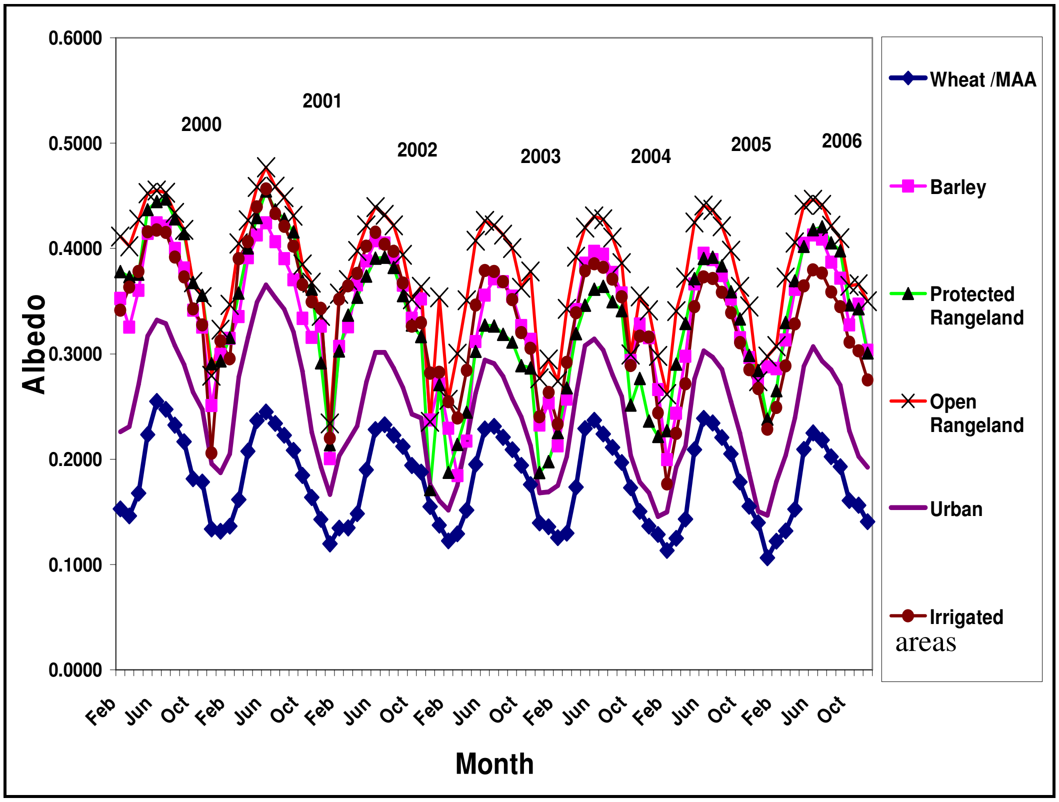


Figure 4.17: Average monthly albedo for all LU/C classes during 2000-2006.

In general, all of the classes showed nearly the same behavior all over the period with slight decrease in 2003 (Figures 4.18 and 4.19). On the other hand, wheat/MAA showed no fluctuations in the temporal trend during the analysis period.

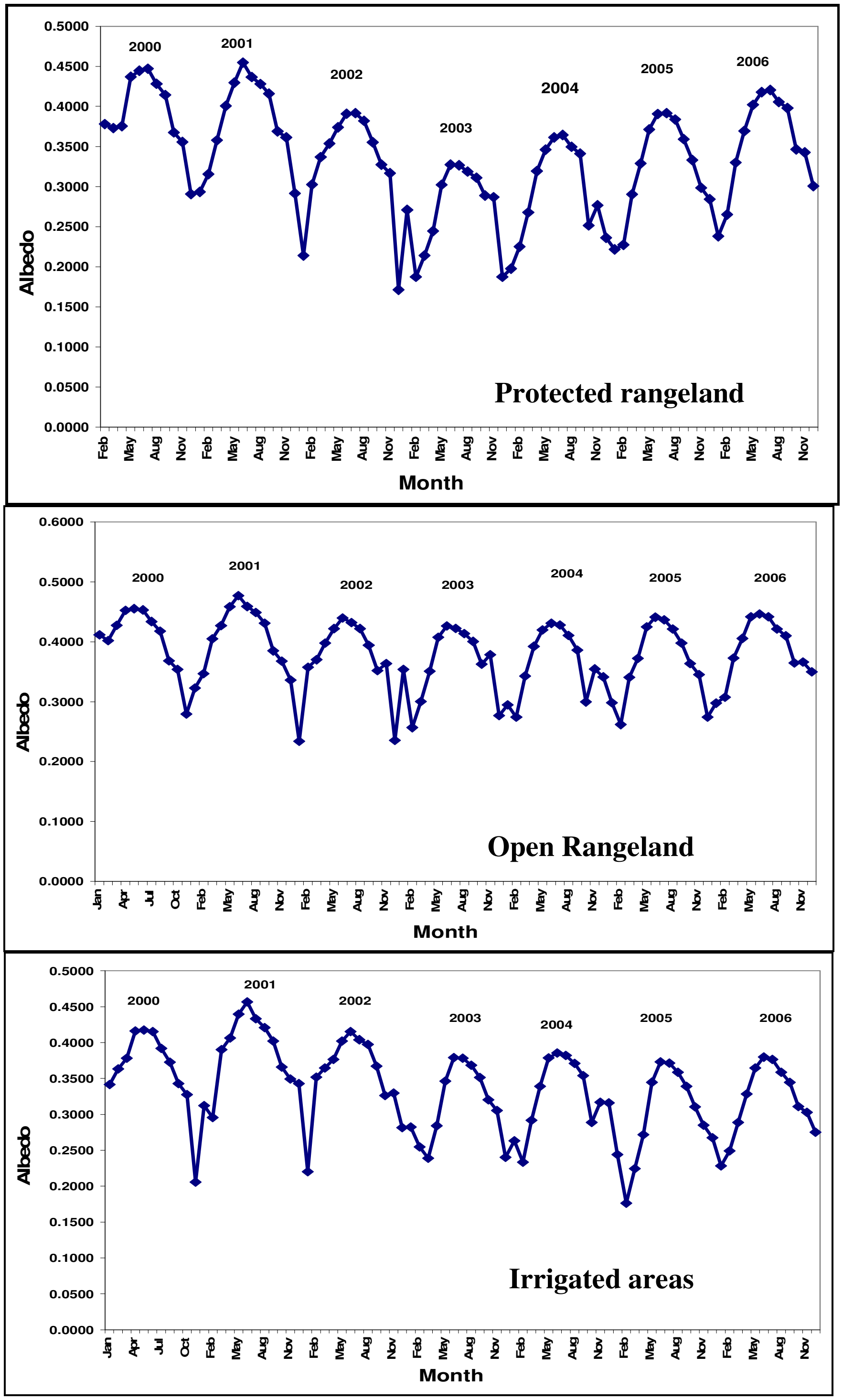


Figure 4.18: Mean monthly albedo for protected rangeland, open rangeland, and irrigated areas during 2000-2006.

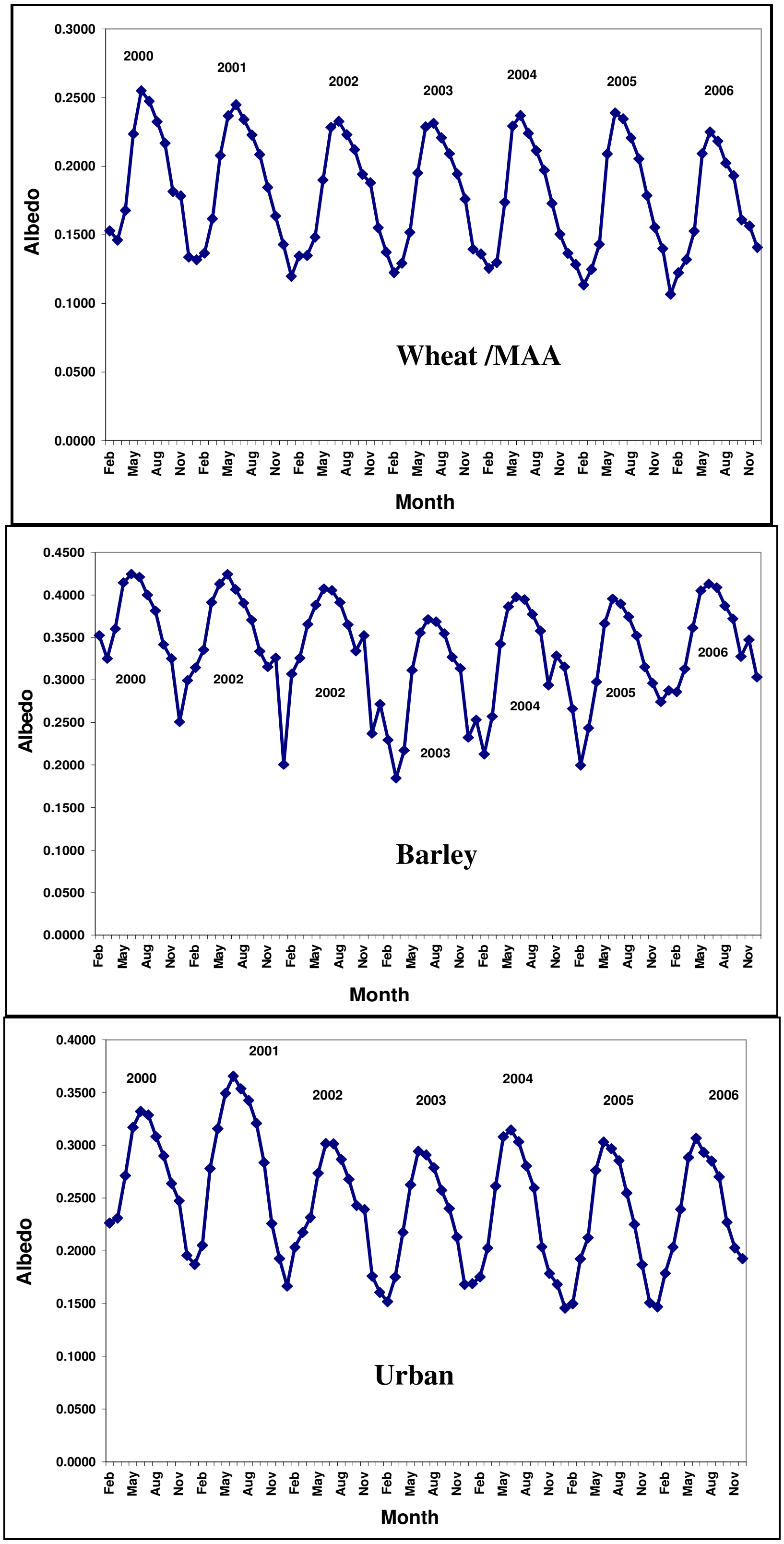


Figure 4.19: Mean monthly albedo for wheat/MAA, barley and urban areas during 2000-2006.

Results of the maximum mean monthly albedo for LU/C classes and for the 16-day albedo showed that all maximum values occurred in June/2000-2001 for all classes except the open rangeland while all minimum albedo values occurred in winter (February) and early spring Table (4.13).

Table 4.13: Maximum and minimum mean monthly albedo and 16-day albedo for the profiles and for all LU/C classes during 2000-2006.

	16-day values				Average monthly values			
Class	Minimum	Year/Month	Maximum	Year/Month	Minimum	Year/Month	Maximum	Year/Month
Protected Rangeland	0.135	2006/January	0.481	2001/June	0.171	2002/December	0.455	2001/June
Wheat /MAA	0.054	2006/April	0.306	2000/June	0.107	2006/January	0.255	2000/June
Open Rangeland	0.072	2003/February	0.518	2003/June	0.234	2002/January	0.477	2001/June
Irrigated areas	0.074	2000/December	0.496	2001/June	0.176	2005/February	0.457	2001/June
Barley	0.134	2005/February	0.444	2001/June	0.184	2003/March	0.424	2000/June
Urban	0.012	2002/December	0.440	2001/June	0.146	2005/January	0.365	2001/June

Results of the maximum monthly albedo profile occurred in June 2001 similar to mean monthly albedo values. The minimum values showed no particular pattern in the time of occurrence in which the values were found in February/2003 for open rangeland while the minimum mean monthly albedo values and 16-day values occurred in January 2006 and for wheat/MAA class (Table 4.14).

Table 4.14: Maximum and minimum monthly albedo profile values for all LU/C classes during 2000-2006.

Monthly Profile Values				
Class	Maximum	Year/Month	Minimum	Year/Month
Protected Rangeland	0.4662	2001/June	0.1667	2003/March
Wheat/MAA	0.3015	2000/June	0.0806	2005/February
Open Rangeland	0.4984	2001/June	0.0723	2003/February
Irrigated	0.4841	2001/June	0.1285	2003/February
Barley	0.4344	2000/July	0.1685	2005/February
Urban	0.4346	2001/June	0.1270	2005/February

Open rangeland had the highest albedo in June/2001. The lowest albedo was for wheat/MAA in January and April during 2003, 2005 and 2006. The lowest monthly profile value was for open rangeland in February/2003.

4.5. NDVI Response to Rainfall.

The data of NDVI was separated into period of rainy months (January, February, March, April, May, October, November and December) and dry months (June ,July, August and September). Results of mean yearly NDVI values in the rainy months are shown in Table (4.15) and Figure (4.20) All classes showed high NDVI values in 2003,except wheat/MAA in 2005.

Table 4.15: Mean annual NDVI for all classes for the rainy months during 2000-2006.

Year/Class	Urban	Open Rangeland	Irrigated areas	Wheat /MAA	Barley	Protected Rangeland
2000	0.179	0.128	0.164	0.257	0.134	0.131
2001	0.166	0.132	0.158	0.238	0.135	0.143
2002	0.203	0.155	0.212	0.289	0.179	0.177
2003	0.210	0.170	0.316	0.299	0.219	0.279
2004	0.196	0.169	0.250	0.264	0.178	0.216
2005	0.200	0.164	0.222	0.304	0.154	0.190
2006	0.174	0.151	0.175	0.237	0.134	0.159

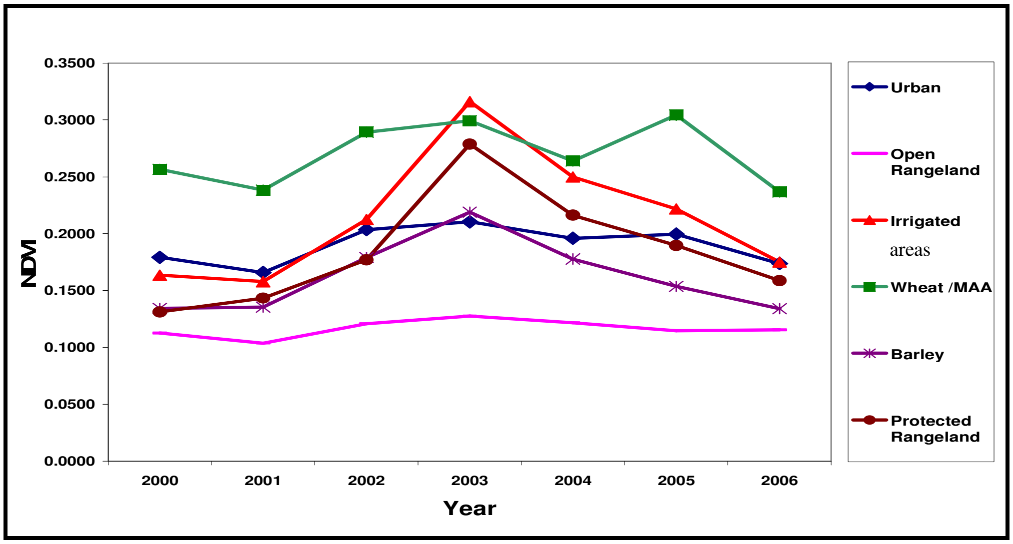


Figure 4.20: Mean annual NDVI for rainy months for all LU/C classes 2000-2006.

Results of mean monthly NDVI values in rainy period are summarized in Table (4.16) and in Figure (4.21). All classes showed a gradual increase in the monthly NDVI values until 2003. However, the NDVI of all classes started to decrease after 2003. Unlike mean yearly NDVI, wheat/MAA had two peaks in 2002 and 2003. Irrigated class showed the highest NDVI value during April to May.

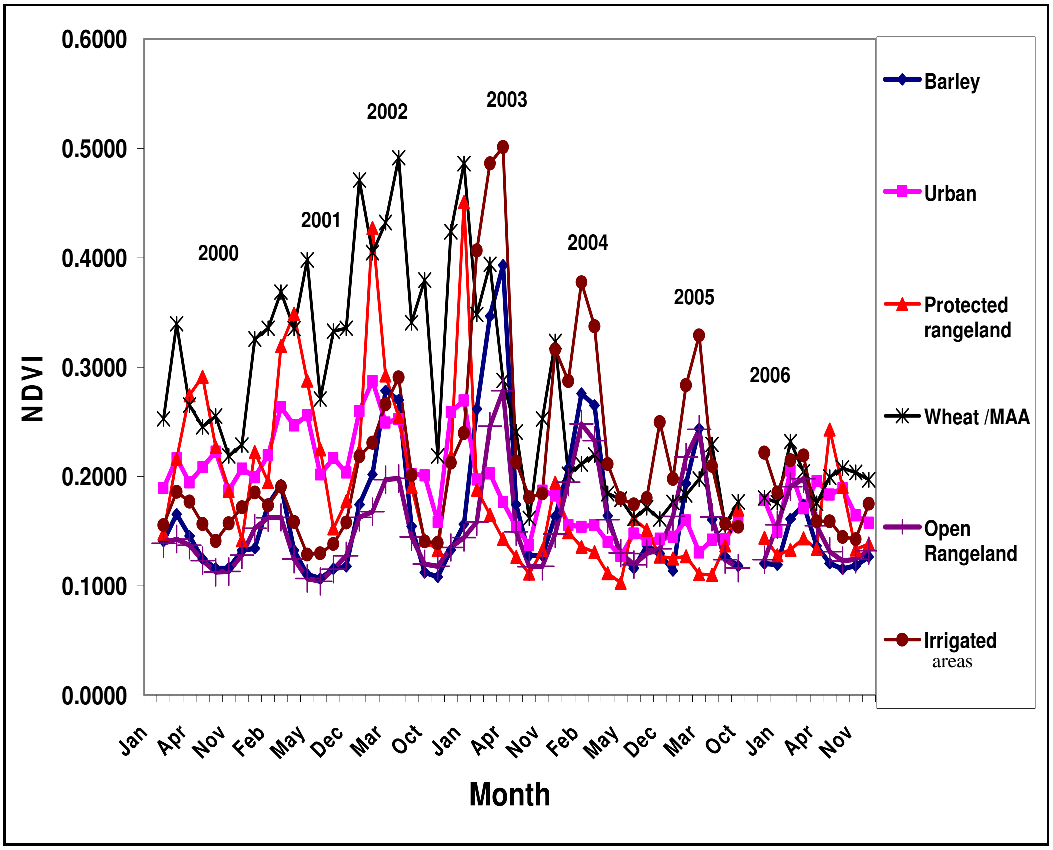


Figure 4.21 Mean monthly NDVI for rainy period for all LU/C classes during 2000-2006.

Table 4.16: Mean monthly NDVI for rainy period for all LU/C classes during 2000-2006.

Year	Month	barley	urban	protected rangeland	Wheat /MAA	Open rangeland	Irrigated areas
2000	Jan						
	Feb	0.141	0.189	0.148	0.253	0.139	0.156
	Mar	0.165	0.217	0.216	0.340	0.143	0.186
	Apr	0.145	0.195	0.274	0.265	0.137	0.177
	may	0.125	0.209	0.291	0.245	0.123	0.157
	Oct	0.116	0.222	0.227	0.255	0.113	0.141
	Nov	0.116	0.187	0.187	0.219	0.113	0.157
	Dec	0.132	0.207	0.142	0.229	0.128	0.172
2001	Jan	0.134	0.199	0.222	0.326	0.153	0.185
	Feb	0.175	0.219	0.195	0.336	0.162	0.174
	Mar	0.192	0.263	0.319	0.369	0.163	0.191
	Apr	0.132	0.247	0.349	0.335	0.124	0.158
	may	0.111	0.256	0.288	0.398	0.107	0.129
	Oct	0.107	0.202	0.225	0.271	0.104	0.130
	Nov	0.115	0.217	0.152	0.333	0.115	0.138
	Dec	0.118	0.204	0.177	0.335	0.127	0.158
2002	Jan	0.174	0.260	0.224	0.471	0.163	0.218
	Feb	0.202	0.287	0.427	0.405	0.168	0.231
	Mar	0.278	0.249	0.292	0.432	0.197	0.266
	Apr	0.270	0.252	0.254	0.492	0.198	0.291
	may	0.155	0.202	0.190	0.341	0.145	0.201
	Oct	0.112	0.201	0.142	0.380	0.120	0.141
	Nov	0.108	0.158	0.133	0.219	0.118	0.139
	Dec	0.133	0.259	0.218	0.424	0.135	0.212
2003	Jan	0.156	0.270	0.451	0.486	0.144	0.240
	Feb	0.262	0.197	0.188	0.348	0.158	0.407
	Mar	0.347	0.203	0.165	0.394	0.246	0.486
	Apr	0.393	0.177	0.143	0.288	0.278	0.501
	may	0.174	0.154	0.127	0.241	0.149	0.213
	Oct	0.128	0.137	0.111	0.162	0.117	0.181
	Nov	0.128	0.187	0.133	0.253	0.118	0.184
	Dec	0.163	0.183	0.194	0.323	0.147	0.316
2004	Jan	0.207	0.156	0.149	0.202	0.195	0.287
	Feb	0.276	0.154	0.136	0.211	0.248	0.378
	Mar	0.265	0.156	0.131	0.220	0.233	0.337
	Apr	0.164	0.140	0.111	0.184	0.161	0.211
	may	0.128	0.127	0.103	0.179	0.130	0.180
	Oct	0.116	0.148	0.161	0.162	0.119	0.174
	Nov	0.137	0.142	0.151	0.171	0.129	0.180
	Dec	0.129	0.143	0.127	0.161	0.134	0.250
2005	Jan	0.114	0.145	0.125	0.176	0.163	0.198
	Feb	0.194	0.160	0.127	0.183	0.218	0.283
	Mar	0.244	0.131	0.111	0.197	0.243	0.329
	Apr	0.160	0.142	0.110	0.229	0.163	0.210
	may	0.127	0.142	0.137	0.155	0.124	0.157
	Oct	0.118	0.160	0.170	0.177	0.116	0.154
	Nov						
	Dec	0.120	0.179	0.144	0.180	0.124	0.222
2006	Jan	0.119	0.149	0.128	0.176	0.156	0.185
	Feb	0.161	0.205	0.133	0.232	0.191	0.215
	Mar	0.174	0.171	0.143	0.204	0.198	0.219
	Apr	0.136	0.196	0.134	0.175	0.155	0.159
	may	0.120	0.183	0.243	0.199	0.131	0.159
	Oct	0.115	0.189	0.190	0.208	0.123	0.145
	Nov	0.118	0.164	0.133	0.204	0.124	0.143
	Dec	0.127	0.158	0.138	0.197	0.132	0.175

Results of mean yearly NDVI values in the period of dry months Table (4.17) and Figure (4.22) showed that year 2003 had the highest annual NDVI value. All classes showed gradual increases in NDVI from 2000 until 2003 followed by a decreasing trend toward until 2006.

Table 4.17: Mean yearly NDVI for all LU/C classes for the dry period during 2000-2006.

Year/Class	Urban	Open Rangeland	Irrigated areas	Wheat /MAA	Barley	Protected Rangeland
2000	0.1256	0.1125	0.1381	0.1614	0.1123	0.1133
2001	0.1277	0.1037	0.1262	0.1471	0.1059	0.1053
2002	0.1483	0.1208	0.1537	0.1606	0.1158	0.1509
2003	0.1502	0.1276	0.1971	0.1933	0.1460	0.1723
2004	0.1392	0.1217	0.1793	0.1658	0.1200	0.1329
2005	0.1384	0.1147	0.1457	0.1722	0.1163	0.1234
2006	0.1353	0.1154	0.1497	0.1604	0.1104	0.1144

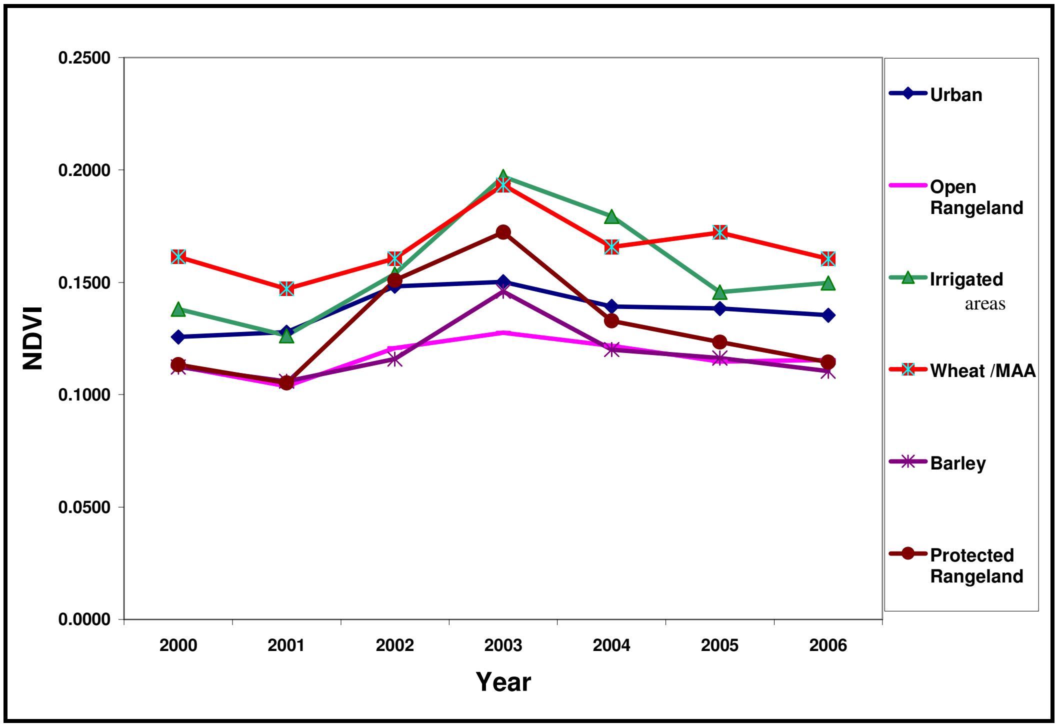


Figure 4.22: Mean annual NDVI for dry months for all LU/C classes during 2000-2006.

Results of mean monthly NDVI values in dry months Table (4.18) and Figure (4.23) showed rough increase in the monthly NDVI values until 2003 and gradual decrease until 2006. Irrigated areas, wheat/MAA and protected rangeland showed the highest NDVI value through the period of dry months.

Table 4.18: Mean monthly NDVI for the dry period during 2000-2006.

Year	Month	barley	urban	protected rangeland	Wheat /MAA	Open rangeland	irrigated
2000	Jun	0.116	0.134	0.117	0.185	0.115	0.146
	Jul	0.113	0.129	0.116	0.161	0.115	0.138
	Aug	0.110	0.121	0.112	0.150	0.111	0.135
	Sep	0.110	0.118	0.108	0.151	0.110	0.134
2001	Jun	0.110	0.132	0.109	0.144	0.106	0.128
	Jul	0.107	0.131	0.107	0.150	0.104	0.128
	Aug	0.103	0.125	0.104	0.143	0.102	0.125
	Sep	0.104	0.123	0.102	0.151	0.103	0.124
2002	Jun	0.125	0.158	0.130	0.179	0.125	0.170
	Jul	0.116	0.149	0.129	0.159	0.121	0.154
	Aug	0.112	0.147	0.135	0.154	0.119	0.145
	Sep	0.111	0.140	0.210	0.151	0.119	0.146
2003	Jun	0.155	0.160	0.180	0.217	0.135	0.210
	Jul	0.147	0.149	0.177	0.196	0.129	0.200
	Aug	0.146	0.146	0.171	0.184	0.126	0.191
	Sep	0.137	0.146	0.161	0.177	0.121	0.187
2004	Jun	0.123	0.148	0.138	0.176	0.125	0.182
	Jul	0.122	0.141	0.133	0.167	0.121	0.187
	Aug	0.119	0.137	0.133	0.163	0.120	0.178
	Sep	0.116	0.131	0.128	0.157	0.121	0.170
2005	Jun	0.121	0.144	0.130	0.186	0.119	0.150
	Jul	0.115	0.136	0.121	0.172	0.114	0.144
	Aug	0.115	0.136	0.121	0.169	0.113	0.142
	Sep	0.115	0.138	0.122	0.162	0.114	0.147
2006	Jun	0.113	0.142	0.119	0.175	0.119	0.152
	Jul	0.110	0.136	0.116	0.159	0.115	0.151
	Aug	0.111	0.133	0.113	0.156	0.116	0.150
	Sep	0.109	0.131	0.110	0.152	0.112	0.146

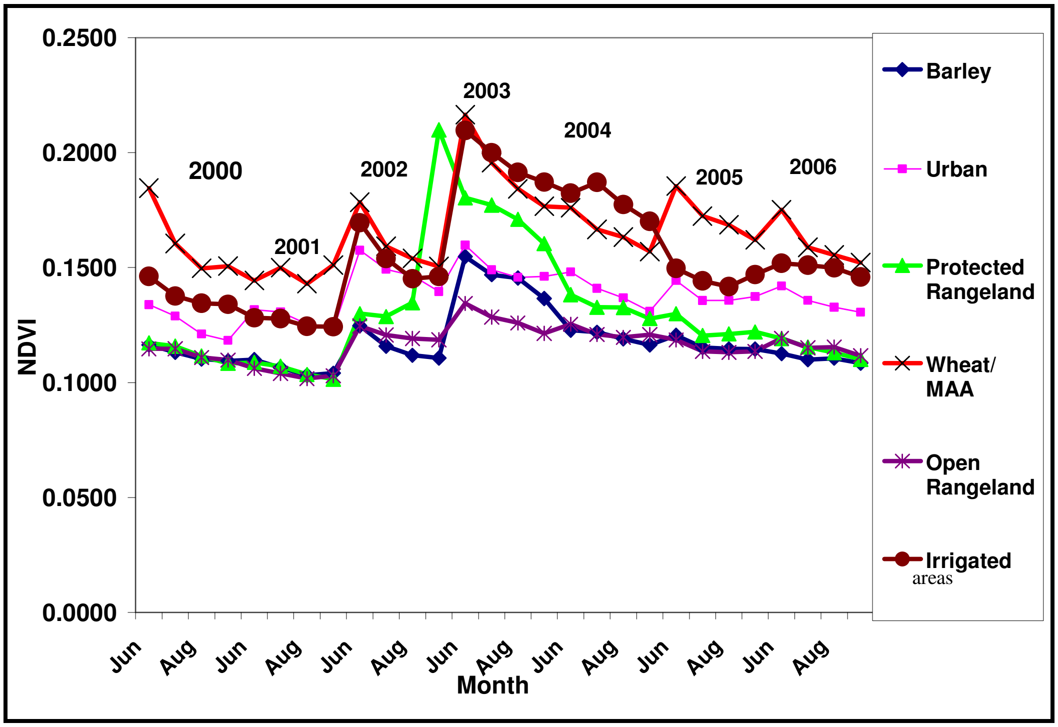


Figure 4.23: Mean monthly NDVI for dry months for all LU/C classes during 2000-2006.

Differences in monthly NDVI values among the different years during the dry period are shown in Figures (4.24) and (4.25). A consistent trend was observed among classes where year 2003 had the highest NDVI values, except protected rangeland where the highest value was obtained at 2002.

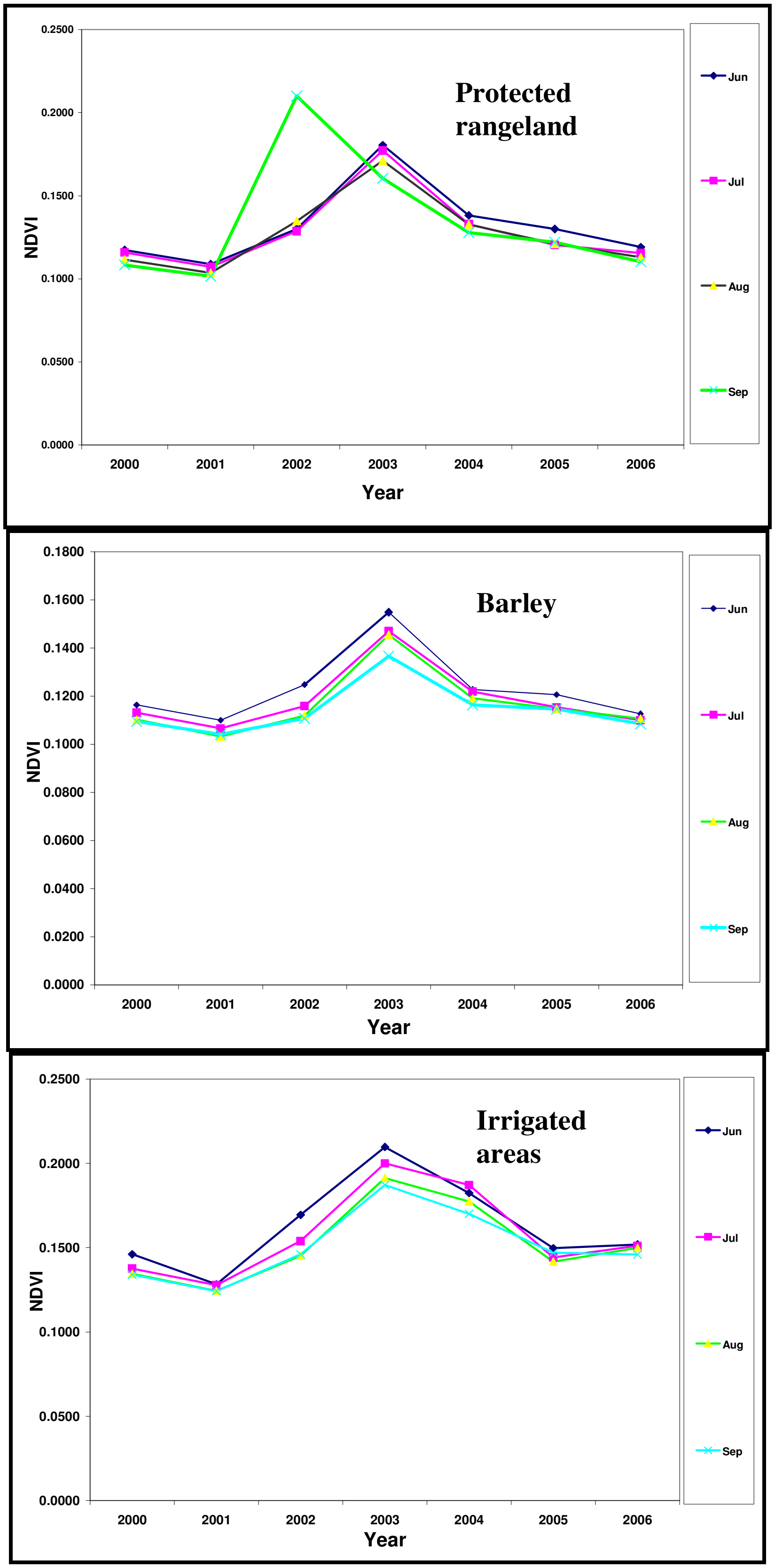


Figure 4.24: Mean monthly NDVI for dry months for protected rangeland, barley and irrigated areas during 2000-2006.

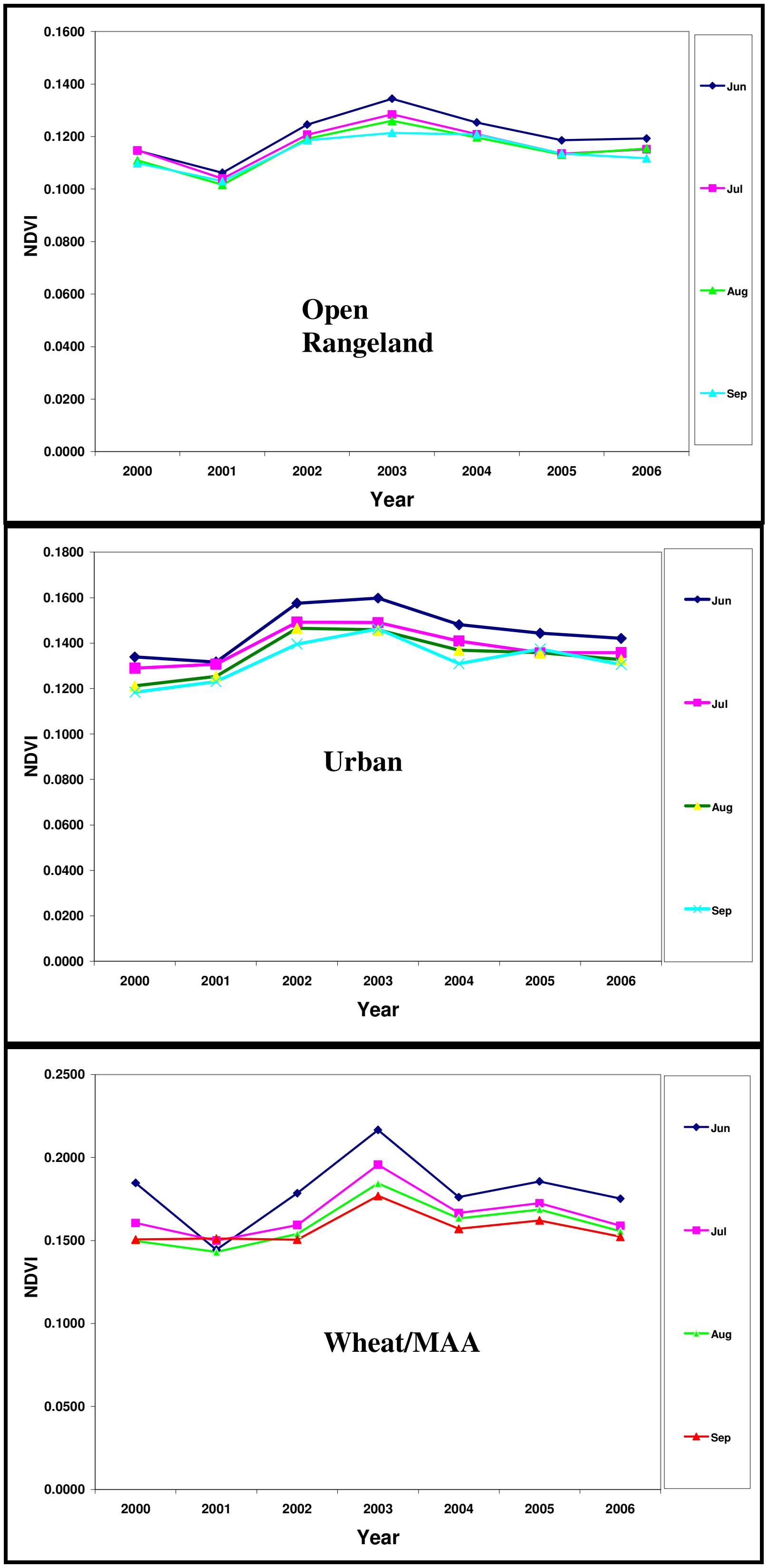


Figure 4.25: Mean monthly NDVI for dry months for open rangeland, urban and wheat/MAA classes during 2000-2006.

Rainfall data for years 2000-2006 are shown in Figures (4.26) and (4.27) for Irbid and Mafraq weather stations, respectively. Monthly rainfall records are shown in Appendix3.

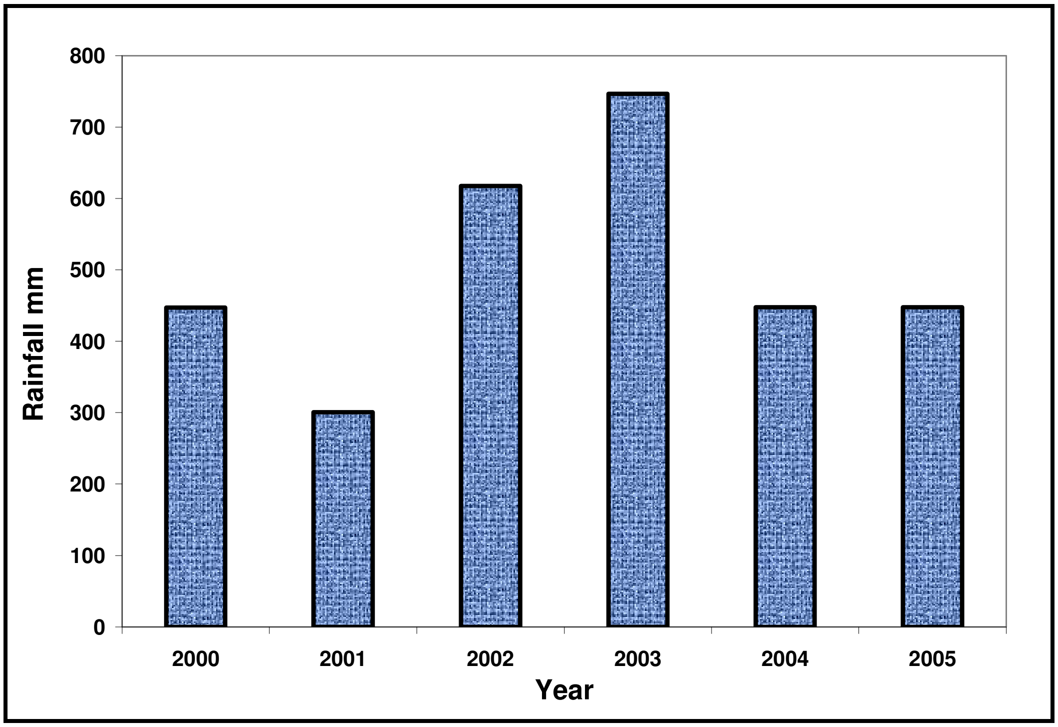


Figure 4.26: Total annual rainfall in Irbid weather station during 2000- 2006.

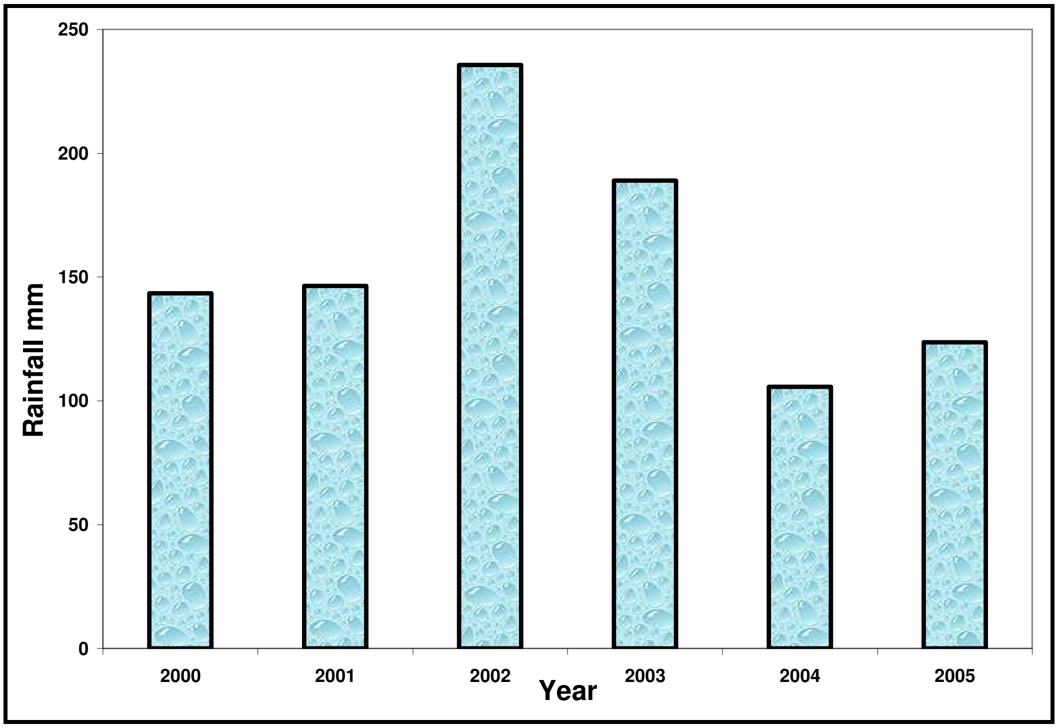


Figure 4.27: Total annual rainfall in Mafraq weather station during 2000-2006.

Summary of yearly NDVI values and annual rainfall is shown in Table (4.19). The behavior of NDVI in relation to rainfall is shown in Figure (4.28).

Table 4.19: Mean yearly NDVI for all classes for rainy months during 2000-2006 and total rainfall for 2000-2005.

Year/Class	Urban	Open Rangeland	Irrigated areas	Wheat /MAA	Barley	Protected Rangeland	Cumulative monthly rainfall in Irbid(mm)	Cumulative monthly rainfall in Mafraq(mm)
2000	0.1792	0.1279	0.1635	0.2565	0.1343	0.1310	446.9	143.5
2001	0.1659	0.1318	0.1578	0.2383	0.1354	0.1433	300.7	146.4
2002	0.2034	0.1553	0.2124	0.2893	0.1790	0.1770	617.5	235.7
2003	0.2103	0.1698	0.3160	0.2994	0.2188	0.2787	746.3	18.9
2004	0.1960	0.1685	0.2497	0.2639	0.1777	0.2163	447.7	105.7
2005	0.1995	0.1644	0.2217	0.3042	0.1538	0.1897	447.6	123.7
2006	0.1737	0.1512	0.1750	0.2367	0.1339	0.1586		

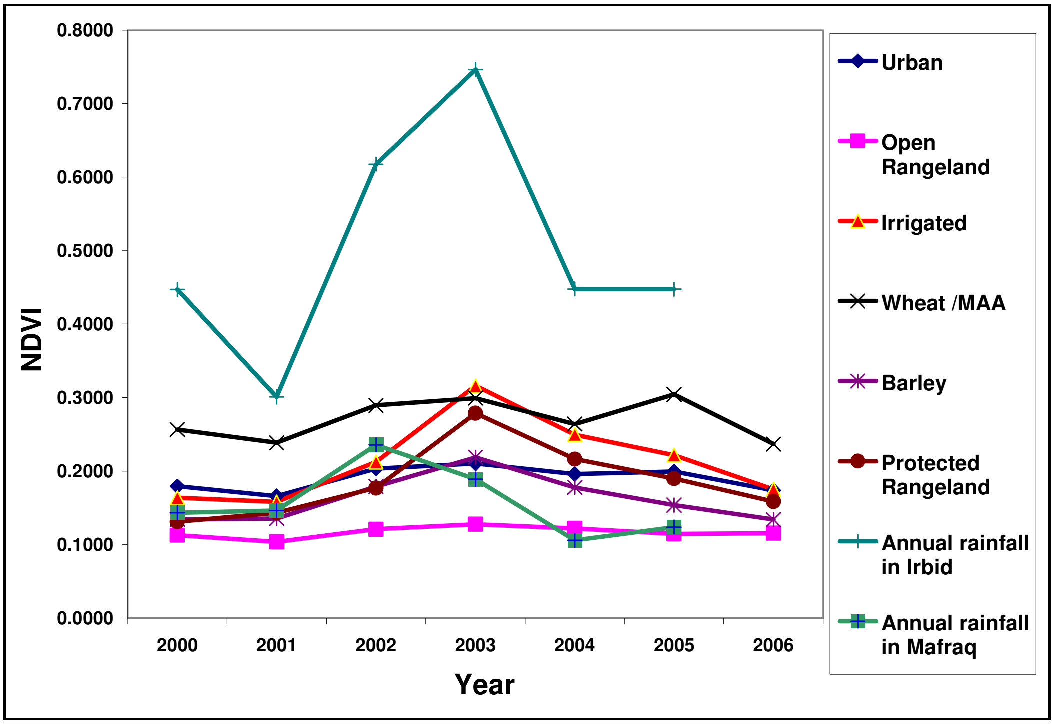


Figure 4.28: Annual NDVI and annual rainfall (*10^{-3} mm) in Irbid and Mafraq weather stations.

Generally, little response was observed for annual data, except in year 2003.

The mean monthly data of NDVI and rainfall in Table (4.20) was plotted in Figure (4.29) for years 2000-2006. The NDVI trends corresponded strongly with the total monthly rainfall in Irbid station for all classes, especially wheat/MAA. Also, the trend was well defined in Irbid than in Mafraq (Figure 4.30). For all classes, seasonal cycles coincided with monthly rainfall pattern through the rainy period. All the peaks of NDVI curves corresponded with the highest rainfall amount during late winter (January and February) and early spring (March and April).

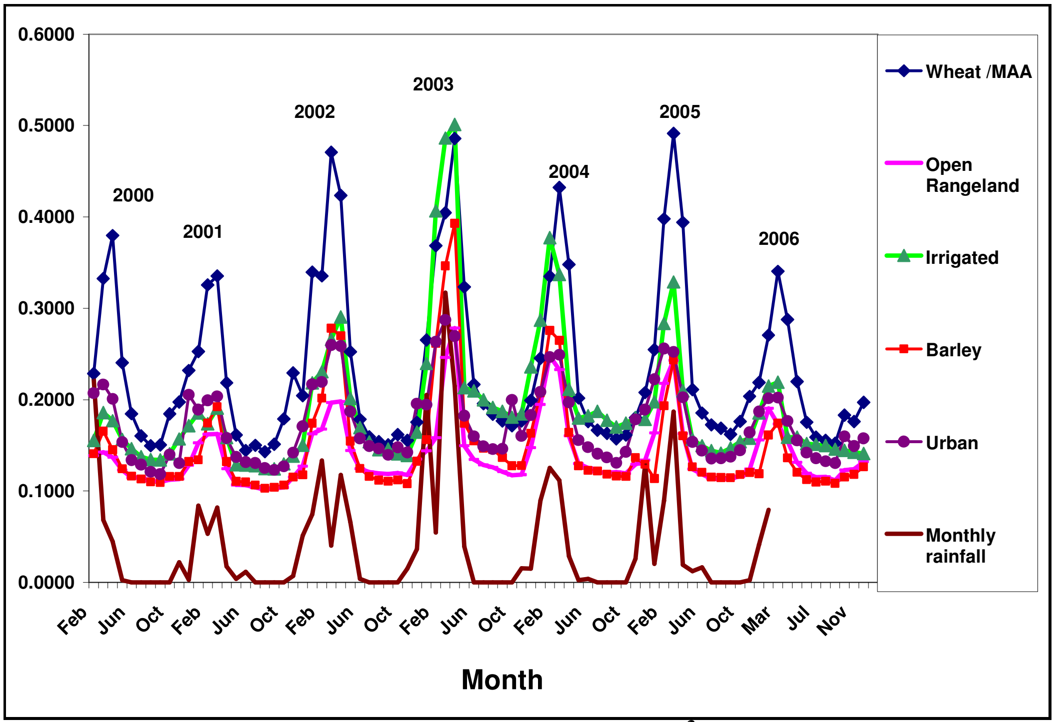


Figure 4.29: Mean monthly NDVI vs. monthly rainfall (10^{-3} mm) in Irbid station for rainy period during (2000-2006).

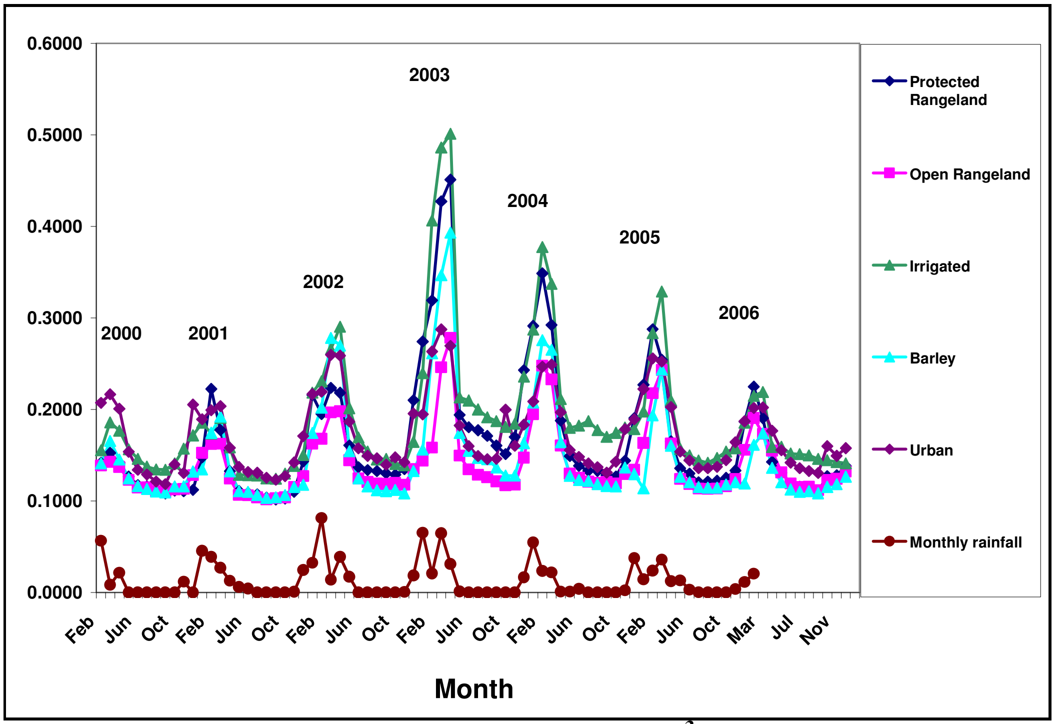


Figure 4.30: Mean monthly NDVI vs. monthly rainfall (10^{-3} mm) in Mafraq station for rainy period during (2000-2006).

Table 4.20: Mean monthly NDVI for all classes and monthly rainfall in Irbid and Mafraq during 2000-2006.

Year	Month	Protected	Wheat /MAA	Open Rangeland	Irrigated areas	Barley	Urban	Monthly rainfall/Mafraq	Monthly rainfall/Irbid
2000	Feb	0.142	0.229	0.139	0.156	0.141	0.207	56.4	222.2
	Mar	0.153	0.333	0.143	0.186	0.165	0.217	8.3	68.3
	Apr	0.142	0.380	0.137	0.177	0.145	0.201	21.6	44.7
	May	0.127	0.241	0.123	0.157	0.125	0.154	0	2.3
	Jun	0.117	0.185	0.115	0.146	0.116	0.134	0	0
	Jul	0.116	0.161	0.115	0.138	0.113	0.129	0	0
	Aug	0.112	0.150	0.111	0.135	0.110	0.121	0	0
	Sep	0.108	0.151	0.110	0.134	0.109	0.118	0	0
	Oct	0.111	0.184	0.113	0.141	0.116	0.140	0	0
	Nov	0.111	0.197	0.113	0.157	0.116	0.131	11.7	22.2
	Dec	0.112	0.232	0.128	0.172	0.132	0.205	0	3
2001	Jan	0.148	0.253	0.153	0.185	0.134	0.189	45.5	84.2
	Feb	0.222	0.326	0.162	0.174	0.174	0.199	38.9	53.3
	Mar	0.177	0.335	0.163	0.191	0.192	0.204	26.9	82
	Apr	0.133	0.219	0.124	0.158	0.132	0.158	12.7	17.4
	May	0.111	0.162	0.107	0.129	0.111	0.137	5.9	3.9
	Jun	0.109	0.144	0.106	0.128	0.110	0.132	4.2	11.6
	Jul	0.107	0.150	0.104	0.128	0.107	0.131	0	0
	Aug	0.104	0.143	0.102	0.125	0.103	0.125	0	0
	Sep	0.102	0.151	0.103	0.124	0.104	0.123	0	0
	Oct	0.103	0.179	0.104	0.130	0.107	0.127	0	0
	Nov	0.110	0.229	0.115	0.138	0.115	0.142	0.8	6.9
	Dec	0.143	0.204	0.127	0.150	0.118	0.171	24.6	51.1
2002	Jan	0.216	0.340	0.163	0.218	0.174	0.217	32.4	74.5
	Feb	0.195	0.336	0.168	0.231	0.202	0.219	81.4	133.3
	Mar	0.224	0.471	0.197	0.266	0.278	0.260	13.9	40.4
	Apr	0.218	0.424	0.198	0.291	0.270	0.259	39	117.7
	May	0.161	0.253	0.145	0.201	0.155	0.187	17.2	65.8
	Jun	0.137	0.179	0.125	0.170	0.125	0.158	0	4
	Jul	0.134	0.159	0.121	0.154	0.116	0.149	0	0
	Aug	0.133	0.154	0.119	0.145	0.112	0.147	0	0
	Sep	0.130	0.151	0.119	0.146	0.111	0.140	0	0
	Oct	0.129	0.162	0.120	0.141	0.112	0.148	0	0
	Nov	0.135	0.155	0.118	0.139	0.108	0.142	0.5	14.9
	Dec	0.210	0.175	0.135	0.165	0.133	0.196	18.5	36.3
2003	Jan	0.274	0.265	0.144	0.240	0.156	0.195	65.2	205.1
	Feb	0.319	0.369	0.158	0.407	0.262	0.263	20.8	54.6
	Mar	0.427	0.405	0.246	0.486	0.347	0.287	64.7	317.3
	Apr	0.451	0.486	0.278	0.501	0.393	0.270	31.1	214.7
	May	0.194	0.323	0.149	0.213	0.174	0.183	1.2	39.3
	Jun	0.181	0.217	0.135	0.210	0.155	0.160	0	0.2
	Jul	0.177	0.196	0.129	0.200	0.147	0.149	0	0
	Aug	0.171	0.184	0.126	0.191	0.146	0.146	0	0
	Sep	0.161	0.177	0.121	0.187	0.137	0.146	0	0
	Oct	0.151	0.171	0.117	0.181	0.128	0.200	0	0
	Nov	0.170	0.177	0.118	0.184	0.128	0.160	0	15.5
	Dec	0.243	0.199	0.147	0.236	0.163	0.183	16.6	15
2004	Jan	0.291	0.245	0.195	0.287	0.207	0.209	54.6	89.7
	Feb	0.349	0.335	0.248	0.378	0.276	0.247	23.6	125.4
	Mar	0.292	0.432	0.233	0.337	0.265	0.249	21.9	111.6
	Apr	0.188	0.348	0.161	0.211	0.164	0.197	1	28.7
	May	0.149	0.202	0.130	0.180	0.127	0.156	1	2.5

Table 4.20: continued.

Year	Month	Protected Rangeland	Wheat /MAA	Open Rangeland	Irrigated areas	Barley	Urban	Monthly rainfall/Mafraq	Monthly rainfall/Irbid
	Jun	0.138	0.176	0.125	0.182	0.123	0.148	4	3.8
	Jul	0.133	0.167	0.121	0.187	0.122	0.141	0	0
	Aug	0.133	0.163	0.120	0.178	0.118	0.137	0	0
	Sep	0.128	0.157	0.121	0.170	0.116	0.131	0	0
	Oct	0.127	0.161	0.119	0.174	0.116	0.143	0	0
	Nov	0.144	0.180	0.129	0.180	0.137	0.179	2.3	26
	Dec	0.190	0.208	0.134	0.178	0.129	0.189	37.5	129.3
2005	Jan	0.227	0.255	0.163	0.198	0.114	0.222	14.4	20.4
	Feb	0.288	0.398	0.218	0.283	0.194	0.256	23.8	89.3
	Mar	0.254	0.492	0.243	0.329	0.244	0.252	35.9	186.8
	Apr	0.165	0.394	0.163	0.210	0.160	0.203	12.3	19.4
	May	0.136	0.211	0.124	0.157	0.127	0.154	13.1	12.3
	Jun	0.130	0.186	0.119	0.150	0.121	0.144	3	16.6
	Jul	0.121	0.172	0.114	0.144	0.115	0.136	0.1	0
	Aug	0.121	0.169	0.113	0.142	0.115	0.136	0	0
	Sep	0.122	0.162	0.114	0.147	0.115	0.137	0	0
	Oct	0.125	0.176	0.116	0.154	0.118	0.145	0	0
	Dec	0.133	0.204	0.124	0.158	0.120	0.164	3.7	2.3
2006	Jan	0.187	0.219	0.156	0.185	0.119	0.187	11.3	41.3
	Feb	0.225	0.271	0.191	0.215	0.161	0.202	20.5	79.6
	Mar	0.191	0.341	0.173	0.219	0.174	0.202		
	Apr	0.143	0.288	0.155	0.159	0.136	0.177		
	May	0.131	0.220	0.131	0.159	0.120	0.156		
	Jun	0.119	0.175	0.119	0.152	0.113	0.142		
	Jul	0.116	0.159	0.115	0.151	0.110	0.136		
	Aug	0.113	0.156	0.116	0.150	0.111	0.133		
	Sep	0.110	0.152	0.112	0.146	0.108	0.131		
	Oct	0.127	0.183	0.123	0.145	0.115	0.160		
	Nov	0.128	0.176	0.124	0.143	0.118	0.149		
	Dec	0.138	0.197	0.132	0.141	0.127	0.158		

Results indicated that the mean monthly NDVI for wheat/MAA, urban, open rangeland, barley, and irrigated classes corresponded strongly with cumulative rainfall in Irbid, especially in April when vegetation was at its peak growth. Summaries of these NDVI-rainfall trends for the different classes are shown in Figures (4.31) and (4.32). On the other hand, barley, open rangeland, protected rangeland, and irrigated areas corresponded well with cumulative rainfall in Mafraq during April except in year 2003.

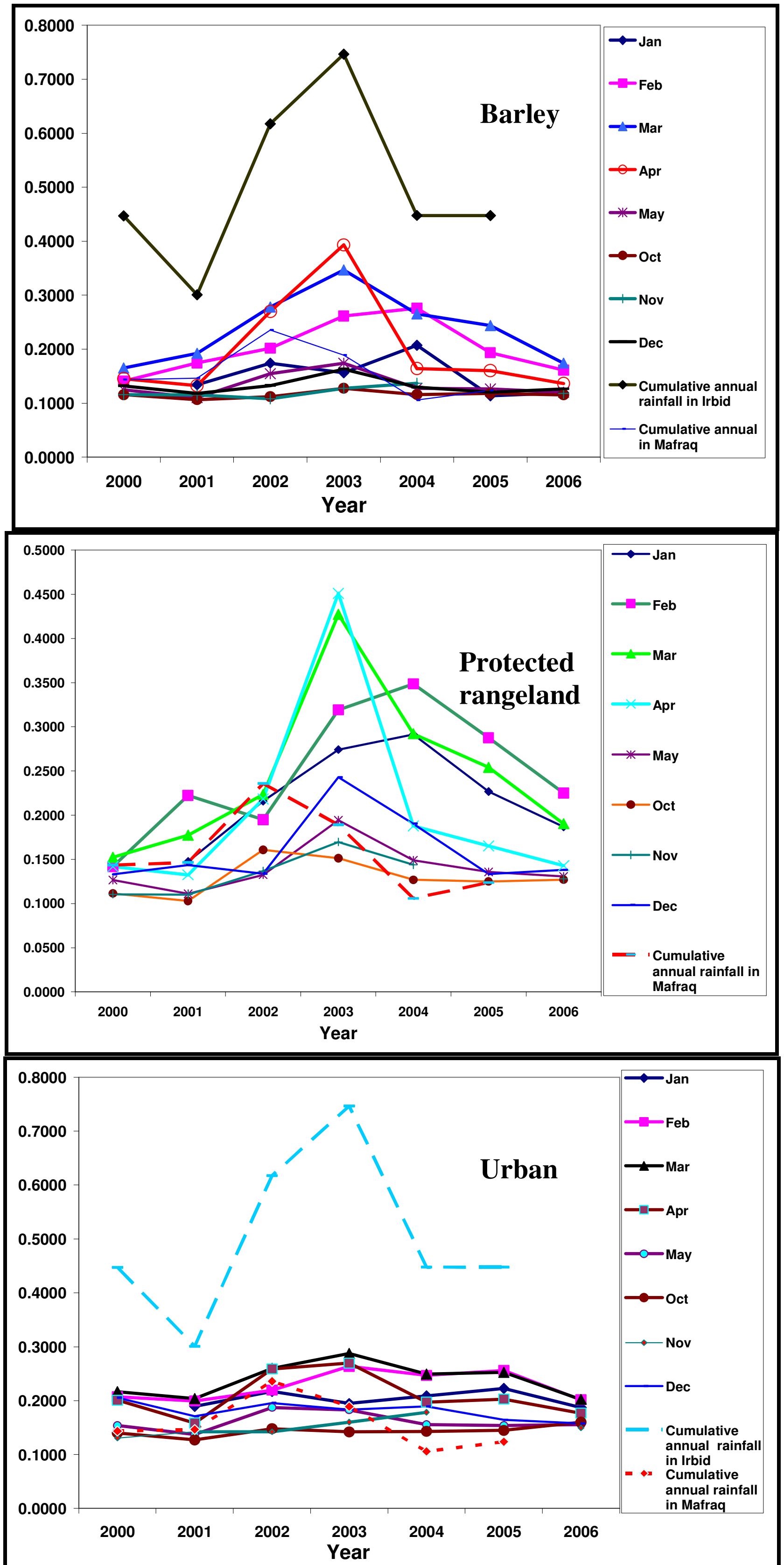


Figure 4.31: Mean monthly NDVI for all LU/C classes for rainy period vs. cumulative annual rainfall (10^{-3} mm) in Irbid and Mafraq stations.

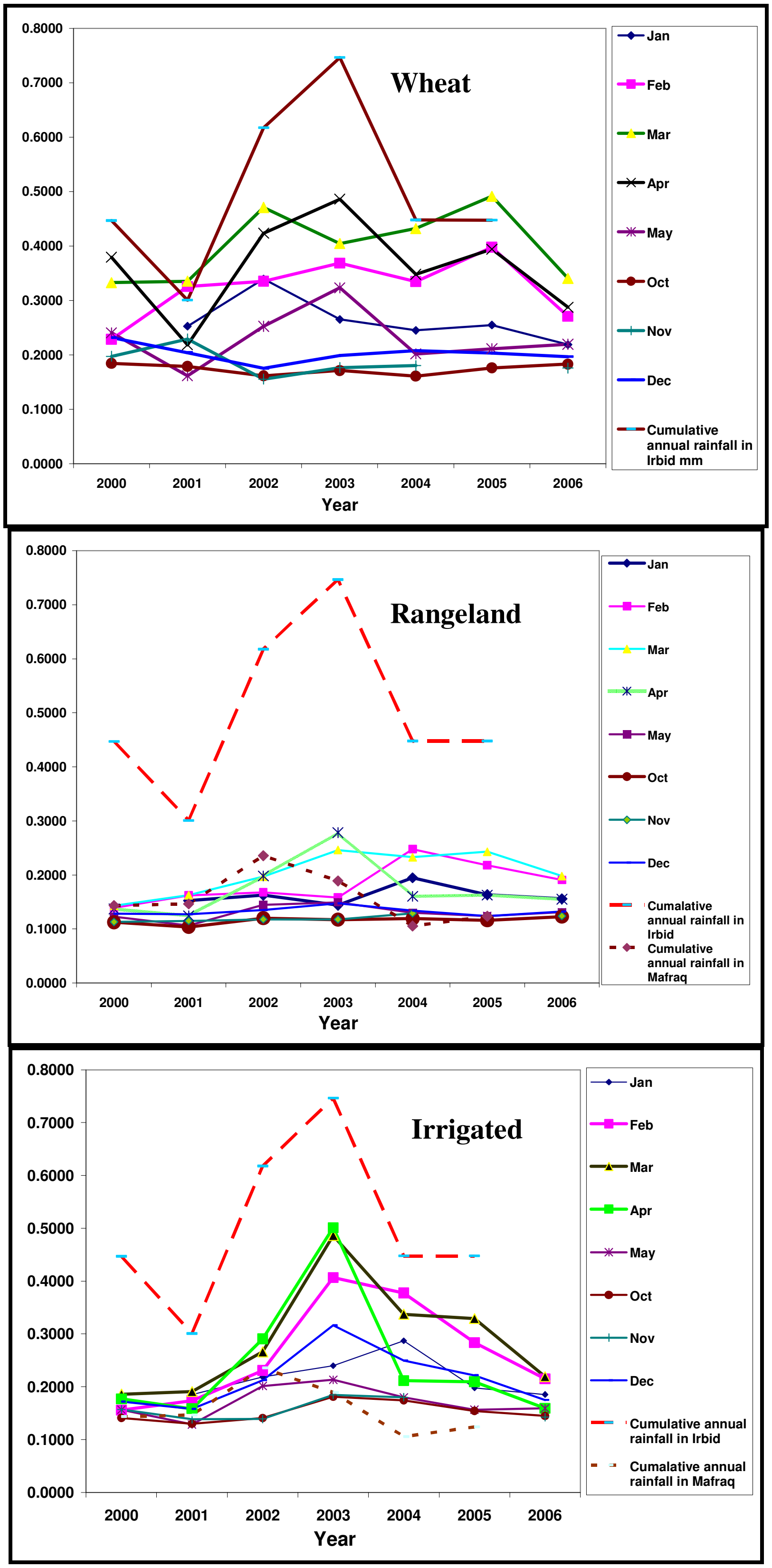


Figure 4.32: Mean monthly NDVI for all LU/C classes for rainy period vs. cumulative rainfall (10^{-3} mm) in Irbid and Mafraq stations.

5. Discussion

5.1 Unsupervised Classification

The unsupervised classification succeeded in isolating some LU/C classes, which were spectrally distinct. On the other hand, the use of USC may fail, to capture the difference between some LU/C classes like protected rangeland, irrigated and urban areas.

5.2 Analysis of Yearly and Monthly NDVI and Albedo

Results showed that the six classes of LU/C were well-separated with intra-annual variation in both NDVI and albedo spectral profiles during all years along with inter-annual variations. Time-series of NDVI shown to capture essential features of seasonal and inter-annual vegetation variability for the different LU/C classes. NDVI values tended to follow a uniform cycle across communities, related directly to vegetation. These findings agree with the findings of Weiss, et al., (2004).

The mean yearly NDVI values of all classes showed unexplained behavior during the analysis period. Wheat/MAA and urban classes showed fluctuations in mean yearly NDVI while the remaining classes showed smooth curves. These findings indicated that averaging the NDVI values to remove inter-annual variations and residuals might result in loss of useful information like the real maximum and minimum values, for some months when the NDVI and albedo increased or decreased. These results go with Du Plessis (1999) and Al-Bakri and Suleiman (2004) who indicated that averaging of maximum composite data would result in loss of useful information related to vegetation and LU/C.

5.3 Time Series of NDVI.

The study obviously showed that the time-series of the 16-day composite had sufficient spectral, temporal, and radiometric resolutions to discriminate the main crop-related land use practices. Most crop classes were separable at some point during the growing season based on their phenology-driven spectral and temporal differences expressed in the NDVI data of 1 km, although in some studies (Wardlow, et al., 2007) the discrimination of different crops was only possible at 250-m resolution.

All LU/C of different vegetation communities displayed increases to NDVI from March into April, followed by a decrease to the end of November. Local maximum were in spring while the local minima were in summer. The former minimum coincides with the beginning of the growing season while the high temperatures and low precipitation in summer promote the latter minimum (Weiss, et al., 2004). Also, all classes exhibited the highest mean monthly 16-day NDVI during the growing season of 2003 except for wheat/MAA at 2002. The monthly NDVI time-series of the vegetation communities generally display uniform behavior through the growing season, as indicated by Williams and Ehleringer, (2000).

Regarding protected rangeland, (Surra reserve) results of this study were in total agreement with Al-Bakri and Abu-Zanat (2007) who indicated that the reason for increasing the NDVI values since 2000 until 2003 was because of excluding grazing animals from the reserve. Results from field visit showed that the current conditions of vegetation were suffering from overgrazing as proved by the uprooting of shrubs and signs of erosion in the area.

The differences between protected rangeland and open rangeland started to disappear after 2003. These results showed that the level of the 1-km data was enough to detect rangeland rehabilitation and degradation for large areas. It was important to determine whether vegetation degradation is due to climate or human induced factors. The impact of human on land use/cover was obviously indicated by the high NDVI value in 2002 and not in 2003. This could be attributed to the complete protection, particularly for the profiles of Mafraq Air Base where full protection of vegetation was guaranteed and relatively high values of NDVI were obtained for this site, which can serve as a reference for rangeland conditions.

Urban areas showed different behavior than the rest of classes in which could be explained by the low probability of being detected because of the moderate spatial resolution. One impact of this resolution was potentially the poor accuracy for urban areas that tended to change at finer scales. The spatial resolution of the MODIS NDVI (1 km) data significantly limited their use for certain applications such as the monitoring of changing in urban areas and the monitoring of other relatively fine-scale conversion events that may be associated with high value ecological resources, as indicated by (Lunetta, et al., 2006).

5.4 NDVI Response to Rainfall

Wheat/MAA and mixed rainfed trees showed fluctuations that could be explained by rainfall and its impacts on vegetation fluctuations. However, high NDVI values and low albedo would suggest that threshold level of NDVI could be reached at certain rainfall level above which no further response could be detected (Al Bakri and Suleiman, 2004).

The behavior of open rangeland, barley, and irrigated areas, increasing in 2000 to 2003 and decreasing in 2003 to 2006, could be related to climatic factors like rainfall and drought. Suzuki, et al. (2000) have found significant correlations between NDVI and rainfall in different regions including arid and semi-arid environments. The derived NDVI was found to be useful as an indicator of environmental changes because it was sensitive to rainfall in different vegetation zones (Schmidt and Gitelson, 2000).

The mean monthly NDVI responded well to the total monthly rainfall in Irbid where all classes ,except urban areas, followed the monthly rainfall especially in 2003 which was the year with highest monthly rainfall that resulted in increasing mean monthly NDVI for wheat/MAA, open rangeland, barley and some irrigated areas. The sensitivity to interannual rainfall anomalies is usually observed for relative dry areas (mean annual rainfall 300–500 mm) with good responses between NDVI and rainfall regardless of soil type or vegetation formations, as indicated by Richard and Poccard. (1998).

Irrigated areas showed smooth monthly NDVI curve and maximum mean annual NDVI during dry period which could be explained to the supplementary irrigation (summer irrigation) so there was littlie effect of drought and lack of water in summer on irrigated crops (Wardlow, et al., 2007).

Mean monthly NDVI and cumulative rainfall in Irbid showed better responses than monthly rainfall where wheat/MAA, barley, open rangeland, urban and irrigated areas responded strongly to cumulative rainfall in Irbid during April and March, this result go with the findings reported by Negro´n Jua´ rez and Liu (2001) where NDVI showed better response with cumulative rainfall in different ecological zones. However the response of protected rangeland, open rangeland, irrigated, urban and barley to cumulative rainfall in Mafraq was less than the response in Irbid except for 2003 which may resulted from low cumulative rainfall, low vegetation biomass and human influences.

5.5 Time Series of Albedo

Time-series of albedo had captured the inter-annual soil and vegetation variability in semi-arid areas. The highest yearly albedo value was for open rangeland and the lowest value was for wheat/MAA. The mean yearly albedo values of all classes almost showed an opposite behavior to mean yearly NDVI in which 2003 was the lowest mean yearly albedo for all classes at contrary it was the highest for NDVI. The minimum monthly albedo values were during the growing season and the maximum values were during summer. This gives an indication that the observed patterns were responding to real variations in surface properties (notably changes in vegetation cover). For example, the lower albedo values during growing season associated with higher proportions of vegetation cover like wheat/MAA, while the higher albedo values during summer associated with sites dominated by bare soil like open rangeland. Such albedo changes were also reported by Barnsley, et al., (2000).

Some of LU/C classes showed incremental decrease in the albedo values from 2000 to 2003, which could be explained by high amount of rainfall, which leaded to increase in NDVI and so in vegetation cover causing low soil reflectance leading to low albedo. The increase in albedo during 2003 to 2006 could be related to the decreasing in NDVI values due to low cumulative rainfall. In protected rangeland of surra, the behaviour of NDVI- decrease, could be only explained by the illegal grazing by intruders.

Wheat/MAA and irrigated areas showed low variations in albedo without a distinct pattern in increasing or decreasing and this could be attributed to the good vegetation cover that made it hard to detect any changes in soil surface. In addition, urban areas showed stable albedo behavior which could be explained by the albedo data that was produced at a spatial resolution of 1 km, while changing typically relate to an area of no more than tens of meters. This requires an understanding of the spatial variability of land surface albedo and a robust means of scaling up from the field to satellite. However, the data of 1km could be used for main urbanized cities were open spaces are absent.

The highest albedo for all values was always for open rangeland during the summer (June) where the vegetation cover and soil moisture were low. The lowest albedo for all values was for wheat/MAA during the winter (February and January) and this might be a direct result of an increased soil moisture content which could enhance biomass production.

5.6 Statistical Analysis

Finally, results of statistical analysis (ANOVA and Z-test) showed that monthly NDVI and albedo showed better discrimination of LU/C classes than the yearly values. The monthly NDVI and albedo values for all classes showed significant differences among LU/C, which mean that MODIS NDVI and albedo can detect the inter-annual variations with good response to rainfall and human impact on vegetation and soil. Also NDVI was able to detect the intra-annual variations between most of LU/C classes better than albedo, which showed no significant differences between most of LU/C classes. This could be related to the effect of vegetation cover, which concealed any change in soil. Spectral mixing between protected rangeland, barley and open rangeland made it difficult to separate them in some periods in the year (as shown by results of Z-test). In addition, it was hard to discriminate between urban with barley and irrigated classes, which could be explained as most of people grew their barley and irrigated crops near their houses or other urban areas. Therefore, the use of higher spatial resolution data of MODIS could reduse this spectral resolution, Particulary outside the borders of the main settlement.

6. Conclusions and Recommendations

6.1 Conclusions

1. Rainfall is the primary factor determining the vegetation behavior of rainfed areas and rangelands in Jordan.
2. Open rangeland, rainfed area of wheat and orchards along with barley can be discriminated using automated signature derived from MODIS satellite imagery.
3. NDVI and albedo can provide useful indices related to soil and vegetation and can detect variability on seasonal and inter-annual time series for the main land use/cover types.
4. NDVI was found to be useful indicator of environmental changes related to rainfall and vegetation behavior in the study area. Therefore, the long-term data of NDVI will help in clarifying relationships and interannual fluctuations of vegetation and climate.
5. It is more useful to use mean monthly NDVI and albedo values than yearly values to monitor vegetation.

6.2 Recommendations

It is recommended to:

1. Apply the approach developed by this research in similar environments in Jordan to detect degradation in any vegetation community. This, however, requires archaizing of this important data.
2. Use MODIS data with higher spatial resolution than (250-500m) to study environmental changes related to urbanization and other land use/cover classes.
3. Use cumulative rainfall and mean monthly NDVI in Mediterranean sites to study the response of vegetation to rainfall and possibly to assess drought.
4. Integrate different techniques and upscaling methods to improve the monitoring of vegetation in arid and semiarid areas.

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APPENDICES

Appendix 1: The 16-day NDVI profile value during 2000-2006.

Appendix 1.1: 16-day NDVI profile values ($*10^4$) for barley during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				1619	1548	1910	1793	1228	1345	1262	1242	1202	1223	1156	1155	1161	1134	1119	1126	1180	1205	1646	1522
	Profile 2				1130	1142	1572	1514	1101	1209	1124	1094	1086	1107	1064	1034	1046	1065	1038	1065	1119	1102	1126	1196
	Profile 3				1479	1862	1892	1871	1210	1299	1230	1171	1182	1149	1087	1110	1105	1097	1113	1291	1175	1171	1278	1163
2001	Profile 1	1357	1568	1774	1945	2097	1679	1405	1327	1168	1151	1181	1120	1117	1130	1096	1091	1115	1084	1153	1151	1258	1267	1395
	Profile 2	1276	1627	1675	2189	2236	1878	1322	1244	1110	1070	1125	1053	1031	1008	1012	991	997	1035	975	1075	1136	1111	1206
	Profile 3	1086	1140	1277	1606	1690	1951	1401	1242	1055	1075	1101	1017	1063	1040	995	1003	1000	1013	1003	1036	1064	987	1099
2002	Profile 1	1782	1318	1701	1756	1931	2068	2118	2037	1560	1338	1269	1208	1199	1192	1157	1174	1144	1146	1195	1148	1126	1117	1486
	Profile 2	1408	1359	1411	2081	2389	2537	2384	1943	1421	1261	1169	1105	1098	1094	1049	1027	1040	1041	1030	1081	1034	1271	1367
	Profile 3	1625	2967	1892	3268	3548	4219	4231	3478	2077	1616	1459	1274	1217	1153	1171	1133	1130	1142	1140	1134	1085	1078	1643
2003	Profile 1	1352	1570	1707	2780	2977	3088	3525		1832	1646	1512	1488	1453	1429	1446	1385	1385	1341	1260	1242	1320	1489	1830
	Profile 2	1265	1408	2039	3109	3105	4315	4219		1954	1866	1695	1576	1531	1500	1565	1513	1432	1362	1443	1237	1240	1335	1729
	Profile 3	1732	2043	2273	3781	3317	3987	4047		1669	1487	1500	1517	1484	1419	1425	1394	1380	1296	1277	1201	1274	1636	1773
2004	Profile 1	2194	2459	2606	2931	3124	2655	1952	1523	1378	1306	1298	1252	1347	1281		1277	1245	1213	1264	1269	1442	1434	1813
	Profile 2	1589	2085	2637	2621	2549	1849	1642	1278	1181	1208	1140	1169	1137	1140		1122	1123	1123	1108	1098	1255	1103	1111
	Profile 3	2001	2115	2690	3057	3432	2290	2010	1434	1312	1261	1264	1242	1205	1203		1173	1163	1115	1117	1101	1400	1077	1224
2005	Profile 1	427	1167	2012	1907	2247	2078	1842	1440		1274	1288	1261	1231	1218	1229	1214	1195	1236	1240	1258		1265	1273
	Profile 2	1165	1406	1648	2022	2756	2447	1855	1376		1288	1201	1139	1115	1124	1127	1106	1112	1124	1140	1137		1087	1354
	Profile 3	1304	1358	1851	2168	2668	2419	1748	1362		1233	1211	1133	1122	1105	1094	1109	1094	1112	1149	1158		1107	1134
2006	Profile 1	1785	1850	2173	2213	2192	2368	1793	1440	1401	1256	1250	1187	1185	1187	1183	1183	1128	1139	1188	1405	1390	1516	
	Profile 2	44	1159	845	1139	1179	1156	1182	1045	1087	1079	1062	1029	1031	1052	1091	1048	1064	1090	1033	1106	1074	1133	
	Profile 3	1082	1218	1680	1624	1716	1837	1533	1186	1274	1128	1136	1091	1069	1075	1074	1057	1057	1028	1067	1120	1086	1147	

Appendix 1.2 : The 16-day NDVI profile values (*10^4) for Irrigated areas during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				2160	2417	2748	2938	2167	2228	2501	2459	2079	1987	1824	1862	1856	1825	1947	1868	2254	2615	2742	2690
	Profile 2				1319	1815	2038	2188	1336	1444	1256	1148	1124	1141	1094	1064	1075	1080	1064	1065	1157	1136	1221	1177
	Profile 3				986	1050	1121	1151	1076	1140	1113	1177	1181	1250	1261	1261	1305	1285	1285	1246	1353	1370	1565	1479
	Profile 4				1756	1870	1808	1926	1373	1473	1366	1280	1247	1246	1205	1178	1160	1128	1109	1149	1183	1163	1229	1631
2001	Profile 1	1054	2515	1230	1374	1447	1421	1413	1385	1156	1149	1259	1223	1269	1215	1226	1252	1195	1310	1281	1340	1364	1173	1273
	Profile 2	1837	1251	1391	1393	1482	1536	1396	1279	1263	1238	1198	1183	1310	1302	1315	1303	1273	1270	1341	1271	1452	1256	1294
	Profile 3	1602	1822	2037	2447	2338	2048	1530	1453	1185	1224	1229	1161	1142	1137	1098	1091	1063	1064	1071	1095	1197	1521	1621
	Profile 4	1588	3163	1737	2281	2523	2463	2156	2059	1555	1518	1572	1432	1428	1423	1325	1350	1349	1417	1442	1537	1514	1476	2413
2002	Profile 1	2873	2479	2688	2946	3124	3748	4052	4663	3410	2479	2439	2476	2104	1767	1732	1628	1669	1865	1594	1602	1540	1296	1911
	Profile 2	1268	1868	1714	1857	2007	2367	2473	2411	1889	1486	1467	1447	1411	1436	1399	1372	1330	1294	1261	1324	1176	1067	1511
	Profile 3	1759	2039	2078	2167	2196	2146	2165	2040	1585	1404	1346	1297	1309	1302	1264	1259	1305	1313	1316	1302	1375	1160	1493
	Profile 4	2893	2292	2385	2617	2632	3053	2785	2649	2083	1777	1564	1522	1510	1476	1536	1427	1487	1426	1384	1465	1472	1864	2868
2003	Profile 1	1655	2260	3669	5132	4922	5970	6239		2269	2372	2216	2086	2068	2025	1914	1886	1825	1705	1658	1540	1601	1699	2109
	Profile 2	2121	3071	5656	4645	4305	5174	6007		2370	2344	2693	2617	2595	2482	2319	2219	2243	2274	2363	2106	2276	2756	2715
	Profile 3	1546	2028	2026	2929	3038	3805	3475		1831	1565	1531	1541	1551	1541	1578	1519	1494	1479	1497	1503	1474	1642	1778
	Profile 4	2921	3565	3593	4883	5262	6426	4323		2222	2087	2120	1974	1967	1774	1944	1933	1973	1982	1862	1937	2023	2743	3434
2004	Profile 1	2999	3893	5010	5058	5229	4151	3163	2198	1833	1879	1947	1894	1892	1749	1684		1589	1674	1733	1873	2022	1727	1880
	Profile 2	1803	2451	3132	3086	3081	2094	1841	1496	1594	1642	1903	2065	1938	2214	1727		1648	1631	1655	1622	1553	1163	1251
	Profile 3	1897	2185	2331	2656	2668	1972	1846	1665	1833	1841	1707	1549	1724	1917	1974		1944	1935	1911	1933	1555	1487	1408
	Profile 4	3434	4314	4378	4546	4374	3404	2636	2062	1958	1804	1819	1708	1680	1859	1714		1629	1561	1628	1596	2079	2664	2694
2005	Profile 1	1424	1916	2337	2901	4080	3643	2640	1939	1442		1311	1276	1299	1231	1267	1431	1332	1443	1503	1453		1257	1506
	Profile 2	1901	2058	2946	3080	3988	3766	2973	2084	1828		1771	1724	1741	1611	1509	1444	1483	1664	1734	1729		1739	2167
	Profile 3	1414	1357	1859	1804	2129	2087	1734	1511	1457		1446	1554	1537	1476	1531	1522	1522	1684	1597	1667		1600	1401
	Profile 4	2758	2988	3933	3806	3790	2831	2065	1818	1538		1472	1424	1306	1340	1326	1310	1295	1338	1288	1347		1452	1499
2006	Profile 1	1571	1494	1296	1812	1803	1788	1668	1352	1417	1233	1180	1195	1242	1275	1243	1216	1176	1154	1137	1200	1213	1244	
	Profile 2	2151	1889	2629	2547	3024	2718	1991	1712	1971	2022	2009	2033	1888	1867	2085	1928	1961	1987	1780	1632	1587	1557	
	Profile 3	1614	2011	1302	1430	1470	1386	1302	1272	1471	1488	1511	1506	1611	1660	1566	1433	1430	1516	1410	1477	1420	1445	
	Profile 4	1629	2474	2836	3340	3027	2317	1899	1531	1693	1424	1387	1335	1309	1234	1273	1244	1223	1226	1435	1497	1480	1398	

Appendix 1.3: The 16-day NDVI profile values (*10^4) for wheat/MAA during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				2830	3027	4215	4485	4384	3119	2327	2135	1967	2010	1909	1564	1643	1543	1576	2448	1870	2574	2422	2629
	Profile 2				2829	3296	5001	5637	4814	3485	2603	2169	1787	1725	1608	1531	1681	1556	1698	2052	2304	2221	2164	3121
	Profile 3				2236	2708	4470	4550	4618	3245	2413	1936	1591	1570	1535	1369	1437	1516	1549	1520	1923	2101	1757	2440
	Profile 4				2811	3723	4144	5089	4619	3800	3007	3459	2339	1912	1981	1781	1858	2306	1603	2579	2644	2711	2437	2810
	Profile 5				2065	2513	3083	3050	2755	2168	1811	1665	1582	1581	1546	1461	1527	1443	1514	1644	1634	1681	3975	2318
	Profile 6				1860	3049	3987	3628	3313	1912	1445	1324	1297	1306	1214	1269	1269	1224	1215	1355	1458	1452	2231	1331
	Profile 7				1996	2701	2893	2920	2695	2209	1976	1908	1739	1682	1583	1592	1516	1479	1467	1637	1851	1714	2626	1723
	Profile 8				1661	2022	2407	2697	1480	1583	1393	1337	1301	1319	1198	1215	1239	1193	1220	1250	1339	1339	1396	1723
2001	Profile 1	2606	3537	3167	3773	3684	2927	2479	1772	1717	1625	1625	1465	1619	1429	1400	1528	1486	1436	1528	2165	3099	2388	2469
	Profile 2	2272	2647	2759	3410	3758	2810	2294	1873	1562	1495	1357	1423	1458	1441	1422	1420	1395	1358	1924	2042	2220	1648	2123
	Profile 3	2505	2483	2936	3309	3262	2592	2155	1868	1624	1590	1396	1449	1416	1451	1469	1497	1482	1526	1463	1876	2910	2023	2505
	Profile 4	2810	2971	3005	3864	3479	3325	3087	3020	2298	1958	1643	1654	2117	1696	1654	1606	2423	2020	2794	2532	3216	2504	2872
	Profile 5	2251	2428	3186	3305	3652	2761	2133	1908	1609	1591	1533	1488	1468	1469	1425	1434	1496	1416	1490	1584	1671	1893	1986
	Profile 6	2015	2468	3319	3479	3969	3837	2434	1966	1502	1499	1418	1342	1380	1348	1346	1365	1346	1451	1422	1495	1510	1535	1872
	Profile 7	1878	2413	2611	2798	3081	2574	2171	1787	1538	1487	1460	1315	1417	1460	1338	1438	1481	1394	1523	1595	1627	1446	1714
	Profile 8	2368	2801	3519	3670	4139	3815	2237	1800	1453	1298	1276	1259	1422	1404	1235	1312	1251	1226	1632	1579	2074	1432	2280
2002	Profile 1	3970	5922	2702	4789	5406	7822	5363	6104	3908	2512	1700	1666	1547	1488	1543	1460	1484	1436	1684	1608	1505	2771	2552
	Profile 2	2741	4029	3428	3308	3807	9249	3376	3828	2954	2346	2205	2101	1870	1874	1834	1717	1722	1654	1844	1903	1823	1750	1661
	Profile 3	2468	6298	4173	3998	4161	6615	4426	4864	3226	2255	1997	1793	1645	1654	1674	1624	1619	1562	1669	1700	1645	1596	1879
	Profile 4	1986	5415	3548	3206	3420	4956	3576	3825	2774	2149	1869	1814	1642	1677	1628	1550	1596	1588	1707	1694	1663	1814	1756
	Profile 5	2009	3506	3036	3441	3456	3936	3855	3960	2693	2113	1831	1765	1637	1643	1576	1577	1541	1539	1661	1644	1547	1590	1723
	Profile 6	1714	3134	2892	3080	3145	3570	3533	4108	2471	2273	1800	1705	1627	1581	1553	1580	1530	1547	1627	1638	1529	1449	1345
	Profile 7	1521	3868	2378	3015	3297	3507	3996	4041	2057	1745	1593	1488	1408	1376	1340	1309	1342	1287	1408	1399	1380	1324	1801
	Profile 8	1625	4140	3038	3646	4223	4777	4316	4613	2928	2002	1667	1561	1414	1406	1348	1325	1324	1306	1313	1375	1340	1319	1707

Appendix 1.3 : continued

Year	Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2003	Profile 1	2593	2956	2913	4935	4841	4431	4602		3893	3331	2212	2788	2130	2004	2040	1899	1926	1912	1942	1943	1968	2078	2480
	Profile 2	2266	2977	2988	5861	4417	4255	5069		3644	2523	2218	2094	2063	1912	1888	1836	1831	1771	1804	2007	1799	1898	2326
	Profile 3	2333	2840	3085	4282	4155	4842	5191		4487	3021	2671	2374	2403	2207	2100	1940	1878	1856	1854	1750	1932	1881	2268
	Profile 4	2229	2827	2916	5018	3959	4218	4807		3655	2655	2315	2191	2153	2045	2005	1931	1890	1799	1809	1822	1935	1885	2150
	Profile 5	2484	2832	2846	4268	3779	3881	4806		4164	2508	2135	1945	1924	1829	1823	1800	1861	1813	1730	1639	1847	1984	2406
	Profile 6	2041	3675	2769	4635	3362	3770	4525		3277	2616	2166	2047	2009	1938	1958	1926	1859	1864	1765	1724	1873	1924	2248
	Profile 7	1748	3618	2341	4020	3580	4154	5057		3640	2358	2084	1880	1728	1729	1745	1663	1653	1576	1548	1407	1424	1566	1705
	Profile 8	1518	3515	2243	3842	3101	3991	4824		3795	2146	1827	1694	1640	1588	1485	1451	1433	1361	1391	1295	1360	1394	1678
2004	Profile 1	2330	3137	3403	4325	4980	5143	4796	3672	2360	2154	2078	1937	1900	1846		1884	1879	1795	1817	1824	2168	2220	2630
	Profile 2	2537	2826	3063	3671	4038	3930	4035	3228	2269	2102	1978	1918	1812	1912		1805	1830	1643	1782	1866	2242	2174	2457
	Profile 3	2247	3066	3296	3906	4484	4050	3810	2798	2173	2066	1928	1787	1773	1722		1691	1649	1595	1607	1773	1983	1930	2282
	Profile 4	2333	3094	3333	4476	5239	5168	4923	3844	2455	2118	1854	1744	1754	1725		1657	1656	1566	1620	1752	2016	2073	2526
	Profile 5	1908	2430	2659	3327	3870	3726	3421	2623	1927	1734	1669	1637	1570	1564		1522	1489	1434	1443	1538	1434	1688	1964
	Profile 6	2248	2832	2899	3548	4127	3910	3536	2886	2165	1974	1904	1817	1796	1753		1772	1665	1675	1693	1734	1835	2061	2283
	Profile 7	1893	2624	2925	3887	4326	4090	3251	2356	1713	1617	1566	1478	1416	1413		1395	1352	1327	1359	1382	1564	1659	1937
	Profile 8	1678	2071	2273	2609	3802	4257	3703	2803	1868	1588	1445	1435	1363	1339		1339	1299	1265	1299	1295	1185	1508	1852
2005	Profile 1	2583	2943	4113	4455	5433	5632	5078	4370	2343		2075	1865	1749	1701	1738	1767	1600	1737	1757	1876		1802	1979
	Profile 2	2539	2891	3876	3918	4687	4726	4162	3607	2233		2058	1970	1857	1770	1797	1734	1636	1683	1872	1948		2203	2264
	Profile 3	2298	2558	3755	3669	4796	4763	4409	3568	2010		1852	1820	1785	1702	1602	1565	1503	1482	1624	1577		1718	1782
	Profile 4	2515	2660	4025	4029	4544	4521	3992	2850	2063		1875	1795	1759	1778	1749	1679	1722	1679	1753	1779		1769	2434
	Profile 5	3093	3144	4896	5608	6458	6206	5356	4235	2432		2108	2041	2085	2068	2048	1960	1820	2102	2240	2467		2643	2428
	Profile 6	2244	2171	3756	3535	4364	4177	3579	3091	1926		1785	1663	1611	1603	1596	1565	1535	1571	1583	1630		1684	1723
	Profile 7	2525	2180	3377	3616	4364	4391	3812	2904	1862		1636	1630	1536	1492	1571	1564	1484	1502	1501	1563		1791	2349
	Profile 8	2212	2247	3356	3679	4469	5103	4488	3545	2031		1823	1685	1580	1513	1551	1500	1429	1448	1491	1536		1869	2128
2006	Profile 1	1979	2800	2614	3322	3530	3634	3535	2964	2651	2198	1946	1687	1648	1650	1731	1666	1519	1531	1940	2119	1889	1864	
	Profile 2	2242	2692	2899	3321	3995	3995	3790	3112	2736	2095	1889	1817	1645	1639	1621	1643	1694	1562	1930	2048	1972	2149	
	Profile 3	1912	2845	2367	3297	3450	3465	3126	2540	2246	1808	1725	1573	1532	1479	1437	1436	1428	1446	1655	1730	1627	1938	
	Profile 4	1852	2296	2354	3089	3407	3345	3079	2513	2417	1982	1898	1689	1640	1595	1539	1553	1546	1518	1772	1857	1753	2145	
	Profile 5	2200	3190	2733	3363	3523	3564	3064	2647	2927	2361	2018	1822	1742	1751	1653	1607	1613	1605	2016	2156	2114	2188	
	Profile 6	1723	2171	2186	2851	3209	3275	3199	2419	2250	1838	1723	1616	1532	1532	1482	1539	1489	1437	1598	1857	1716	2008	
	Profile 7	1837	2186	2032	2618	2574	3061	2342	2177	2153	1955	1857	1858	1726	1697	1681	1667	1673	1729	1903	1837	1667	1949	
	Prof 8	1400	1685	1787	2497	2980	3476	3031	2484	1973	1569	1521	1388	1304	1301	1299	1331	1288	1272	1397	1460	1341	1512	

Appendix 1.4: The 16-day NDVI profile values ($*10^4$) for urban areas during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				2000	3531	3382	3585	3113	2338	2006	1813	1632	1607	1520	1475	1435	1446	1436	1534	1874	1625	4083	2684
	Profile 2				2452	1717	2205	1798	1511	1475	1376	1316	1272	1321	1277	1217	1214	1201	1148	1587	1423	1293	1998	1587
	Profile 3				1763	1097	1064	1062	976	1023	1003	1001	1000	1028	985	973	955	927	947	982	997	996	716	1255
2001	Profile 1	1818	1968	2016	2142	2040	1790	1602	1467	1351	1318	1322	1280	1249	1255	1225	1222	1167	1167	1083	1242	1316	1474	1622
	Profile 2	978	1463	1050	1075	1081	1050	1047	982	956	954	959	944	939	944	919	918	906	936	903	912	987	1028	969
	Profile 3	2598	2526	2545	3127	3232	3019	2215	2174	1840	1814	1759	1638	1720	1735	1616	1622	1561	1647	1690	1797	1958	2412	2742
2002	Profile 1	2040	2080	2224	2520	2561	2793	2940	2863	2274	1917	1655	1699	1568	1615	1572	1595	1541	1449	1500	1704	1540	1617	1931
	Profile 2	1399	1063	1076	1223	1219	1330	1266	1246	1057	1015	983	985	992	964	975	952	958	966	961	981	883	1127	1277
	Profile 3	2952	3476	2983	3136	3310	4366	3530	3685	2710	2242	2049	2082	1894	1920	1892	1808	1672	1790	1810	1911	1845	3288	2501
2003	Profile 1	1794	1896	1972	3295	2510	2510	2405		1888	1646	1558	1478	1463	1380	1357	1332	1347	1458	1243	1664	1628	1738	1776
	Profile 2	1247	1472	1329	2642	2313	2108	2000		1286	1236	1146	1125	1102	1098	1089	1072	1027	996	979	902	1099	1443	1329
	Profile 3	2425	2837	2944	3619	4048	3752	3679		2688	2206	2218	2064	2002	1898	1925	1973	1960	1982	1881	1848	2079	2252	2457
2004	Profile 1	1776	1998	2242	2502	2473	2357	1980	1666	1475	1423	1394	1343	1332	1266	1279		1203	1198	1259	1318	1885	1779	1803
	Profile 2	1491	1824	1797	1988	1901	1578	1458	1238	1167	1147	1114	1093	1089	1092	1087		1041	1026	1025	1164	767	1384	1253
	Profile 3	2457	2967	3131	3141	3526	3111	2984	2496	2046	2075	2043	1896	1820	1856	1741		1725	1662	1912	1892	2703	2648	2486
2005	Profile 1	1945	1984	2280	2337	2350	2031	1909	1538		1365	1304	1286	1196	1175	1280	1255	1191	1186	1290	1273		1384	1589
	Profile 2	1520	1346	1741	1510	1625	1463	1277	1187		1101	1084	1045	1051	1034	1019	1026	994	1031	1114	1102		1224	1266
	Profile 3	3505	3042	3703	3785	3932	3738	3452	2792		2151	2051	1891	1821	1867	1800	1766	1876	1967	1890	2011		2132	2260
2006	Profile 1	1732	1905	1996	1897	2172	1765	1719	1579	1486	1375	1323	1262	1308	1227	1253	1209	1159	1238	1586	1581	1400	1571	
	Profile 2	1202	1294	1650	1238	1199	1256	1157	1180	1106	1074	1053	1043	1066	1043	1061	1036	1003	981	1029	1156	1116	1231	
	Profile 3	2504	2585	2509	2806	2838	2902	2547	2413	2326	1965	2013	1826	1771	1733	1708	1698	1760	1696	2033	2202	1963	1928	

Appendix 1.5 : The 16-day NDVI profile values ($*10^4$) of open rangeland during 2000-2006.

Year		JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				2152	2248	2671	2876	2051	2185	1854	1718	1589	1626	1562	1525	1546	1501	1557	1531	1603	1554	1566	1868
	Profile 2				1522	1276	1452	1504	1080	1192	1163	1150	1147	1162	1151	1100	1121	1101	1100	1032	1106	1109	1501	1273
	Profile 3				1040	1016	1121	1168	990	1024	1017	1032	1034	1031	1037	1029	1020	1010	1019	1025	1076	1061	1202	1129
	Profile 4				849	886	941	969	820	858	855	868	867	887	918	841	862	844	865	909	905	906	1092	1089
	Profile 5				1571	1081	1270	1312	1013	1124	1068	1055	1047	1090	1067	1045	1055	1046	1026	1054	1094	1070	1044	1200
	Profile 6				1195	1516	1644	1487	1188	1233	1180	1124	1123	1135	1098	1094	1065	1062	1048	1042	1122	1085	1151	1259
2001	Profile 1	1531	2748	1449	1510	1636	1513	1340	1223	1052	1068	1092	1010	1036	1051	1022	1017	1048	1032	1048	1059	1063	1071	1161
	Profile 2	953	998	1081	956	968	1008	969	915	881	875	901	857	843	861	826	838	848	820	811	823	966	948	1089
	Profile 3	932	1027	1150	1145	1159	1161	1077	1037	959	965	997	947	975	972	942	936	944	971	965	980	973	1034	1453
	Profile 4	910	922	1075	922	938	886	906	823	814	817	834	796	804	817	794	804	818	831	810	846	902	811	937
	Profile 5	2047	2717	2431	3104	3271	2864	2001	1825	1472	1492	1522	1431	1443	1415	1398	1432	1484	1401	1487	1454	1747	1812	2127
	Profile 6	1698	1827	2207	2434	2306	1786	1440	1373	1219	1185	1218	1139	1120	1140	1109	1084	1081	1081	1080	1109	1258	1413	1412
2002	Profile 1	1669	1599	1670	1728	1904	2291	2313	2150	1689	1335	1238	1172	1131	1147	1121	1133	1119	1138	1145	1090	1000	1009	1644
	Profile 2	1458	1302	1864	1821	1967	2142	2328	2212	1721	1412	1273	1273	1233	1246	1242	1242	1228	1209	1221	1232	1244	657	1732
	Profile 3	1089	1247	1044	1018	1075	1163	1224	1101	1024	953	960	903	915	922	900	920	926	943	920	894	854	881	1312
	Profile 4	1671	1613	1318	1750	1877	1906	1933	1632	1296	1210	1165	1127	1104	1114	1083	1099	1069	1062	1102	1083	1060	1037	1653
	Profile 5	2496	2726	3023	2863	3046	4015	3360	3181	2450	2065	1863	1760	1756	1724	1686	1665	1667	1632	1674	1695	1757	1631	2328
	Profile 6	1357	1282	1010	1029	1067	1172	1188	1146	1103	1087	1100	1112	1093	1098	1096	1115	1112	1125	1166	1160	1148	1074	1231
2003	Profile 1	1310	1699	1667	2965	2445	3589	3808		1656	1602	1508	1442	1398	1366	1354	1372	1305	1256	1191	1197	1196	1382	1570
	Profile 2	2171	2564	3105	585	3280	3244	3418		1947	1832	1730	1642	1645	1571	1544	1537	1562	1539	1530	1460	1557	1914	2161
	Profile 3	1193	1278	1156	203	1422	1826	1898		1380	1302	1273	1285	1232	1213	1235	1205	1180	1164	1176	1142	1241	1428	1212
	Profile 4	1020	1113	811	1320	1278	1743	1512		1170	1067	993	955	960	982	976	999	940	920	900	881	756	1314	1052
	Profile 5	1069	1221	1188	1619	2072	2346	2086		1338	1250	1170	1150	1112	1109	1127	1094	1072	1073	1068	1115	1113	1271	1229
	Profile 6	1219	1419	1630	2750	2609	3677	3978		1843	1543	1529	1457	1468	1358	1345	1325	1296	1257	1193	1217	1205	1478	1674
2004	Profile 1	2051	3067	3893	3694	3562	2693	1951	1519	1348	1272	1255	1245	1190	1172	1138		1185	1154	1127	1123	1347	1149	1275
	Profile 2	1285	1601	1730	1857	1754	1468	1303	1134	1103	1093	1054	1076	1069	1001	1019		1058	1052	1051	1096	1250	1056	1154
	Profile 3	1265	1342	1461	1634	1616	1523	1358	1166	1108	1156	1118	1124	1117	1120	1149		1161	1153	1109	1174	1267	1056	1108
	Profile 4	1229	1399	1456	1709	1581	1361	1307	1094	1044	1037	1027	1062	1023	993	1023		1036	1035	1024	1040	979	1060	1039
	Profile 5	2811	3281	3473	3446	3970	3527	2929	2336	1975	1842	1893	1783	1763	1732	1713		1738	1658	1643	1721	2054	2293	2395
	Profile 6	1701	2347	2613	2760	2869	2015	1775	1391	1284	1313	1216	1192	1164	1166	1140		1143	1127	1084	1117	861	1206	1269
2005	Profile 1	1521	1895	2177	2245	3210	2783	2457	1530		1253	1217	1179	1153	1152	1150	1142	1130	1156	1155	1177	1105		1298
	Profile 2	1634	1628	2555	2680	3280	3110	1961	1420		1265	1209	1157	1140	1090	1124	1103	1083	1145	1095	1125	1091		1368
	Profile 3	1041	1571	1546	1308	1428	1361	1135	1081		1019	1018	999	999	959	965	989	980	1020	1014	1042	1042		1400
	Profile 4	2303	2535	3161	3351	3552	3102	2675	2010		1642	1599	1549	1498	1489	1472	1474	1436	1500	1462	1476	1579		1626
	Profile 5	1677	966	2060	1921	2290	2090	1615	1322		1209	1166	1119	1109	1102	1088	1104	1088	1088	1158	1148	1126		1157
	Profile 6	1364	1469	1606	1530	1557	1409	1192	1134		1054	1024	991	978	954	968	998	992	1008	1042	1041	1041		1031
2006	Profile 1	1666	2086	1986	2549	2591	2780	2319	2017	1882	1628	1548	1587	1473	1454	1418	1434	1385	1354	1596	1741	1678	1584	
	Profile 2	1577	1581	2126	2018	2342	2303	1844	1389	1336	1194	1146	1126	1094	1087	1109	1116	1082	1058	1048	1149	1137	1256	
	Profile 3	1424	1275	1947	1786	1895	1945	1712	1385	1312	1175	1140	1113	1096	1101	1104	1134	1105	1088	1080	1086	1123	1185	
	Profile 4	1492	2260	2116	2500	2406	2246	1700	1535	1476	1319	1307	1227	1218	1227	1197	1215	1184	1123	1316	1379	1305	1435	
	Profile 5	1583	1202	1349	1165	1156	1112	1138	1032	1083	1051	1022	992	1017	998	1032	994	1006	1012	1069	1103	1108	1136	

Appendix 1.6: The 16-day NDVI profile values (*10^4) for protected rangeland during 2000-2006.

Year	2000		2001		2002		2003		2004		2005		2006	
Month/profile	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2
JAN			1014	1602	1749	2893	1476	2833	1939	3324	1717	2758	1184	2527
JAN			1467	1822	1700	2292	1590	5068	2195	4192	1610	2988	1292	2464
FEB			3047	2037	1304	2385	1745	3544	2550	4438	2135	3933	1812	2670
FEB	1079	1756	1361	2447	1491	2617	2694	4783	2588	4372	1628	3806	1366	3149
MAR	1167	1870	1381	2338	1601	2632	2862	4540	2451	4133	1867	3790	1277	2844
MAR	1251	1808	1325	2048	1655	3053	3389	6302	1829	3273	1679	2831	1286	2209
APR	1314	1926	1180	1530	1683	2785	3162	5860	1681	2514	1438	2065	1245	1814
APR	1059	1373	1137	1453	1609	2649			1365	1954	1282	1818	1184	1465
MAY	1122	1473	1012	1185	1295	2083	1871	2445	1256	1857	1176	1538	1168	1614
MAY	1097	1366	1017	1224	1273	1777	1676	1772	1276	1571			1103	1345
JUN	1082	1280	970	1229	1202	1564	1580	2079	1221	1601	1167	1472	1115	1308
JUN	1084	1247	992	1161	1185	1522	1604	1953	1172	1536	1134	1424	1070	1271
JUL	1126	1246	1010	1142	1173	1510	1570	1899	1149	1546	1087	1306	1063	1252
JUL	1057	1205	996	1137	1186	1476	1524	2095	1122	1496	1085	1340	1068	1237
AUG	1063	1178	984	1098	1163	1536	1600	1893	1095	1559	1099	1326	1086	1205
AUG	1061	1160	970	1091	1173	1427	1557	1792	1125	1477	1112	1310	1052	1177
SEP	1041	1128	959	1063	1156	1487	1465	1817	1116	1397	1082	1295	1057	1154
SEP	1057	1109	974	1064	1132	1426	1445	1692	1073	1436	1167	1338	1050	1145
OCT	1063	1149	963	1071	1160	1384	1402	1720	1069	1492	1181	1288	1158	1351
OCT	1060	1183	983	1095	1139	1465	1471	1458	1042	1838	1186	1347	1147	1424
NOV	1149	1163	1002	1197	1223	1472	1467	1928	1389	2367	1196	1452	1161	1396
DEC	1183	1229	1172	1521	1757	1864	1665	2719	1414	2444	1184	1499	1186	1577
DEC	1274	1631	1419	1621	1909	2868	2011	3324						

Appendix 2: The 16-day Albedo profile values during 2000-2006

Appendix 2.1: The 16-day Albedo profile values ($*10^4$) for barley during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				3679	3543	3300	3388	3933	4110	4150	4232	4179	4129	4195	4065	3957	3757	3932	3176	3370	3137	2502	2021
	Profile 2				3391	2995	3038	3082	3908	4130	4092	4248	4189	4126	4126	3957	3879	3790	3755	3243	3162	3091	2601	2152
	Profile 3				3504	3553	3080	3326	3979	4121	4250	4340	4271	4266	4422	4097	4045	3931	3711	3838	3709	3528	3212	2558
2001	Profile 1	3529	2939	3359	3279	3319	3540	3893	4051	4094	4197	4380	4194	4193	4059	4002	3941	3807	3707	3510	3232	3192	3513	3337
	Profile 2	3178	2592	2822	2828	2895	3084	3625	3775	3935	4040	4158	4024	3984	3860	3791	3711	3540	3480	3253	3202	2958	3126	2855
	Profile 3	3415	2324	3231	3355	3608	3682	3937	4198	4198	4307	4442	4257	4217	4077	4053	3916	3856	3831	3504	3313	3315	3423	3311
2002	Profile 1	2018	1954	3140	3528	3624			3855	3957	4092	4250	4277	4277	4264	4137	4054	3942	3391	3459	3633	3903	1862	1976
	Profile 2	1886	2069	2596	3127	2945			3600	3652	3784	3844	3834	3775	3766	3612	3651	3546	3384	3276	3107	3288	3077	1823
	Profile 3	1909	2204	2893	3139	3204			3505	3837	3972	4095	4139	4129	4103	4010	4013	3918	3719	3361	3200	3375	3609	1886
2003	Profile 1	2926	2688	3130	2414	2120	1581	1871	2538	3001	3523	3756	3946	4007	3901	3931	3895	3822	3675	3509	3460	3259	1949	2783
	Profile 2	2760	2400	2426	1772	2048	1809	2022	2573	3017	3160	3397	3451	3538	3439	3475	3418	3371	3254	3118	2975	2943	2163	2491
	Profile 3	2892	2632	2479	1546	1931	1576	1583	2453	2961	3027	3312	3467	3693	3687	3692	3694	3647	3507	3474	3080	3205	2110	2443
2004	Profile 1	2803	2676	2202	2053	2407	2832	3265	3729	3864	4013	4072	4162	4111	4055	3911	3864	3795	3688	3137	2848	3495	3302	
	Profile 2	2667	2177	2314	2162	2386	2698	3001	3515	3637	3744	3759	3772	3722	3724	3551	3522	3432	3280	3043	2633	3020	2865	
	Profile 3	2607	2262	2137	1893	2359	2744	3244	3778	3909	3997	4034	4039	4036	4026	3913	3862	3751	3515	3145	2828	3337	3294	
2005	Profile 1	2429	2443	1342	2028	2022	2318	2715		3283	3367	3499	3812	3558	3634	3464	3370	3331	3239	3022	2830	2644	2656	2141
	Profile 2	2515	2734	1730	2431	2448	2733	3122		3772	3866	3999	4008	3976	3954	3855	3724	3571	3450	3407	3219	2948	2870	2251
	Profile 3	2869	2981	1785	2658	2414	2679	3095		3750	3947	4132	4277	4128	4120	4011	4030	3870	3670	3438	2998	3298	3430	3107
2006	Profile 1	3340	2414	2678	2968	2805	3062	3248	3605	4104	4020	4196	4043	4149	4048	3949	3843	3853	3645	2834	3391	3555	3456	2338
	Profile 2	3043	3113	2788	3287	3405	3464	3666	3960	4222	4138	4236	4226	4231	4152	3995	3908	3925	3838	3144	3746	3664	3665	3203
	Profile 3	2888	2464	2394	3048	2869	3184	3423	3768	3897	3918	4098	3978	4003	3946	3831	3693	3584	3473	3092	3443	3197	3219	2326

Appendix 2.2: The 16-day albedo profile values($*10^4$) for Irrigated areas during 2000-2006.

Year	Month Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				4102	4155	4085	4245	4516	4687	4711	4731	4653	4644	4629	4507	4465	4352	3987	3781	3780	3665	3124	2500
	Profile 2				2585	2411	2363	2455	3017	3271	3369	3435	3377	3382	3478	3162	3188	3133	2741	3089	2850	2584	2331	1625
	Profile 3				3383	4040	3965	3840	4187	4377	4377	4402	4265	4247	4208	3984	3946	3911	3909	3246	3690	3423	2192	1919
	Profile 4				3590	4065	3972	3959	4036	4158	4327	4315	4221	4250	4378	4057	4040	3814	3977	3538	3443	3425	741	2025
2001	Profile 1	3819	3069	2807	3554	3840	3998	4130	4063	4424	4463	4702	4472	4421	4322	4322	4195	4108	4070	3853	3756	3700	3745	3411
	Profile 2	1726	2833	2547	3714	3696	3861	3893	3788	4074	4200	4503	4191	4126	4020	3998	3970	3845	3742	3581	3435	3620	3203	3161
	Profile 3	3518	2654	1844	3363	3813	3665	4031	3909	4113	4414	4571	4398	4327	4231	4212	4099	4001	3902	3763	3471	3058	3457	2813
	Profile 4	3792	3559	1933	3874	4201	4138	4259	4430	4682	4785	4957	4725	4680	4542	4506	4380	4298	4203	4084	3322	3596	3978	3672
2002	Profile 1	2268	2233	3308	3592	3637	3802			4073	4170	4246	4278	4200	4147	4104	4145	3933	3560	3470	3291	3430	3594	2285
	Profile 2	1743	2183	3178	3295	3211	3298			3570	3605	3791	3753	3649	3618	3641	3509	3410	3206	3018	2868	2978	3273	1942
	Profile 3	2232	2145	3476	3931	3947	4283			4287	4411	4449	4455	4384	4325	4296	4232	4119	3884	3693	3329	3484	3771	2132
	Profile 4	2267	2531	3527	3826	3789	3674			3958	4097	4135	4122	3993	4004	3984	3871	3799	3473	3355	3088	3291	3503	2033
2003	Profile 1	2186	2002	1360	1210	1527	1278	1536	2014	2490	2845	3184	3475	3564	3477	3509	3381	3320	3195	3167	2775	2738	1891	1660
	Profile 2	3188	3428	2794	2106	2852	2500	3008	3375	3723	3991	4120	4140	4165	4024	4064	4021	3926	3768	3656	3316	3327	2323	3292
	Profile 3	3240	2880	3209	3082	2538	2325	2668	3186	3462	3609	3693	3723	3685	3626	3590	3529	3489	3337	3172	3091	2858	2060	2821
	Profile 4	2997	2679	3386	3222	3018	3082	3377	3575	3732	3856	3990	3995	3922	3794	3754	3626	3593	3486	3233	3212	3296	2305	2857
2004	Profile 1	1917	1681	1663	1794	2152	2477	2710	3083	3159	3239	3342	3433	3477	3440	3332	3340	3388	3169	3087	2323	2768	2361	
	Profile 2	2981	2571	2157	2634	2723	3281	3463	3565	3814	3952	3949	3967	3941	3880	3808	3725	3638	3488	2789	2743	3427	3258	
	Profile 3	3032	2726	2630	2590	3163	3317	3521	3592	3832	4020	3932	3859	3762	3819	3722	3711	3555	3376	2980	2756	2894	3246	
	Profile 4	3246	2902	2654	2540	2891	3343	3655	3530	4077	4199	4170	4177	4133	4115	4053	3979	3923	3789	3533	2891	3589	3776	
2005	Profile 1	2543	2563	1420	2044	1941	2103	2509		3225	3416	3540	3590	3619	3665	3554	3446	3370	3284	3161	3056	2944	3067	2348
	Profile 2	2756	2650	1475	2026	1900	2103	2554		3427	3665	3841	4009	3868	3999	3847	3829	3659	3637	3468	3309	3124	3160	2359
	Profile 3	2370	2149	1469	2026	2110	2435	2711		3316	3465	3614	3692	3622	3620	3496	3502	3357	3266	2902	2989	2766	2804	2536
	Profile 4	2116	2371	1284	2368	2540	2824	3090		3412	3659	3727	3840	3661	3671	3558	3450	3310	3237	3107	2853	2569	2735	2366
2006	Profile 1	2503	2325	2478	2646	2884	3070	3272	3441	3754	3628	3884	3836	3799	3731	3641	3475	3412	3273	3071	3038	3004	2832	2579
	Profile 2	2247	1894	1938	2008	2175	2287	2516	2876	3092	3122	3259	3213	3202	3189	3051	3046	2957	2892	2775	2542	2527	2489	2291
	Profile 3	2472	2739	2778	3178	3234	3448	3559	3642	3952	3835	3956	4015	3935	3891	3778	3636	3545	3612	3276	3191	3154	2964	2839
	Profile 4	1347	2743	2254	2638	2839	3161	3318	3633	3873	3918	4090	4131	4216	4154	4095	3966	3956	3919	3634	3345	3424	3338	2678

Appendix 2.3: The 16-day albedo profile values(*10^4) for urban areas during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				2738	2853	2866	3084	3428	3723	3874	3959	3894	3906	3925	3696	3673	3524	3492	3073	3157	2855	2512	2239
	Profile 2				2398	2449	2217	2772	3045	3227	3290	3370	3325	3298	3280	3090	3013	3006	2837	2872	2787	2730	1781	2214
	Profile 3				1651	1725	1743	1840	2100	2375	2527	2711	2667	2651	2658	2548	2468	2366	2173	2000	1934	1832	1619	1376
2001	Profile 1																							
	Profile 2		2297		3448	3589	3802	3795	3977	4063	4203	4400	4292	4226	4137	4071	3986	3864	3733	3635	3296		2070	
	Profile 3	1914	1638	1729	2084	2316	2493	2719	2843	3021	3275	3327	3360	3267	3237	3178	3167	2991	2884	2781	2400	2347	1797	
2002	Profile 1	1911	1552	1571	1825	2207	2267	2757	2849	3093	3294	3237	3309	3221	3122	3125	3015	2917	2861	2634	2264	2169	1908	
	Profile 2	1370	1321	1453	1647	1699			1713	2090	2321	2397	2499	2542	2467	2401	2349	2259	2053	2044	2027	1988	1809	1022
	Profile 3	1601	1602	1884	1895	1961			2095	2325	2641	2791	2902	2836	2860	2747	2643	2569	2496	2295	2179	2194	1629	1552
2003	Profile 1	1780	2314	2565	2757	2861			3141	3424	3604	3722	3783	3693	3689	3557	3500	3438	3253	3079	2951	2994	2649	1895
	Profile 2	1832	1762	1800	1416	2001	1961	2333	2462	2763	2922	3124	3216	3148	2996	2986	2908	2776	2658	2858	2534	2333	1696	1717
	Profile 3	1600	1288	1344	1442	1713	1631	1942	2101	2428	2668	2848	3028	2947	2887	2819	2797	2723	2518	2460	2299	2114	1526	1781
2004	Profile 1	1608	1544	1608	1490	1546	1657	2025	2178	2452	2520	2656	2785	2771	2697	2629	2579	2449	2311	2227	2028	1941	1686	1677
	Profile 2	1771	1542	1542	1735	1631	1927	2193	2524	2754	2774	2840	2856	2815	2745	2586	2538	2455	2265	2131	1659	1690	1436	
	Profile 3	2023	1478	1890	2149	2287	2413	2827	3112	3447	3451	3512	3443	3388	3247	2978	3023	2892	2722	2470	1759	1892	1844	
2005	Profile 1	1801	1514	1531	1669	1869	2027	2341	2674	2992	3060	3105	3103	3035	2972	2880	2810	2708	2532	2468	1731	1771	1762	
	Profile 2	1494	1479	1476	1970	2150	2402	2341		2975	3304	3362	3444	3409	3267	3204	3146	2931	2676	2648	2143	1867	1559	1446
	Profile 3	1446	1541	1347	1653	1894	2064	2278		2680	3034	3095	3169	3008	3047	2965	2913	2451	2641	2572	2173	1933	1758	1328
2006	Profile 1	1468	1308	1027	1513	1431	1593	1751		2153	2421	2482	2628	2562	2513	2468	2423	2383	2204	2099	1863	1798	1843	1101
	Profile 2	1427	1534	1789	2207	2139	2550	2534	2820	3188	3188	3382	3348	3248	3234	3143	3048	2921	2940	2582	2215	2140	2208	1915
	Profile 3	1827	1385	1394	1921	1722	2083	2154	2454	2864	2885	3065	3080	2624	2982	2888	2825	2812	2695	2425	2322	2113	2034	1798

Appendix 2.4: The 16-day albedo profile values (*10^4) for protected rangeland during 2000-2006.

Year	2000		2001		2002		2003		2004		2005		2006	
Month/Profile	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2	Profile 1	Profile 2
JAN				3382	2199	1907	3009	2365		1917	2362	1807	2923	1347
JAN			2165	2807	2228	2217	3216	2246	2391	1681		2348	2511	2743
FEB			2960	2928	3291	2482	2453	2026	2808	1663	2161	1465	2263	2254
FEB	3641	3919	3743	2985	3470	2861		1509	2739	1794	3163	2296	3452	2638
MAR	3591	3873	3679	3227	3566	3167	2768	1694	2936	2152	3231	2354	3460	2839
MAR	3587	3868	3940	3459			2455	1640	3139	2477	3351	2674	3733	3161
APR	3767	3849	4014	3790	3818	3257	2562	1885	3310	2710	3601	2977	3778	3318
APR	4220	4221	4253	3962			2995	2341	3668	3083	3780	3399	4046	3633
MAY	4341	4303	4384	4098	3775	3470	3238	2723	3690	3159	4010	3662	4149	3873
MAY	4491	4343	4461	4237	3971	3739	3292	2838	3755	3239	3961	3762	4136	3918
JUN	4524	4422	4812	4528	3979	3806	3588	2915	3851	3342	4113	3783	4240	4090
JUN	4494	4343	4512	4333	4028	3815	3580	3007	3824	3433	4031	3807	4252	4131
JUL	4505	4342	4468	4340	4019	3836	3541	2965	3855	3477	4000	3827	4252	4216
JUL	4616	4415	4405	4255	3956	3856	3486	3065	3798	3440	3903	3826	4197	4154
AUG	4434	4183	4428	4264	3938	3713	3436	2959	3676	3332	3838	3773	4120	4095
AUG	4320	4187	4239	4184	3880	3752	3454	2896	3636	3340	3783	3653	4032	3966
SEP	4166	4095	4276	4094	3746	3617	3397	2919	3652	3388	3427	3500	4057	3956
SEP	4263	4041	4235	4024	3484	3357	3326	2799	3432	3169	3451	3395	3979	3919
OCT	3795	3539	4106	3900	3397	3321	3276	2589	3250	3087	3258	3218	3363	3634
OCT	3724	3643	3832	2922	3151	3225	3211	2479	1403	2323	3217	2753	3511	3345
NOV	3576	3533	3804	3421	3189	3142	3058	2675		2768	3206	2798	3428	3424
DEC	3267			3314	1687	1736	2178	1617		2361	2682			3338
DEC	2544		2244	2779			1872	1826						2678

Appendix 2.5: The 16-day albedo profile values (*10^4) for wheat/MAA during 2000-2006.

Year	Month / Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1				1461	1360	986	1136	1129	1837	2102	2404	2344	2249	2333	2114	2064	1954	1922	1721	1717	1641	1188	1340
	Profile 2				1530	1720	1615	1748	1944	2311	2359	2482	2579	2371	2555	2227	2320	2056	2022	1775	1879	1824	1435	1052
	Profile 3				1492	1392	1433	1375	1981	2188	2399	2698	2657	2588	2609	2439	2397	2338	2238	1892	1813	1798	1380	1485
	Profile 4				1085	1052	1056	1078	1404	1518	1603	1947	1922	1834	1813	1696	1633	1636	1546	1171	1193	1164	915	1015
	Profile 5				1474	1622	1290	1493	1837	2138	2280	2589	2540	2473	2483	2345	2315	2235	2068	1745	1754	1707	1367	1463
	Profile 6				1531	1544	1633	1839	1937	2305	2291	2429	2487	2376	2341	2394	2337	2189	2107	1787	1839	1818	1385	1359
	Profile 7				1959	1889	1658	1774	2276	2620	2827	3059	2971	2946	2926	2821	2781	2674	2623	2350	2278	2270	1342	1660
	Profile 8				1697	1649	1486	1661	2223	2447	2543	2863	2822	2812	2866	2668	2627	2551	2512	1992	2128	2044	1474	1536
2001	Profile 1	1113	1083	1056	1156	1221	1559	1869	2059	2212	2292	2393	2280	2219	2117	2023	1972	1973	1964	1775	1678	1614	1311	1170
	Profile 2	1275	1207	1204	1391	1380	1570	2002	2077	2289	2446	2496	2384	2403	2281	2337	2307	2166	2113	2023	1784	1636	1455	1292
	Profile 3	1408	1175	1320	1414	1521	1611	1966	2079	2293	2365	2398	2445	2358	2265	2241	2294	2061	2006	1879	1622	1599	1522	1456
	Profile 4	1416	1121	1473	1594	1780	1914	2190	2327	2425	2670	2720	2537	2654	2488	2431	2287	2182	2223	2109	2054	1695	1555	1436
	Profile 5	955	907	901	1001	1026	1234	1351	1616	1693	1758	1816	1734	1695	1656	1629	1452	1463	1482	1310	1026	1222	1126	975
	Profile 6	1501	1672	1410	1628	1709	1910	2224	2369	2508	2601	2713	2621	2587	2482	2479	2377	2269	2230	1975	2019	1748	1661	1447
	Profile 7	1533	1461	1355	1611	1675	1775	2002	2252	2391	2524	2603	2539	2519	2479	2415	2410	2333	2173	2057	1956	1711	1628	1347
	Profile 8	1693	1563	1588	1757	1824	2164	2361	2499	2676	2730	2753	2733	2663	2581	2575	2396	2399	2327	2301	1965	1869	1887	1598
2002	Profile 1	1046	1141	1191	1224	1206			1201	1615	1923	2135	2295	2265	2262	2197	2126	2076	1873	1874	2025	1950	1905	1481
	Profile 2	1107	999	1042	1139	1176			1364	1546	1664	1788	1828	1826	1752	1579	1682	1623	1690	1449	1294	1372	1282	1118
	Profile 3	876	862	964	1031	1046			1277	1510	1605	1711	1762	1734	1765	1644	1579	1575	1562	1363	1409	1178	1143	889
	Profile 4	1125	1166	1258	1411	1509			1605	1939	2145	2338	2295	2329	2401	2249	2380	2223	2106	2076	1963	1978	1797	1399
	Profile 5	1312	1336	1462	1511	1456			1634	2002	2167	2503	2741	2735	2736	2714	2619	2550	2455	2301	2158	2242	1910	1863
	Profile 6	1338	1445	1600	1581	1495			1629	1897	2175	2473	2729	2676	2695	2647	2523	2510	2386	2327	2313	2259	2120	1455
	Profile 7	1355	1513	1744	1666	1570			1545	1989	2320	2551	2788	2737	2708	2614	2590	2541	2480	2313	2260	2246	2043	1410
	Profile 8	1260	1266	1377	1330	1332			1607	1831	2046	2234	2361	2291	2316	2282	2248	2200	2077	2060	1854	1811	1607	1384

Appendix 2.5: continued

Year	Profile	JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2003	Profile 1	1150	1396	1420	1023	1432	1823	1637	1665	1150	1396	1420	1023	1432	1823	1637	1665	1150	1396	1420	1023	1432	1823	1637
	Profile 2	1176	1202	1292	921	1275	1555	1503	1497	1176	1202	1292	921	1275	1555	1503	1497	1176	1202	1292	921	1275	1555	1503
	Profile 3	1002	1321	1339	918	1245	1499	1304	1397	1002	1321	1339	918	1245	1499	1304	1397	1002	1321	1339	918	1245	1499	1304
	Profile 4	895	1194	1213	1149	1141	1384	1187	1397	895	1194	1213	1149	1141	1384	1187	1397	895	1194	1213	1149	1141	1384	1187
	Profile 5	1051	1160	1318	924	1254	1443	1560	1567	1051	1160	1318	924	1254	1443	1560	1567	1051	1160	1318	924	1254	1443	1560
	Profile 6	1021	1294	1315	875	1357	1540	1503	1505	1021	1294	1315	875	1357	1540	1503	1505	1021	1294	1315	875	1357	1540	1503
	Profile 7	1318	1422	1717	1052	1518	1807	1435	1695	1318	1422	1717	1052	1518	1807	1435	1695	1318	1422	1717	1052	1518	1807	1435
	Profile 8	1280	1383	1954	1184	1678	1792	1350	1699	1280	1383	1954	1184	1678	1792	1350	1699	1280	1383	1954	1184	1678	1792	1350
2004	Profile 1	1156	1366	1389	1111	1446	2003	1734	1745	1156	1366	1389	1111	1446	2003	1734	1745	1156	1366	1389	1111	1446	2003	1734
	Profile 2	989	1081	1190	940	1126	1467	1539	1470	989	1081	1190	940	1126	1467	1539	1470	989	1081	1190	940	1126	1467	1539
	Profile 3	949	1271	1239	871	1099	1357	1395	1475	949	1271	1239	871	1099	1357	1395	1475	949	1271	1239	871	1099	1357	1395
	Profile 4	1021	1266	1269	938	1308	1590	1440	1608	1021	1266	1269	938	1308	1590	1440	1608	1021	1266	1269	938	1308	1590	1440
	Profile 5	1093	1101	1406	868	1318	1329	1138	1418	1093	1101	1406	868	1318	1329	1138	1418	1093	1101	1406	868	1318	1329	1138
	Profile 6	1260	1226	1702	998	1486	1604	1244	1585	1260	1226	1702	998	1486	1604	1244	1585	1260	1226	1702	998	1486	1604	1244
	Profile 7	1330	1192	1884	1094	1627	1782	1362	1682	1330	1192	1884	1094	1627	1782	1362	1682	1330	1192	1884	1094	1627	1782	1362
	Profile 8	1731	1961	2210	1488	2164	2266	1920	2088	1731	1961	2210	1488	2164	2266	1920	2088	1731	1961	2210	1488	2164	2266	1920
2005	Profile 1	973	1107	1020	838	1311	1573	1501		1602	2021	1798	1568	2068	2513	2384	1789	1602	2021	1798	1568	2068	2513	2384
	Profile 2	955	1293	1160	1128	1566	1522	1706		1783	2180	2165	1716	2299	2699	2743	2108	1783	2180	2165	1716	2299	2699	2743
	Profile 3	933	1109	1006	686	1114	1066	1191		1881	2251	2232	1752	2426	2891	2888	2468	1881	2251	2232	1752	2426	2891	2888
	Profile 4	965	1219	1170	925	1259	1593	1622		1950	2323	2254	1806	2540	2978	2982	2582	1950	2323	2254	1806	2540	2978	2982
	Profile 5	949	1158	1104	977	1390	1523	1434		1849	2282	2236	1753	2425	2866	2898	2474	1849	2282	2236	1753	2425	2866	2898
	Profile 6	1100	1276	1189	1033	1435	1651	1376		1840	2287	2169	1754	2398	2854	2905	2529	1840	2287	2169	1754	2398	2854	2905
	Profile 7	1339	1389	1336	1231	1532	1859	1494		1800	2182	2102	1687	2328	2692	2759	2367	1800	2182	2102	1687	2328	2692	2759
	Profile 8	973	1107	1020	838	1311	1573	1501		1783	2034	2033	1635	2242	2682	2699	2260	1783	2034	2033	1635	2242	2682	2699
2006	Profile 1	1224	895	1449	1247	1174	1503	979	1563	1224	895	1449	1247	1174	1503	979	1563	1224	895	1449	1247	1174	1503	979
	Profile 2	921	1032	1030	868	1067	704	861	542	921	1032	1030	868	1067	704	861	542	921	1032	1030	868	1067	704	861
	Profile 3	1071	1144	1227	1017	1061	1451	909	1204	1071	1144	1227	1017	1061	1451	909	1204	1071	1144	1227	1017	1061	1451	909
	Profile 4	1127	1185	1229	1368	1445	1603	971	1559	1127	1185	1229	1368	1445	1603	971	1559	1127	1185	1229	1368	1445	1603	971
	Profile 5	1156	1006	1294	1281	1318	1664	1077	1523	1156	1006	1294	1281	1318	1664	1077	1523	1156	1006	1294	1281	1318	1664	1077
	Profile 6	1224	1111	1232	1309	1562	1627	1126	1607	1224	1111	1232	1309	1562	1627	1126	1607	1224	1111	1232	1309	1562	1627	1126
	Profile 7	1329	1264	1361	1397	1613	1905	1112	1718	1329	1264	1361	1397	1613	1905	1112	1718	1329	1264	1361	1397	1613	1905	1112
	Prof 8	1383	1539	1538	1550	1741	2065	1149	1764	1383	1539	1538	1550	1741	2065	1149	1764	1383	1539	1538	1550	1741	2065	1149

Appendix 2.6: the 16-day albedo profile values ($*10^4$) for open rangeland during 2000-2006.

Year		JAN	JAN	FEB	FEB	MAR	MAR	APR	APR	MAY	MAY	JUN	JUN	JUL	JUL	AUG	AUG	SEP	SEP	OCT	OCT	NOV	DEC	DEC
2000	Profile 1					3913	3697	3921	4341	4458	4473	4465	4470	4398	4480	4293	4179	4064	4157	3551	3509	3449		1834
	Profile 2					4133	3884	4064	4438	4407	4432	4470	4380	4353	4416	4195	4110	4016	3982	3518	3673	3615		2495
	Profile 3				4262	4227	4006	4337	4586	4627	4662	4716	4605	4606	4682	4496	4413	4325	4520	3680	3659	3482	3198	3179
	Profile 4					4466	4118	4182	4508	4623	4558	4597	4543	4541	4590	4416	4391	4267	4191	3632	3863	3531	1763	3192
	Profile 5				4041	3996	3774	4031	4470	4470	4428	4601	4526	4529	4619	4405	4312	4192	4098	3975	3883	3656	3497	3117
	Profile 6				4040	4055	3982	3964	4451	4568	4585	4664	4581	4520	4633	4432	4409	4239	4082	3570	3653	3499		
2001	Profile 1		3598	3308	3825	4259	4572	4470	4143	4844	4798	5184	4784	4841	4737	4749	4702	4623	4604	4342	3893	3523		4026
	Profile 2		3094	2481	4243	4236	4030	4335	4337	4693	4784	4971	4760	4751	4645	4631	4550	4434	4365	4225	3932	3756	3646	3144
	Profile 3		3296		4045	4227	4278	4408	4453	4612	4722	5035	4753	4729	4652	4650	4572	4469	4447	4235	3730	3954		
	Profile 4		1959	3454	3927	4062	4179	4259	4274	4289	4495	4712	4485	4460	4360	4324	4239	4116	4069	3828	3497	3577		2022
	Profile 5	3787	3100	3602	3781	3919	3976	4198	4095	4453	4545	4800	4508	4494	4355	4334	4287	4175	4094	3937	3215	3946	3825	3457
	Profile 6	3290	2476	2851	2929	3254	3596	3962	4267	4280	4495	4662	4594	4572	4465	4441	4377	4210	4126	3796	3543	3303		2296
2002	Profile 1	2496	4270	4264	4385	4312		4443			4538	4556	4570	4502	4509	4396	4479	4374	4067	3739	3393	3906	1812	2417
	Profile 2	3237	4039	4131	4170	4600		4513			4601	4640	4630	4556	4529	4485	4407	4317	4069	3868	3437	3674		1924
	Profile 3			3420	3508	3528		4013			4239	4399	4470	4355	4338	4225	4200	4081	3786	3456	3719	3977		
	Profile 4	2352	2749	3133	3263	3812		4004			4227	4325	4346	4308	4304	4245	4172	4037	3787	3594	3377	3744	3486	2090
	Profile 5	2009	3081	3226	3372	3589		3752			3986	4098	4125	4030	4001	3941	3821	3697	3361	3216	3193	3125		1797
	Profile 6	2271		3481	3500	4018		4117			4202	4308	4275	4236	4176	4192	4079	3959	3756	3644	3566	3392		
2003	Profile 1	4071	3658		4526	3750	3819	4044	4335	4488	4586	4629	4651	4577	4494	4466	4240	4393	4354	3901	4168	4533	3043	3804
	Profile 2	3357	2981		723	3383	3397	3909	4024	4169	4214	4292	4271	4286	4198	4196	4184	4078	3972	3742	3460	3751	2751	2783
	Profile 3		3923		3529	3157	3172	3495	3950	4249	4302	4291	4289	4307	4197	4189	4150	4070	3912	3680	3522	3845	2996	
	Profile 4				3919	3913	3179	3691	3986	4123	4323	4362	4397	4366	4314	4257	4231	4173	4129	3575	3694	3712		948
	Profile 5	3401	3575	2722	2976	2641	2313	2848	3389	3670	3986	4098	4117	4142	4026	4041	4021	3938	3873	3741	3442	3384	2451	3364
	Profile 6		3171	1905	1230	1821	1486	1871	2580	3192	3584	3798	3954	3938	3810	3823	3802	3794	3371	3377	3229	3472		
2004	Profile 1	3806	3474	3772	4018	4239	4296	4361	4710	4632	4652	4672	4691	4667	4654	4521	4489	4269	3924	3615	2432	4056	3974	
	Profile 2		3310		3513	3822	4018	4014	4391	4407	4362	4488	4477	4475	4428	4300	4258	4174	4012	3636				
	Profile 3		3193	1352	3824	3788	3900	3989	4172	4318	4377	4437	4443	4354	4345	4258	4154	4129	3911	3864	2439			
	Profile 4	2953	2218	2363	2057	2468	2951	3345	3829	3999	4100	4285	4299	4289	4203	4052	4023	3977	3635	3597	2072	3642		
	Profile 5	2407	1993	2179	2002	2373	2936	3208	3579	3716	3755	3859	3864	3897	3846	3746	3657	3618	3379	3232	2511	3066	2795	
	Profile 6	2985	2952	2583	2772	2979	3356	3613	3874	4072	3990	4051	4109	4158	4029	3938	3840	3773	3540	3186	2888	3417	3469	
2005	Profile 1	2364		1635	3062	3180	3426	3619		4098	4267	4372	4448	4372	4369	4260	4189	3945	3955	3713	3502	3286	2714	
	Profile 2			2338	3947	3997	4159	4339		4314	4370	4375	4606	4458	4504	4254	4254	4120	4002	4050	3790	3738	3559	3588
	Profile 3	3344	2694	2250	3096	3171	3405	3621		4181	4349	4228	4344	4211	4183	4049	4009	3849	3655	3494	3090	3106	3219	
	Profile 4			1905	3765	3816	3906	3971		4529	4597	4603	4628	4577	4608	4500	4399	4302	3964	3805	3300	3691	3712	1206
	Profile 5	3193	3293	1996	2962	3055	3212	3450		3971	4261	4292	4371	4255	4259	4144	4101	3994	3854	3788	3422	3243	3221	1691
	Profile 6			1662	2793	2671	2866	3342		3847	4200	4257	4379	4277	4324	4185	4194	4061	4042	3998	3677	3637	3494	
2006	Profile 1	3736	3825	2915	4169	4001	4265	4108	4507	4584	4461	4367	4260	4263	4071	4059	4124	4114	3966	3757	3528	3598	3718	3469
	Profile 2		3188	2064	3778	3689	3986	4054	4275	4369	4336	4430	4374	4401	4275	4136	4062	4026	3872	3369	3826	3711	3666	3379
	Profile 3				3398	3667	3840	3898	4252	4411	4353	4531	4488	4504	4441	4220	4193	4219	4057	3482	3759	3692		
	Profile 4	1781	3653		4071	4070	4269	4241	4309	4590	4538	4668	4580	4620	4589	4517	4398	4287	4302	3910	4049	3807		3674
	Profile 5	2045	3046		3322	3068	3502	3565	4015	4342	4268	4445	4390	4455	4339	4180	4110	4124	4028	3270	3902	3499		2703
	Profile 6				3193	3043	3304	3515	3944	4381	4353	4540	4484	4567	4460	4374	4201	4176	4017	3218	3680			

Appendix 3: Rainfall data in Irbid and Mafraq weather stations during 2000-2005.

Appendix 3.1: Total monthly rainfall (mm) in Irbid weather station during 2000-2005.

Month\Year	2000	2001	2002	2003	2004	2005
January	222.2	53.3	133.3	54.6	125.4	89.3
February	68.3	82	40.4	317.3	111.6	186.8
March	44.7	17.4	117.7	214.7	28.7	19.4
April	2.3	3.9	65.8	39.3	2.5	12.3
May	0	11.6	4	0.2	3.8	16.6
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	22.2	6.9	14.9	15.5	26	2.3
November	3	51.1	36.3	15	129.3	41.3
December	84.2	74.5	205.1	89.7	20.4	79.6
Total	446.9	300.7	617.5	746.3	447.7	447.6

Source: www.jometeo.gov.jo

Appendix 3.2: Total monthly rainfall (mm) in Mafraq weather station during 2000-2005.

Month\Year	2000	2001	2002	2003	2004	2005
January	56.4	38.9	81.4	20.8	23.6	23.8
February	8.3	26.9	13.9	64.7	21.9	35.9
March	21.6	12.7	39	31.1	1	12.3
April	0	5.9	17.2	1.2	1	13.1
May	0	4.2	0	0	4	3
June	0	0	0	0	0	0.1
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	11.7	0.8	0.5	0	2.3	3.7
November	0	24.6	18.5	16.6	37.5	11.3
December	45.5	32.4	65.2	54.6	14.4	20.5
Total	143.5	146.4	235.7	189	105.7	123.7

Source:www.jometeo.gov.jo

Appendix 4: Statistical analysis (ANOVA).

Appendix 4.1: ANOVA results of yearly NDVI profile values during 2000-2006.

NDVI for Protected Rangeland						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	244464.3	1	244464.3	3.714028	0.077962	4.747225
Within Groups	789862.6	12	65821.88			
Total	1034327	13				
NDVI for Open Rangeland						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	5332867	5	1066573	26.64369	3.61E-11	2.477169
Within Groups	1441116	36	40030.99			
Total	6773983	41				
NDVI for Urban Areas						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	5259378	2	2629689	114.9134	5.62E-11	3.554557
Within Groups	411913.6	18	22884.09			
Total	5671292	20				
NDVI for Irrigated Areas						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	1469233	3	489744.3	5.817559	0.003897	3.008787
Within Groups	2020412	24	84183.82			
Total	3489645	27				
NDVI for Barley						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	179328.6	2	89664.28	2.160807	0.144186	3.554557
Within Groups	746923.1	18	41495.73			
Total	926251.6	20				
NDVI for Wheat/MAA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	3692865	7	527552.1	6.891271	1.12E-05	2.207436
Within Groups	3674576	48	76553.67			
Total	7367441	55				

Appendix 4.2: ANOVA results of yearly albedo profile values during 2000-2006.

Albedo for Protected Rangeland						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	330632.5	1	330632.5	1.522373	0.240881	4.747225
Within Groups	2606187	12	217182.3			
Total	2936820	13				
Albedo for Open Rangeland						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	1939747	5	387949.5	3.232134	0.016393	2.477169
Within Groups	4321041	36	120028.9			
Total	6260789	41				
Albedo for Urban areas						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	348188.3	2	174094.1	7.441742	0.004412	3.554557
Within Groups	421096.9	18	23394.27			
Total	769285.2	20				
Albedo for Irrigated areas						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	1056160	3	352053.4	1.861249	0.163142	3.008787
Within Groups	4539576	24	189149			
Total	5595736	27				
Albedo for Barley						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	227414.3	2	113707.2	1.70375	0.210068	3.554557
Within Groups	1201309	18	66739.36			
Total	1428723	20				
Albedo for Wheat/MAA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	5926205	7	846600.7	46.95711	2.45E-19	2.207436
Within Groups	865403.1	48	18029.23			
Total	6791608	55				

Appendix 4.3 : ANOVA results of monthly NDVI for protected rangeland during 2000-2006.

Monthly NDVI profile values-2000						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	647957	1	647957	16.1944	0.000263	4.098172
Within Groups	1520425	38	40011			
Total	2168382	39				
Monthly NDVI profile values -2001						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	741680	1	741680	3.954256	0.052995	4.061706
Within Groups	8252859	44	187565			
Total	8994539	45				
Monthly NDVI profile values -2002						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	4413783	1	4413783	21.00395	3.77E-05	4.061706
Within Groups	9246185	44	210140.6			
Total	13659968	45				
Monthly NDVI profile values-2003						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	11700820	1	11700820	9.221158	0.004099	4.072654
Within Groups	53294224	42	1268910			
Total	64995045	43				
Monthly NDVI profile values-2004						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	7947500	1	7947500	11.0426	0.001853	4.072654
Within Groups	30227938	42	719713			
Total	38175438	43				
Monthly NDVI profile values-2005						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	4476642	1	4476642	9.212902	0.004213	4.084746
Within Groups	19436402	40	485910			
Total	23913044	41				
Monthly NDVI profile values-2006						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2988978	1	2988978	14.20617	0.000505	4.072654
Within Groups	8836800	42	210400			
Total	11825778	43				

Appendix 4.4: ANOVA results of monthly NDVI for protected rangeland during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	44930.06	1	44930.06	0.234572	0.631088	4.113165
Within Groups	6895455	36	191540.4			
Total	6940385	37				
Monthly albedo profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	657263.6	1	657263.6	1.625835	0.209289	4.072654
Within Groups	16979011	42	404262.2			
Total	17636275	43				
Monthly albedo profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	505350.4	1	505350.4	1.148351	0.290654	4.098172
Within Groups	16722514	38	440066.2			
Total	17227864	39				
Monthly albedo profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	4454440	1	4454440	17.57014	0.000135	4.067047
Within Groups	10901501	43	253523.3			
Total	15355941	44				
Monthly albedo profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	2735520	1	2735520	6.85796	0.012503	4.091278
Within Groups	15556416	39	398882.5			
Total	18291936	40				
Monthly albedo profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	1322198	1	1322198	3.227695	0.079957	4.084746
Within Groups	16385658	40	409641.4			
Total	17707855	41				
Monthly albedo profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	911965.7	1	911965.7	2.09904	0.154817	4.072654
Within Groups	18247654	42	434468			
Total	19159620	43				

Appendix 4.5: ANOVA results of monthly NDVI for open rangeland during 2000-2006.

Monthly NDVI profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**10476026.67**	**5**	**2095205**	**52.20285**	**6.55E-28**	**2.293911**
Within Groups	**4575486**	**114**	**40135.84**			
Total	**15051512.67**	**119**				
Monthly NDVI profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**17084489.78**	**5**	**3416898**	**29.24163**	**6.87E-20**	**2.282856**
Within Groups	**15424258.35**	**132**	**116850.4**			
Total	**32508748.12**	**137**				
Monthly NDVI profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**22302198.09**	**5**	**4460440**	**28.07583**	**2.7E-19**	**2.282856**
Within Groups	**20970993.57**	**132**	**158871.2**			
Total	**43273191.65**	**137**				
Monthly NDVI profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13661813.45**	**5**	**2732363**	**8.203548**	**9.85E-07**	**2.286184**
Within Groups	**41966928.18**	**126**	**333070.9**			
Total	**55628741.64**	**131**				
Monthly NDVI profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**23360873.52**	**5**	**4672175**	**14.38686**	**3.88E-11**	**2.286184**
Within Groups	**40918871**	**126**	**324752.9**			
Total	**64279744.52**	**131**				
Monthly NDVI profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**11485693.71**	**5**	**2297139**	**8.190033**	**1.11E-06**	**2.289851**
Within Groups	**33657573.71**	**120**	**280479.8**			
Total	**45143267.43**	**125**				
Monthly NDVI profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**7000808.879**	**5**	**1400162**	**11.63335**	**2.98E-09**	**2.286184**
Within Groups	**15165048.45**	**126**	**120357.5**			
Total	**22165857.33**	**131**				

Appendix 4.6: ANOVA results of monthly albedo for open rangeland during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**840725.4**	**5**	**168145.1**	**0.595422**	**0.703487**	**2.299234**
Within Groups	**30216446**	**107**	**282396.7**			
Total	**31057171**	**112**				
Monthly albedo profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**5756953**	**5**	**1151391**	**3.342637**	**0.007277**	**2.288588**
Within Groups	**42023595**	**122**	**344455.7**			
Total	**47780547**	**127**				
Monthly albedo profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**6315755**	**5**	**1263151**	**2.5182**	**0.033691**	**2.296868**
Within Groups	**55176958**	**110**	**501608.7**			
Total	**61492713**	**115**				
Monthly albedo profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**15917534**	**5**	**3183507**	**7.021716**	**8.67E-06**	**2.289851**
Within Groups	**54405623**	**120**	**453380.2**			
Total	**70323157**	**125**				
Monthly albedo profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**16861990**	**5**	**3372398**	**8.540653**	**6.4E-07**	**2.291828**
Within Groups	**46199109**	**117**	**394864.2**			
Total	**63061099**	**122**				
Monthly albedo profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**3727631**	**5**	**745526.3**	**1.484166**	**0.200279**	**2.29251**
Within Groups	**58269125**	**116**	**502320**			
Total	**61996757**	**121**				
Monthly albedo profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**2090202**	**5**	**418040.4**	**1.489008**	**0.198707**	**2.29251**
Within Groups	**32567117**	**116**	**280751**			
Total	**34657319**	**121**				

Appendix 4.7: ANOVA results of monthly NDVI for urban areas during 2000-2006.

Monthly NDVI profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13792359.43**	**2**	**6896180**	**22.64386**	**5.79E-08**	**3.158843**
Within Groups	**17359332.75**	**57**	**304549.7**			
Total	**31151692.18**	**59**				
Monthly NDVI profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**14888861.83**	**2**	**7444431**	**55.14805**	**8.3E-15**	**3.135918**
Within Groups	**8909335.13**	**66**	**134989.9**			
Total	**23798196.96**	**68**				
Monthly NDVI profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**25382548.29**	**2**	**12691274**	**44.19491**	**6.62E-13**	**3.135918**
Within Groups	**18952954.26**	**66**	**287166**			
Total	**44335502.55**	**68**				
Monthly NDVI profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**14144300.21**	**2**	**7072150**	**22.27596**	**4.82E-08**	**3.142809**
Within Groups	**20001182.23**	**63**	**317479.1**			
Total	**34145482.44**	**65**				
Monthly NDVI profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13037955.36**	**2**	**6518978**	**31.57278**	**3.18E-10**	**3.142809**
Within Groups	**13007902.23**	**63**	**206474.6**			
Total	**26045857.59**	**65**				
Monthly NDVI profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**19551790.22**	**2**	**9775895**	**33.49873**	**1.7E-10**	**3.150411**
Within Groups	**17509728.86**	**60**	**291828.8**			
Total	**37061519.08**	**62**				
Monthly NDVI profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**11780981.12**	**2**	**5890491**	**65.34689**	**4.32E-16**	**3.142809**
Within Groups	**5678937.318**	**63**	**90141.86**			
Total	**17459918.44**	**65**				

Appendix 4.8: ANOVA results of monthly albedo for urban areas during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13988288.63**	**2**	**6994144**	**32.55293**	**3.72E-10**	**3.158843**
Within Groups	**12246707.1**	**57**	**214854.5**			
Total	**26234995.73**	**59**				
Monthly albedo profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**16037246.23**	**2**	**8018623**	**23.02832**	**3.79E-08**	**3.150411**
Within Groups	**20892421.32**	**60**	**348207**			
Total	**36929667.56**	**62**				
Monthly albedo profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13704016.89**	**2**	**6852008**	**27.45033**	**3.43E-09**	**3.150411**
Within Groups	**14976886.76**	**60**	**249614.8**			
Total	**28680903.65**	**62**				
Monthly albedo profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**1194281.855**	**2**	**597140.9**	**2.088835**	**0.131942**	**3.135918**
Within Groups	**18867595.48**	**66**	**285872.7**			
Total	**20061877.33**	**68**				
Monthly albedo profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**2228376.121**	**2**	**1114188**	**3.260169**	**0.044947**	**3.142809**
Within Groups	**21530736.5**	**63**	**341757.7**			
Total	**23759112.62**	**65**				
Monthly albedo profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**3227589.303**	**2**	**1613795**	**4.086415**	**0.021445**	**3.142809**
Within Groups	**24879769.32**	**63**	**394917**			
Total	**28107358.62**	**65**				
Monthly albedo profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**2099018.812**	**2**	**1049509**	**3.611643**	**0.032473**	**3.135918**
Within Groups	**19178977.83**	**66**	**290590.6**			
Total	**21277996.64**	**68**				

Appendix 4.9 : ANOVA results of monthly NDVI for irrigated areas during 2000-2006.

Monthly NDVI profile values-2000						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	13199985.63	2	6599993	76.6896	6.87E-17	3.158843
Within Groups	4905484.1	57	86061.12			
Total	18105469.73	59				
Monthly NDVI profile values -2001						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2948617.076	3	982872.4	7.487459	0.000161	2.708187
Within Groups	11551685.48	88	131269.2			
Total	14500302.55	91				
Monthly NDVI profile values -2002						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	11153185.95	3	3717729	10.18632	7.96E-06	2.708187
Within Groups	32117589.22	88	364972.6			
Total	43270775.16	91				
Monthly NDVI profile values-2003						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	16218041.86	3	5406014	3.657215	0.015652	2.713227
Within Groups	124166941.7	84	1478178			
Total	140384983.6	87				
Monthly NDVI profile values-2004						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	9029737.5	3	3009913	3.920155	0.011347	2.713227
Within Groups	64495578.82	84	767804.5			
Total	73525316.32	87				
Monthly NDVI profile values-2005						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	3201380.667	3	1067127	1.976271	0.124171	2.718785
Within Groups	43197587.9	80	539969.8			
Total	46398968.57	83				
Monthly NDVI profile values-2006						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	6012408.943	3	2004136	12.92528	5.07E-07	2.713227
Within Groups	13024663.95	84	155055.5			
Total	19037072.9	87				

Appendix 4.10: ANOVA results of monthly albedo for irrigated areas during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	17197782.34	3	5732594	12.76653	7.67E-07	2.724944
Within Groups	34126501.05	76	449032.9			
Total	51324283.39	79				
Monthly albedo profile values -2001						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	3276956.565	3	1092319	3.059731	0.032359	2.708187
Within Groups	31415855.91	88	356998.4			
Total	34692812.48	91				
Monthly albedo profile values -2002						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	3983879.857	3	1327960	3.157365	0.029196	2.718785
Within Groups	33647300.95	80	420591.3			
Total	37631180.81	83				
Monthly albedo profile values-2003						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	12573691.42	3	4191230	11.40028	2.18E-06	2.708187
Within Groups	32352566.78	88	367642.8			
Total	44926258.21	91				
Monthly albedo profile values-2004						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	7830741.398	3	2610247	8.754611	4.07E-05	2.713227
Within Groups	25045175.59	84	298156.9			
Total	32875916.99	87				
Monthly albedo profile values-2005						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	574905.5	3	191635.2	0.418454	0.740217	2.713227
Within Groups	38468638.09	84	457960			
Total	39043543.59	87				
Monthly albedo profile values-2006						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	8449846.467	3	2816615	9.637065	1.45E-05	2.708187
Within Groups	25719672.26	88	292269			
Total	34169518.73	91				

Appendix 4.11: ANOVA results of monthly NDVI for barley during 2000-2006.

Monthly NDVI profile values-2000						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	407904.1	2	203952.1	4.080677	0.022066	3.158843
Within Groups	2848857.15	57	49979.95			
Total	3256761.25	59				
Monthly NDVI profile values -2001						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	305479.3913	2	152739.7	1.566435	0.216451	3.135918
Within Groups	6435518.348	66	97507.85			
Total	6740997.739	68				
Monthly NDVI profile values -2002						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	4039585.507	2	2019793	3.974041	0.023462	3.135918
Within Groups	33544270.26	66	508246.5			
Total	37583855.77	68				
Monthly NDVI profile values-2003						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	401770.6364	2	200885.3	0.282667	0.754722	3.142809
Within Groups	44772806.23	63	710679.5			
Total	45174576.86	65				
Monthly NDVI profile values-2004						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	828486.0303	2	414243	1.076836	0.346858	3.142809
Within Groups	24235173.5	63	384685.3			
Total	25063659.53	65				
Monthly NDVI profile values-2005						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	4825.365079	2	2412.683	0.011763	0.988308	3.150411
Within Groups	12306652.29	60	205110.9			
Total	12311477.65	62				
Monthly NDVI profile values-2006						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	2612942.939	2	1306471	13.7581	1.1E-05	3.142809
Within Groups	5982490.045	63	94960.16			
Total	8595432.985	65				

Appendix 4.12: ANOVA results of monthly albedo for barley during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**584366.5333**	**2**	**292183.3**	**0.920801**	**0.404041**	**3.158843**
Within Groups	**18086904.45**	**57**	**317314.1**			
Total	**18671270.98**	**59**				
Monthly albedo profile values -2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**1346775.739**	**2**	**673387.9**	**3.211612**	**0.046664**	**3.135918**
Within Groups	**13838410.7**	**66**	**209672.9**			
Total	**15185186.43**	**68**				
Monthly albedo profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**924724.0317**	**2**	**462362**	**0.866714**	**0.425526**	**3.150411**
Within Groups	**32007925.05**	**60**	**533465.4**			
Total	**32932649.08**	**62**				
Monthly albedo profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**1113943.507**	**2**	**556971.8**	**1.152973**	**0.321973**	**3.135918**
Within Groups	**31882923.13**	**66**	**483074.6**			
Total	**32996866.64**	**68**				
Monthly albedo profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**775885.9394**	**2**	**387943**	**0.929683**	**0.400025**	**3.142809**
Within Groups	**26288965.82**	**63**	**417285.2**			
Total	**27064851.76**	**65**				
Monthly albedo profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**3110735.03**	**2**	**1555368**	**3.549002**	**0.034634**	**3.142809**
Within Groups	**27610058.14**	**63**	**438254.9**			
Total	**30720793.17**	**65**				
Monthly albedo profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**1250530.116**	**2**	**625265.1**	**2.303826**	**0.107855**	**3.135918**
Within Groups	**17912594.7**	**66**	**271402.9**			
Total	**19163124.81**	**68**				

Appendix 4.13 : ANOVA results of monthly NDVI for wheat/MAA during (2000-2006).

Monthly NDVI profile values-2000						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	28993016.78	7	4141860	5.386657	1.56E-05	2.070311
Within Groups	116874473.6	152	768911			
Total	145867490.4	159				
Monthly NDVI profile values -2001						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	7946260.082	7	1135180	2.105344	0.045269	2.061938
Within Groups	94897388	176	539189.7			
Total	102843648.1	183				
Monthly NDVI profile values -2002						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	18948463.26	7	2706923	1.506196	0.167848	2.061938
Within Groups	316305704.8	176	1797192			
Total	335254168	183				
Monthly NDVI profile values-2003						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	6564565.267	7	937795	0.843827	0.552524	2.06446
Within Groups	186708403.6	168	1111360			
Total	193272968.9	175				
Monthly NDVI profile values-2004						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	12011607.7	7	1715944	1.867246	0.077849	2.06446
Within Groups	154387076.5	168	918970.7			
Total	166398684.2	175				
Monthly NDVI profile values-2005						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	13336267.5	7	1905181	1.352266	0.22924	2.067237
Within Groups	225420785.1	160	1408880			
Total	238757052.6	167				
Monthly NDVI profile values-2006						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	6322487.795	7	903212.5	2.117781	0.044266	2.06446
Within Groups	71650318.36	168	426490			
Total	77972806.16	175				

Appendix 4.14: ANOVA results of monthly albedo for wheat/MAA during 2000-2006.

Monthly albedo profile values-2000						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**12043837.88**	**7**	**1720548**	**8.761448**	**5E-09**	**2.070311**
Within Groups	**29849329.5**	**152**	**196377.2**			
Total	**41893167.38**	**159**				
Monthly albedo profile values f-2001						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**11613831.78**	**7**	**1659119**	**9.288557**	**9.04E-10**	**2.061938**
Within Groups	**31437057.22**	**176**	**178619.6**			
Total	**43050888.99**	**183**				
Monthly albedo profile values -2002						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**13389274.99**	**7**	**1912754**	**10.6699**	**5.44E-11**	**2.067237**
Within Groups	**28682604**	**160**	**179266.3**			
Total	**42071878.99**	**167**				
Monthly albedo profile values-2003						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**11013193.3**	**7**	**1573313**	**8.753563**	**3.23E-09**	**2.061938**
Within Groups	**31633191.65**	**176**	**179734**			
Total	**42646384.96**	**183**				
Monthly albedo profile values-2004						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**15042618.99**	**7**	**2148946**	**10.81474**	**3.16E-11**	**2.06446**
Within Groups	**33382492.23**	**168**	**198705.3**			
Total	**48425111.22**	**175**				
Monthly albedo profile values-2005						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**14878915.9**	**7**	**2125559**	**9.215666**	**1.25E-09**	**2.06446**
Within Groups	**38748582.32**	**168**	**230646.3**			
Total	**53627498.22**	**175**				
Monthly albedo profile values-2006						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F critical**
Between Groups	**11335162.26**	**7**	**1619309**	**8.889266**	**2.34E-09**	**2.061938**
Within Groups	**32060954.35**	**176**	**182164.5**			
Total	**43396116.6**	**183**				

Appendix 5: Statistical analysis (Z-test)

Appendix 5.1: Z-test results of monthly NDVI profile values for 6 classes /2000

z-Test: Two Sample for Means	Wheat/MAA+ Barley y		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2228	1261	2228	1588	2228	1910
Known Variance	917406	55199	917406	527995	917406	256248
Observations	160	60	160	60	160	92
Hypothesized Mean Difference	0		0.0000		0.0000	
z	11.85		5.31		3.44	
P(Z<=z) one-tail	0		0.0000		0.0003	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0006	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+ Protected Rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2228	1219	2228	1223	1261	1588
Known Variance	917406	126483	917406	76188	55199	527995
Observations	160	120	160	40	60	60
Hypothesized Mean Difference	0		0		0	
z	12.24		11.49		-3.32	
P(Z<=z) one-tail	0		0.0000		0.0005	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0009	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1261	1910	1261	1219	1261	1223
Known Variance	55199	256248	55199	126483	55199	76188
Observations	60	92	60	120	60	40
Hypothesized Mean Difference	0		0.0000		0.0000	
z	-10.66		0.93		0.70	
P(Z<=z) one-tail	0		0.1756		0.2414	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.3512		0.4828	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.1: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1588	1910	1219	1910	1219	1223
Known Variance	527995	256248	527995	126483	527995	76188
Observations	60	92	120	92	120	40
Hypothesized Mean Difference	0		0		0	
z	-2.99		-9.09		-0.05	
P(Z<=z) one-tail	0.00		0.0000		0.4793	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.9587	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1910	1219	1910	1223	1219	1223
Known Variance	256248	126483	256248	76188	126483	76188
Observations	92	120	92	40	120	40
Hypothesized Mean Difference	0		0.0000		0.0000	
z	11.14		10.02		-0.08	
P(Z<=z) one-tail	0		0.0000		0.4698	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.9397	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.2: Z-test results of monthly NDVI profile values for 6 classes /2001.

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2070	1260	2070	1537	2070	1470
Known Variance	561987	99132	561987	349973	561987	159344
Observations	184	69	184	69	184	92
Hypothesized Mean Difference	0		0.0000		0.0000	
z	12.08		5.92		8.67	
P(Z<=z) one-tail	0		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2070	1228	2070	1306	1260	1537
Known Variance	561987	237290	561987	199879	99132	349973
Observations	184	138	184	44	69	69
Hypothesized Mean Difference	0		0		0	
z	12.19		8.76		-3.43	
P(Z<=z) one-tail	0		0.0000		0.0003	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0006	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1260	1470	1260	1228	1260	1306
Known Variance	99132	159344	99132	237290	99132	199879
Observations	69	92	69	138	69	44
Hypothesized Mean Difference	0		0.0000		0.0000	
z	-3.73		0.58		-0.59	
P(Z<=z) one-tail	9.58787E-05		0.2816		0.2762	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.000191757		0.5633		0.5524	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.2: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1537	1470	1537	1228	1537	1306
Known Variance	349973	159344	349973	237290	349973	199879
Observations	69	92	69	138	69	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	0.81		3.75		2.35	
P(Z<=z) one-tail	0.21		0.0001		0.0094	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.42		0.0002		0.0188	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1470	1228	1470	1306	1228	1306
Known Variance	159344	237290	159344	199879	237290	199879
Observations	92	138	92	44	138	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	4.13		2.07		-0.99	
P(Z<=z) one-tail	1.84337E-05		0.0192		0.1609	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	3.68675E-05		0.0384		0.3217	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.3: Z-test results of monthly NDVI profile values for 6 classes /2002

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2504	1601	2504	1881	2504	1910
Known Variance	1831990	552704	1831990	525315	1831990	475503
Observations	184	69	184	66	184	92
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	6.74		4.66		4.83	
P(Z<=z) one-tail	8.14593E-12		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	1.62919E-11		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2504	1449	2504	1698	1601	1881
Known Variance	1831990	315863	1831990	303555	552704	525315
Observations	184	138	184	46	69	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	9.53		6.26		-2.21	
P(Z<=z) one-tail	0.0000		0.0000		0.0134	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0268	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1601	1910	1601	1449	1601	1698
Known Variance	552704	475503	552704	315863	552704	303555
Observations	69	92	69	138	69	46
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-2.69		1.49		-0.80	
P(Z<=z) one-tail	0.003542323		0.0676		0.2117	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.007084646		0.1352		0.4233	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.3: continued.

z-Test: Two Sample for Means	Urban + Irrigated		Urban+Open Rangeland		Urban +Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1881	1910	1881	1449	1881	1698
Known Variance	525315	475503	525315	315863	525315	303555
Observations	66	92	66	138	66	46
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-0.26		4.26		1.52	
P(Z<=z) one-tail	0.40		0.0000		0.0646	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.80		0.0000		0.1293	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated + Open Rangeland		Irrigated +Protected Rangeland		Open Rangeland +Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1910	1449	1910	1698	1449	1698
Known Variance	475503	315863	475503	303555	315863	303555
Observations	92	138	92	46	138	46
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	5.34		1.96		-2.63	
P(Z<=z) one-tail	4.77156E-08		0.0251		0.0042	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	9.54312E-08		0.0503		0.0084	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.4 : Z-test results of monthly NDVI profile values for 6 classes /2003.

-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA +Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2579	1885	2579	1881	2579	2631
Known Variance	1104417	694993	1104417	525315	1104417	1613621
Observations	176	66	176	66	176	88
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	5.35		5.85		-0.33	
P(Z<=z) one-tail	4.31075E-08		0.0000		0.3711	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	8.62151E-08		0.0000		0.7422	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	**Wheat/MAA+Open Rangeland**		**Wheat/MAA+protected rangeland**		**Barley+Urban**	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2579	1519	2371	1519	1885	1881
Known Variance	1104417	424647	1104417	1511513	694993	525315
Observations	176	132	44	132	66	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	10.88		4.46		0.03	
P(Z<=z) one-tail	0.0000		0.0000		0.4870	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.9740	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	**Barley+Irrigated**		**Barley+Open Rangeland**		**Barley+ Protected Rangeland**	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1885	2631	1885	1519	1885	2371
Known Variance	694993	1613621	694993	424647	694993	1511513
Observations	66	88	66	132	66	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-4.39		3.12		-2.30	
P(Z<=z) one-tail	5.70718E-06		0.0009		0.0108	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	1.14144E-05		0.0018		0.0217	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.4: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1881	2631	1881	1519	1881	2371
Known Variance	525315	1613621	525315	424647	525315	1511513
Observations	66	88	66	132	66	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-4.63		3.42		-2.39	
P(Z<=z) one-tail	0.00		0.0003		0.0085	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0006		0.0170	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2631	1519	2631	2371	1519	2371
Known Variance	1613621	424647	1613621	1511513	424647	1511513
Observations	88	132	88	44	132	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	7.57		1.13		-4.40	
P(Z<=z) one-tail	1.83187E-14		0.1294		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	3.66374E-14		0.2589		0.0000	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.5: Z-test results of monthly NDVI profile values for 6 classes /2004

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2366	1885	2366	1881	2366	2631
Known Variance	950850	694993	950850	525315	950850	1613621
Observations	176	66	176	66	176	88
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	3.81		4.20		-1.72	
P(Z<=z) one-tail	6.89723E-05		0.0000		0.0430	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.000137945		0.0000		0.0861	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2366	1555	2366	1930	1612	1788
Known Variance	950850	490685	950850	887801	385595	400706
Observations	176	132	176	44	66	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	8.49		2.72		-1.61	
P(Z<=z) one-tail	0		0.0032		0.0540	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0064		0.1081	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1612	2240	1612	1555	1612	1930
Known Variance	385595	845119	385595	490685	385595	887801
Observations	66	88	66	132	66	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-5.05		0.59		-1.97	
P(Z<=z) one-tail	2.1819E-07		0.2783		0.0244	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	4.36379E-07		0.5566		0.0487	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.5: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1788	2240	1788	1555	1788	1930
Known Variance	400706	845119	400706	490685	400706	887801
Observations	66	88	66	132	66	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-3.61		2.35		-0.88	
P(Z<=z) one-tail	0.00		0.0093		0.1895	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0186		0.3789	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2240	1555	2240	1930	1555	1930
Known Variance	845119	490685	845119	887801	490685	887801
Observations	88	132	88	44	132	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	5.94		1.80		-2.43	
P(Z<=z) one-tail	1.43809E-09		0.0362		0.0076	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	2.87618E-09		0.0725		0.0152	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.6: Z-test results of monthly NDVI profile values for 6 classes /2005

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2583	1407	2583	1788	2583	2240
Known Variance	1429683	198572	1429683	400706	1429683	845119
Observations	168	63	168	66	168	88
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	10.89		6.59		2.55	
P(Z<=z) one-tail	0.0000		0.0000		0.0054	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0108	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2583	1555	2583	1930	1407	1788
Known Variance	1429683	490685	1429683	887801	8247266283	400706
Observations	168	132	168	44	63	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	9.30		3.86		-0.03	
P(Z<=z) one-tail	0.0000		0.0001		0.4867	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0001		0.9735	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1407	1897	1407	1474	1407	1670
Known Variance	198572	559024	198572	361146	198572	583245
Observations	63	84	63	126	63	42
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-4.95		-0.86		-2.01	
P(Z<=z) one-tail	3.75547E-07		0.1950		0.0222	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	7.51095E-07		0.3900		0.0444	

Appendix 5.6: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	**1783**	**1897**	**1783**	**1474**	**1783**	**1670**
Known Variance	**597766**	**559024**	**597766**	**361146**	**597766**	**583245**
Observations	**63**	**84**	**63**	**126**	**63**	**42**
Hypothesized Mean Difference	**0.0000**		**0.0000**		**0.0000**	
z	**-0.90**		**2.78**		**0.74**	
P(Z<=z) one-tail	**0.18**		**0.0027**		**0.2294**	
z Critical one-tail	**1.64**		**1.64**		**1.64**	
P(Z<=z) two-tail	**0.37**		**0.0054**		**0.4588**	
z Critical two-tail	**1.96**		**1.96**		**1.96**	
z-Test: Two Sample for Means	**Irrigated+Open Rangeland**		**Irrigated+Protected Rangeland**		**Open Rangeland+Protected Rangeland**	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	**1897**	**1474**	**1897**	**1670**	**1474**	**1670**
Known Variance	**559024**	**361146**	**559024**	**583245**	**361146**	**583245**
Observations	**84**	**126**	**84**	**42**	**126**	**42**
Hypothesized Mean Difference	**0.0000**		**0.0000**		**0.0000**	
z	**4.34**		**1.59**		**-1.51**	
P(Z<=z) one-tail	**7.19046E-06**		**0.0562**		**0.0652**	
z Critical one-tail	**1.64**		**1.64**		**1.64**	
P(Z<=z) two-tail	**1.43809E-05**		**0.1124**		**0.1304**	
z Critical two-tail	**1.96**		**1.96**		**1.96**	

Appendix 5.7: Z-test results of monthly NDVI profile values for 6 classes /2006

	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	***Variable 2***
Mean	2135	1264	2135	1616	2135	**1657**
Known Variance	445559	317458	445559	268614	445559	**218817**
Observations	176	66	176	66	176	**88**
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	10.17		6.39		6.75	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	***Variable 2***
Mean	2135	1403	2135	1448	1264	**1616**
Known Variance	445559	169205	445559	275018	317458	**268614**
Observations	176	132	176	44	66	**66**
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	11.86		7.33		-3.73	
P(Z<=z) one-tail	0		0.0000		0.0001	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0002	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		**Barley+Protected Rangeland**	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	***Variable 2***
Mean	1264	1657	1264	1403	1264	**1448**
Known Variance	317458	218817	317458	169205	317458	**275018**
Observations	66	88	66	132	66	**44**
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-4.60		-1.78		-1.75	
P(Z<=z) one-tail	2.10201E-06		0.0378		0.0398	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	**4.20403E-06**		**0.0757**		**0.0796**	

Appendix 5.7: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1616	1657	1616	1403	1616	1448
Known Variance	268614	218817	268614	169205	268614	275018
Observations	66	88	66	132	66	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-0.51		2.91		1.65	
P(Z<=z) one-tail	0.31		0.0018		0.0497	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.61		0.0036		0.0993	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1657	1403	1657	1448	1403	1448
Known Variance	218817	169205	218817	275018	169205	275018
Observations	88	132	88	44	132	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	4.14		2.23		-0.53	
P(Z<=z) one-tail	1.70916E-05		0.0128		0.2993	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	3.41832E-05		0.0256		0.5985	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.8: Z-test results of monthly Albedo profile values for 6 classes /2000

z-Test: Two Sample for Means	Wheat/MAA+ Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1970	3658	1970	2774	1970	3611
Known Variance	263479	316462	263479	444661	263479	649674
Observations	160	60	160	60	160	60
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-20.29		-8.45		-14.70	
P(Z<=z) one-tail	0		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/ MAA+ Open Rangeland		Wheat/MAA+protected rangeland		Barley+ Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1970	4115	1970	4026	3658	2774
Known Variance	263479	277296	263479	187578	316462	444661
Observations	160	113	160	38	60	60
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-33.51		-25.34		7.85	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+ Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3658	3611	3658	4115	3658	4026
Known Variance	316462	649674	316462	277296	316462	187578
Observations	60	60	60	113	60	38
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	0.36		-5.21		-3.65	
P(Z<=z) one-tail	0.357751566		0.0000		0.0001	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.715503133		0.0000		0.0003	

Appendix 5.8: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2774	3611	2774	4115	2774	4026
Known Variance	444661	649674	444661	277296	444661	187578
Observations	60	60	60	113	60	38
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-6.20		-13.50		-11.27	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3611	4115	3611	4026	4115	4026
Known Variance	444661	277296	444661	187578	277296	187578
Observations	60	113	60	38	113	38
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-5.07		-3.73		1.04	
P(Z<=z) one-tail	1.94851E-07		0.0001		0.1495	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	3.89703E-07		0.0002		0.2989	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.9: Z-test results of monthly albedo profile values for 6 classes /2001

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	Variable 1	*Variable 2*
Mean	1908	3861	1908	2964	1908	3861
Known Variance	235251	381240	235251	595640	235251	381240
Observations	184	92	184	63	184	92
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-26.52		-10.20		-26.52	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	Variable 1	*Variable 2*
Mean	1908	4112	1908	3823	3861	2964
Known Variance	235251	376225	235251	410146	381240	595640
Observations	184	128	184	44	92	63
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-33.95		-18.60		7.69	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+ Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	Variable 1	*Variable 2*
Mean	3861	3861	3861	4112	3861	3823
Known Variance	381240	381240	381240	376225	381240	410146
Observations	92	92	92	128	92	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	0.0000		-2.99		0.33	
P(Z<=z) one-tail	0.5		0.0014		0.3709	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	1		0.0028		0.7418	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.9: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+ Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2964	3861	2964	4112	2964	3823
Known Variance	595640	381240	595640	376225	595640	410146
Observations	63	92	63	128	63	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-7.69		-10.31		-6.26	
P(Z<=z) one-tail	0.00		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3861	4112	3861	3823	4112	3823
Known Variance	381240	376225	381240	410146	376225	410146
Observations	92	128	92	44	128	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-2.99		0.33		2.62	
P(Z<=z) one-tail	0.001396271		0.3709		0.0044	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.002792543		0.7418		0.0089	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.10: Z-test results of monthly albedo profile values for 6 classes /2002

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1833	3388	1833	2442	1833	3525
Known Variance	251927	531172	251927	462595	251927	453388
Observations	168	63	168	63	168	84
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-15.61		-6.47		-20.37	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+ Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1833	3758	1833	3326	3388	2442
Known Variance	251927	534719	251927	441740	531172	462595
Observations	168	116	168	40	63	63
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-24.63		-13.33		7.54	
P(Z<=z) one-tail	0		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3388	3525	3388	3758	3388	3326
Known Variance	531172	453388	531172	534719	531172	441740
Observations	63	84	63	116	63	40
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-1.16		-3.24		0.44	
P(Z<=z) one-tail	0.122514073		0.0006		0.3285	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.245028146		0.0012		0.6570	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.10: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+ Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2442	3861	2442	3758	2442	3326
Known Variance	462595	381240	462595	534719	462595	441740
Observations	63	92	63	116	63	40
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-13.24		-12.04		-6.52	
P(Z<=z) one-tail	0.00		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3525	3758	*3524.881*	*3326.2*	3758	3326
Known Variance	453388	534719	453388	441740	534719	441740
Observations	84	116	84	40	116	40
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-2.33		1.5495		3.45	
P(Z<=z) one-tail	0.009811923		0.06		0.0003	
z Critical one-tail	1.64		1.6449		1.64	
P(Z<=z) two-tail	0.019623846		0.12		0.0006	
z Critical two-tail	1.96		1.9600		1.96	

Appendix 5.11: Z-test results of monthly albedo profile values for 6 classes /2003

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1780	2956	1780	2263	1780	3128
Known Variance	233040	485248	233040	295028	233040	493695
Observations	184	66	184	69	184	92
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-12.66		-6.49		-16.55	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1780	3687	1780	2742	2956	2263
Known Variance	233040	562585	233040	348999	485248	295028
Observations	184	126	184	45	66	69
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-25.18		-10.12		6.42	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2956	3128	2956	3687	2956	2742
Known Variance	485248	493695	485248	562585	485248	348999
Observations	66	92	66	126	66	45
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-1.53		-6.72		1.74	
P(Z<=z) one-tail	0.063627366		0.0000		0.0407	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.127254732		0.0000		0.0814	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.11: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2263	3128	2263	3687	2263	2742
Known Variance	295028	493695	295028	562585	295028	348999
Observations	69	92	69	126	69	45
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-8.80		-15.23		-4.36	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3128	3687	3128	2742	3687	2742
Known Variance	493695	562585	493695	348999	562585	348999
Observations	92	126	92	45	126	45
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-5.64		3.3714		8.55	
P(Z<=z) one-tail	8.58383E-09		0.0000		0.0000	
z Critical one-tail	1.64		1.6449		1.64	
P(Z<=z) two-tail	1.71677E-08		0.00		0.0000	
z Critical two-tail	1.96		1.9600		1.96	

Appendix 5.12: Z-test results of monthly albedo profile values for 6 classes /2004

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1800	3267	1800	2409	1800	3276
Known Variance	276715	416382	276715	1472356	276715	377884
Observations	176	66	176	66	176	88
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-16.53		-3.94		-19.28	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0001		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1800	3698	1800	3028	3267	2409
Known Variance	276715	516894	276715	516894	416382	365525
Observations	176	123	176	41	66	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-24.98		-10.32		7.88	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+ Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3267	3276	3267	3698	3267	3028
Known Variance	416382	377884	416382	516894	416382	457298
Observations	66	88	66	123	66	41
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-0.09		-4.20		1.81	
P(Z<=z) one-tail	0.464897622		0.0000		0.0353	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.929795245		0.0000		0.0706	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.12: continued

z-Test: Two Sample for Means	Urban+Irrigated		Urban+ Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2409	3276	2409	3698	2409	3028
Known Variance	1472356	377884	365525	516894	365525	457298
Observations	66	88	66	123	66	41
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-5.31		-13.05		-4.79	
P(Z<=z) one-tail	0.00		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+ Open Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3276	3698	*3276.0114*	*3028*	3698	3028
Known Variance	377884	516894	377884	457298	516894	457298
Observations	88	123	88	41	123	41
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-4.57		1.9954		5.40	
P(Z<=z) one-tail	2.39568E-06		0.02		0.0000	
z Critical one-tail	1.64		1.6449		1.64	
P(Z<=z) two-tail	4.79135E-06		0.05		0.0000	
z Critical two-tail	1.96		1.9600		1.96	

Appendix 5.13: Z-test results of monthly albedo profile values for 6 classes /2005

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1766	3158	1766	2253	1766	2989
Known Variance	306443	472628	306443	432421	306443	448776
Observations	176	66	176	66	176	88
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-14.75		-5.35		-14.79	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+ Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1766	3728	1766	3276	3158	2253
Known Variance	306443	512370	306443	431899	472628	432421
Observations	176	122	176	42	66	66
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-25.46		-13.77		7.72	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+ Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3158	2989	3158	3728	3158	3276
Known Variance	472628	448776	472628	512370	472628	431899
Observations	66	88	66	122	66	42
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	1.52		-5.35		-0.90	
P(Z<=z) one-tail	0.063737179		0.0000		0.1848	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.127474358		0.0000		0.3696	
z Critical two-tail	1.96		1.96		1.96	

Appendix 5.13: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+ Open Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2253	2989	2253	3728	2253	3276
Known Variance	432421	446776	432421	512370	432421	431899
Observations	66	88	66	122	66	42
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-6.82		-14.22		-7.88	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Irrigated+Rangeland		Irrigated+Protected Rangeland		Open Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2989	3728	*2989.0682*	*3727.901639*	3728	3276
Known Variance	448776	512370	448776	512370	512370	431899
Observations	88	122	88	122	122	42
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-7.66		-7.6616		3.75	
P(Z<=z) one-tail	9.21485E-15		0.0000		0.0001	
z Critical one-tail	1.64		1.6449		1.64	
P(Z<=z) two-tail	1.84297E-14		0.0000		0.0002	
z Critical two-tail	1.96		1.9600		1.96	

Appendix 5.14: Z-test results of monthly albedo profile values for 6 classes /2006.

z-Test: Two Sample for Means	Wheat/MAA+Barley		Wheat/MAA+Urban		Wheat/MAA+Irrigated	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1688	3512	1688	2376	1688	3179
Known Variance	237137	281811	237137	312912	237137	375489
Observations	184	69	184	69	184	92
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-24.88		-9.02		-20.35	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Wheat/MAA+ Open Rangeland		Wheat/MAA+protected rangeland		Barley+Urban	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	1688	3963	1688	3558	3512	2376
Known Variance	237137	286424	237137	445573	281811	312912
Observations	184	122	184	44	69	69
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-37.73		-17.50		12.23	
P(Z<=z) one-tail	0.0000		0.0000		0.0000	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0000	
z Critical two-tail	1.96		1.96		1.96	
z-Test: Two Sample for Means	Barley+Irrigated		Barley+ Open Rangeland		Barley+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3512	3179	3512	3963	3512	3558
Known Variance	281811	375489	281811	286424	281811	445573
Observations	69	92	69	122	69	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	3.68		-5.63		-0.39	
P(Z<=z) one-tail	0.000116136		0.0000		0.3485	
z Critical one-tail	1.64		1.64		1.64	
P(Z<=z) two-tail	0.000232272		0.0000		0.6970	

Appendix 5.14: continued.

z-Test: Two Sample for Means	Urban+Irrigated		Urban+Rangeland		Urban+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	2376	3179	2375.9275	3963.336066	2376	3558
Known Variance	312912	375489	312911.72	286424.1258	312912	445573
Observations	69	92	69	122	69	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-8.65		-19.134167		-9.76	
P(Z<=z) one-tail	0.00		0.0000		0.0000	
z Critical one-tail	1.64		1.6448536		1.64	
P(Z<=z) two-tail	0.00		0.0000		0.0000	
z Critical two-tail	1.96		1.959964		1.96	
z-Test: Two Sample for Means	Irrigated+Open Rangeland		Irrigated+Protected Rangeland		Rangeland+Protected Rangeland	
	Variable 1	*Variable 2*	*Variable 1*	*Variable 2*	*Variable 1*	*Variable 2*
Mean	3179	3963	*3178.9457*	*3558*	3963	3558
Known Variance	375489	286424	375489	445573	286424	445573
Observations	92	122	92	44	122	44
Hypothesized Mean Difference	0.0000		0.0000		0.0000	
z	-9.78		-3.1801		3.63	
P(Z<=z) one-tail	0.0000		0.0000		0.0001	
z Critical one-tail	1.64		1.6449		1.64	
P(Z<=z) two-tail	0.0000		0.0000		0.0003	
z Critical two-tail	1.96		1.9600		1.96	

مراقبة تغيرات النبات والانعكاسية لحوض اليرموك من بيانات الإاستشعار عن بعد

إعداد
هبه مشهور عبد الفتاح الخرابشه

المشرف
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ملخــــــــــــص

يهدف هذا البحث الذي تم إجراؤه على منطقة حوض اليرموك إلى دمج استخدام تقنيات الاستشعار عن بعد مع نظام المعلومات الجغرافية لتقييم و دراسة التقسيمات النباتية و الانعكاسية كمؤشرات لتدهور حالة الأرض في الحوض. لقد اعتمد أسلوب البحث على تحميل ومعالجة بيانات الاستشعار ذات العزل المكاني المتوسط ونظام المعلومات الجغرافية بالإضافة إلى برنامج لمعالجة صور الأقمار الصناعية للحصول على خارطة استعمال الأراضي للحوض و لتحليل كل من الفرق المطيع للمؤشر النباتي (NDVI) و الانعكاسية لاستعمالات الأراضي المختلفة.

لقد تم تحليل كل من الفرق المطيع للمؤشر النباتي و الانعكاسية باستخدام بيانات مرتبة زمنيا من2000-٢٠٠٦ لقراءة التغيرات السنوية و الشهرية و لقد تم دراستها بهدف الحصول على البيانات النمطية وللتعرف على دورات الاخضرار. يضاف إلى ذلك دراسة العلاقة بين الفرق المطيع للمؤشر النباتي و معدل تساقط الأمطار في المنطقة بغية معرفة سبب تدهور الأرض إما الاستغلال البشري أو الأثر المناخي. لقد تم تقسيم العام الواحد إلى مجموعتين من الأشهر, الأشهر الماطرة (كانون ثاني , شباط , آذار , نيسان , أيار,تشرين الأول, تشرين ثاني ,كانون أول) والأشهر الجافة (حزيران, تموز, آب, أيلول) بهدف دراسة أثر الأمطار على الفرق المطيع للمؤشر النباتي. فقد تمت مقارنة قيم الفرق المطيع للمؤشر النباتي خلال الأشهر الماطرة مع قيم معدلات الأمطار التراكمية . وبالمقابل فقد تم تحليل قيم الفرق المطيع للمؤشر النباتي خلال الأشهر الجافة لدراسة التوزع النباتي في فترة شح الأمطار من ٢٠٠٠-٢٠٠٦.

أظهرت التقسيمات الرقمية باستخدام الماسح الغرضي المحسَن لصورة القمر الصناعي الأمريكي (لاندسات) ستة مستويات مرتبطة بإستعمالات الأراضي المختلفة: أراض مزروعة بالقمح ومحاصيل متنوعة أخرى، مراعي مفتوحة, مناطق سكنية ،مناطق زراعة الشعير، مراعي محمية و أراض مروية. إن التقسيم غير المباشر للفرق المطيع للمؤشر النباتي وصور الانعكاسية أفضت إلى تحديد الأراضي المزروعة بالقمح والمحاصيل المتنوعة وأراضي الرعي المفتوحة و الأراضي المزروعة بالشعير و التمييز بينها باستخدام أطيافها. أظهرت النتائج استجابة قوية

للأمطار التراكمية من قبل الفرق المطيع للمؤشر النباتي خلال الأشهر الماطرة بوضوح حيث أن هناك علاقة بين الفرق المطيع للمؤشر النباتي و الأمطار التراكمية على الأراضي شبه القاحلة حيث نسب تساقط من٣٠٠ – ٥٠٠ مم سنويا أكثر وضوحا منها على الأراضي القاحلة حيث الأمطار أقل من ١٠٠ مم سنويا. لقد حصل انخفاض كبير في نسب الفرق المطيع للمؤشر النباتي من ٢٠٠٣ – ٢٠٠٦ الذي أظهر ارتباطا كبيرا بالتغيرات المناخية مثل الجفاف. وبالمقابل فان الانعكاسية ارتفعت من ٢٠٠٣ – ٢٠٠٦ مما يشير إلى أن هناك زيادة في نسبة التربة المكشوفة بسبب تناقص المساحات الخضراء.

لقد كان التغير في التوزع النباتي في المناطق المدنية بمقاييس صغيرة يصعب التحقق منه باستخدام الانعكاسية أو الفرق المطيع للمؤشر النباتي عبر البيانات ذات العزل المكاني المتوسط (١ كم). لقد أظهرت التحليلات الإحصائية تغيرات كبيرة في القيم الشهرية و السنوية للفرق المطيع للمؤشر النباتي والانعكاسية حسب تصنيفات الأراضي المختلفة خلال مدة الدراسة. دلت النتائج على أن الفرق المطيع للمؤشر النباتي يمثل أداة فعالة لدراسة تغير التوزع النباتي موسميا و سنويا مما يعكس علاقة أساسية بينه و بين الظروف المناخية و ممارسات الإنسان في المنطقة.