Preface

The work described in this dissertation was performed under the supervision of Prof. Dr. Christiane Schmullius and Dr. Sören Hese at the Institute of Geography, Department of Remote Sensing at the University of Jena in Germany (Friedrich-Schiller-Universität Jena) from 2007 to 2011.

This thesis deals spatially and regionally with the natural boundaries of the Euphrates River Basin (ERB) in Syria. Scientifically, the research covers the application of remote sensing science (optical remote sensing: LANDSAT-MSS, TM, and ETM+ ; and TERRA: ASTER); and methodologically, in Land Use/Land Cover (LULC) classification and mapping, automatically and/or semi-automatically; in LULC-change detection; and finally in the mapping of historical irrigation and agricultural projects for the extraction of differing crop types and the estimation of their areas. With regard to time, the work is based on the years 1975, 1987, 2005, and 2007.

The remote sensing-based available data used are: LANDSAT-MSS data (eight scenes) acquired in June 1975; LANDSAT-TM data (16 scenes) acquired in May 1987, and in August 1987 (eight scenes for the extraction of the winter crops and eight scenes for extraction of the summer crops); LANDSAT-TM data (16 scenes) acquired in May 2007 and in August 2007 (eight scenes for extraction of the winter crops and eight scenes for extraction of the summer crops); and finally TERRA-ASTER data acquired in May and August 2005 (for extraction of the winter and summer crops). These have been combined with LANDSAT-ETM+ data (14 scenes) for two reasons; first to obtain complete spatial coverage of the study area, and second, to increase the spectral resolution of the ASTER-data. The LANDSAT-data was received from NASA-GLCF, while the TERRA-ASTER-data was obtained from the General Organization of Remote Sensing (GORS) in Syria.

Initially, preprocessing of the satellite data (geometric- and radiometric-processing, image enhancement, best bands composite selection, transformation, mosaicing and finally subsetting) was carried out. Then, the Land Use/Land Cover Classification System (LCCS) of the Food and Agriculture Organization (FAO) was chosen. The following steps were followed in LULC-classification and change detection mapping: visual interpretation in addition to digital image processing techniques; pixel-based classification methods; unsupervised classification:

ISODATA-method; and supervised classification and multistage supervised approaches using the algorithms: Maximum Likelihood Classifier (MLC), Neural Network classifier (NN), and Support Vector Machines (SVM). These were trialed on a test area to determine the optimized classification approach/algorithm for application on the whole study area (ERB) based on the available imagery. Pre- and post-classification change detection methods (comparison approaches) were used to detect changes in land use/land cover-classes (for the years 1975, 1987, and 2007) in the study area.

Classification accuracy has been improved by adopting historical statistical and ancillary data for the year 1975. For the 1987 coverages, the ground truth points from the International Center for Agriculture Research in Dry Areas (ICARDA) in Aleppo were adopted. For the other coverage years, 2005 and 2007, ground truth points were used that had been collected through two campaigns in Syria and through the GORS project in the Euphrates River Basin in Syria, which was completed between 2005 and 2010. Therefore, the accuracy of the results presented in this study is only as true as the quality and accuracy of the data used.

The remote sensing methods show a high potential in mapping historical and present land use/land cover classes and its changes over time. Significant results are also possible for agricultural crop classification in relatively large regional areas (the ERB in Syria is almost 50,335 km^2).

LULC-maps have been obtained automatically depending upon the satellite remotely sensed imagery and digital image processing available. Interpretation for the years 1975, 1987, 2005 and 2007 has been achieved by using digital image interpretation software (ERDAS v. 9.1, ENVI v. 4.3 and later 4.6, and ArcGIS 9.3).

The results of the different applied classification methods and algorithms were obtained keeping in mind the accuracies dependent on historical, statistical, ancillary, and ground truth data using the *kappa coefficient and error matrix*. Based on these accuracy measurements, the most successful approaches were the multistage classification and algorithm (Maximum Likelihood-MLC).

Change trends in the study area and period was characterized by land-intensive agricultural expansion. The rapid, more labor- and capital-intensive growth in the agricultural sector was enabled by the introduction of fertilizer, improved access to rural roads and markets, and the expansion of the government irrigation projects. Results from land cover change analysis, carried out from the post-classification approach, show that the cultivated land increased from 1,123,268 ha in 1975 to 1,783,286 ha in 2007 on account of a decrease in the natural vegetation area and an increase in bare areas. This approach shows obvious and detailed results. Pre-classification approach results were generalized but very effective in relation to the estimation of the occurred change on the cultivated areas, especially when these areas were vegetated and not fallow. The total change in the whole study area (5,062,082 ha, 100 %) between 1975 and 2007 was about 600,967 ha (11.93 %), in which 238,646 ha (4.74 %) was changed from natural vegetated areas to bare areas and 362,321 ha (7.19 %) changed from bare areas to cultivated areas (especially to irrigated agriculture). Areas recording no change equaled about 4,461,115 ha (88.62 %).

Irrigated areas increased 148 % in the past 32 years from 249,681 ha in 1975 to 596,612 ha in 2007.

These statistics were taken from the maps of the general LULC- classes based on LANDSAT-MSS-data acquired in June 1975, LANDSAT-TM-data in May 1987 and 2007, and ASTER-data, May 2005. The products of the post-classification change detection method were also used. The data mentioned above were also used to map the historical development of the irrigation projects in the ERB. Winter crops maps (especially wheat, barley, and sugar beet) were mapped based on LANDSAT-TM-data acquired in May 1987 and 2007, in addition to the ASTER data acquired in May 2005. The summer crops (especially cotton, maize, and watermelon) were mapped based on LANDSAT-TM-data from August 1987 and 2007, in addition to ASTER data from August 2005.

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