CHANGE DETECTION USING REMOTE SENSING-
LAND COVER CHANGE ANALYSIS OF THE TEBA CATCHMENT IN SPAIN
(A CASE STUDY)

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1. Introduction

1.1 Background: Periodic and precise change detection of Earth’s surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making. Remote sensing data are primary sources extensively used for change detection in recent decades. Many change detection techniques have been developed. In this paper the Normalized Difference Vegetation Index (NDVI) which is a simple numerical indicator that can be used to analyze remote sensing measurements, and assess whether the target being observed contains live green vegetation is being used. Land use land cover change study is a diagnostic tool for determining sustainability and hence its precise and proper execution is important for sustainable development of mountainous region. Though land cover change detection for a region with complex topography and geology is an important challenge, use of Geographical Information System (GIS) and satellite imageries provide reliable data for such study. Use of remote sensing involves the application of multi-temporal datasets to quantitatively analyse the temporal effects of the phenomenon. Because of the advantages of repetitive data acquisition, its synoptic view, and digital format suitable for computer processing, remotely sensed data, such as Thematic Mapper (TM), Satellite Probatoire’ Observation de la Terre (SPOT), radar and Advanced Very High Resolution Radiometer (AVHRR), have become the major data sources for different change detection applications during the past decades. This study presents a simple repeatable methodology for land cover change detection using high multispectral Landsat TM satellite data.

1.2 Objectives:

- To delineate the land cover changes spatially and quantitatively
- To derive temporal and spatial rainfall trends
- To delineate suitable agriculture areas and relate the areas to NDVI differences with changing rainfall patterns.
1.3 **Aim:** The aim of this study was to derive suitable agriculture areas in the Taba area of Spain working in a GIS environment and relate these delineated areas to vegetation index differences due to climatic variations especially in rainfall.

2. **Materials and Methods**

2.1 **Study Area:** The Taba area of Spain had been taken as study area as it had witnessed radical changes in crop yield from the year 91 to 94

2.2 **DataSource:**

- 7 bands of LANDSAT TM image of 91 and 94
- Location of the rainfall gauging stations
- Rainfall data for the period 1990-1995
- Classified land cover map
- Terrain Mapping Units
- Contour lines
- Catchment boundaries

2.3 **Methodology**

2.3.1 **Analysis of Satellite Imageries:** Multispectral Landsat data for the two years 91 and 94 was selected to derive NDVI for the years 91 and 94 using the Red (VIS) and NIR bands of the data using the following formula

\[ \text{NDVI} = \frac{\text{NIR} - \text{VIS}}{\text{NIR} + \text{VIS}} \]

After getting these differences, change detection was carried out as \( \text{NDVI}_{94} - \text{NDVI}_{91} \).

(Flowchart 1).

2.3.2 **Analysis of Rainfall Data:** The rainfall data was statistically fitted through linear curve best–fit (\( y = ax + b \)) using the weather data and gaps in the data were filled. Then data was analysed graphically (Time versus average rainfall) to derive the temporal changes from the year 90-95. Next the rainfall data was also spatially analysed using the orographic method (Flowchart 2).

2.3.3 **Delineation of Suitable Agriculture Areas:** Different geographical layers could be combined to delineate production areas through framing suitable decision rules. In this case six layers (Lithology, Soil Depth, Runoff, Erosion Signs, Slope percentage, and Aspect) were generated through terrain characteristics and topographic characteristics. These were further classified by assigning scores to sub categories.
Then suitability analysis was performed using Index Overlay technique of digitally processed layers by the formula

\[
\sum_{i=1}^{6} \frac{W_i}{\sum W_i} \text{Map}_i
\]

where Map\(_i\) (i=1 to 6) are the six maps and W\(_i\) are the six weights (Wight is directly proportional to agriculture suitability).

Agriculture suitable areas were delineated which were further subdivided into three categories as Not suitable, Moderately suitable and Most suitable (1-9, higher the value higher the suitability) (Flowchart 3).
Step-wise three flowcharts for the methodology are as follows:
3. Results and Discussion:

3.1 Land Cover (Vegetation) Changes: NDVI changes derived were visualized as in Map 1 and the change statistics are presented in Table 2. These changes were observed within -1 to 1 (values). Threshold values were selected for decreasing, no change and increasing vegetation index.

<table>
<thead>
<tr>
<th>NDVI</th>
<th></th>
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<tbody>
<tr>
<td>decreased</td>
<td>65%</td>
</tr>
<tr>
<td>No Change</td>
<td>6%</td>
</tr>
<tr>
<td>increased</td>
<td>29%</td>
</tr>
</tbody>
</table>

3.2 Rainfall Temporal and Spatial Trends: This data when fitted through linear curve, provided the fill in values for the missing data (table 2) and significant decrease trend was observed graphically in the rainfall from the year 90 to 95 (Graph 1). The spatial variation of the average rainfall within the entire catchment for the period 1990-1995 derived through interpolation indicates trend change in increase of rainfall pattern from north east to south west in the study area (Map 2).

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>ALTITUDE</th>
<th>Year 90-91</th>
<th>Year 91-92</th>
<th>Year 92-93</th>
<th>Year 93-94</th>
<th>Year 94-95</th>
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<tbody>
<tr>
<td>1</td>
<td>500</td>
<td>482</td>
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<td>375</td>
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<td>2</td>
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<td>580</td>
<td>623</td>
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<td>401.200</td>
<td>395</td>
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</tr>
<tr>
<td>4</td>
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<td>716.5</td>
<td>525.900</td>
<td>433.799</td>
<td>473.13</td>
<td>281.5</td>
</tr>
<tr>
<td>5</td>
<td>735</td>
<td>693.9</td>
<td>639.59</td>
<td>448.899</td>
<td>532.599</td>
<td>417</td>
</tr>
</tbody>
</table>

Table 2: Rainfall data (with Fill in Values):
Graph 1

Average Rainfall Trend (90-95)

Map 1: NDVI Differences (94-91)

Map 2: Rainfall Map (Average Rainfall 90-95)
3.3 **Agriculture Suitable Areas:** Agriculture suitable areas delineated were presented as in Map 3. When compared to NDVI Map, agriculture suitable areas were observed only in those areas where NDVI increase was also seen (Map 1).
4. Conclusions

- Significant NDVI differences (decreasing trends) were observed from the year 91 to 94 through the multispectral satellite imageries.
- Temporal decreasing trends from the year 91-94 were also seen in the rainfall data which is the main source of biomass.
- It was seen that decreasing trends of rainfall has directly affected the crop areas in the decreasing of biomass (NDVI).
- Suitable agriculture areas were delineated based upon available terrain and topographic characteristics. Most suitable areas were found to be those areas where NDVI had also increased which authenticates the
- People/farmers can focus on these areas while investing for agriculture for better yield
- This approach to satellite-image based change detection and delineation of suitable agricultural areas based upon terrain characteristics addresses several related challenges in areas with complex topography and geology.

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References