REMOTELY SENSED DATA & GIS IN LAND RESOURCES MANAGEMENT FOR REGIONAL PLANNING OVER SEMI-ARID PARTS OF NE BRAZIL

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KEY WORDS: Semi-Arid, Land Resources Management, SPOT Imagery, ERDAS , Image Processing, Regional Planning, Remote Sensing, Geographical Information system

ABSTRACT:

The present study was carried out by digital interpretation **(Supervised Classification-MAXCLAS)**, which is based on the methodology utilized by **Kennard et all (**The research work of our project was carried out through the **1988).** The Satellite Data were received from the **Aero Space Research Establishment of Germany (DLR-Oberpfaffenhofen).** The LANDSAT and SPOT data were processed with ERDAS Software, operating on a high performance micro-computer. The digital interpretation was applied to one million pixels in each area of each State **(Paraiba, Ceará and Piaui)** to derive land use/land cover and major soil associations information. In the digital image classification, based on the field observations and using interactive capabilities of ERDAS, total 120 observations (40 observation in each area), were selected for land use/ land cover classes. The digital interpretation was modified and corrected in accordance with the conditions of the area. By using RECODE program of ERDAS Software for land use/land cover classes, two maps, such as, land use/land cover map at the Level-II and major soil associations map for each area were generated. The comparison of digital interpretation with reference information indicated that the digital interpretation is closely resembled field observation and the overall classification accuracy was observed more than 85% in all the three areas of three States. The results of our study were found very beneficial for land development, natural resources management, land evaluation, soil conservation and land reforms programs of the Federal Government in the semi-arid region of northeastern Brazil.

1. INTRODUCTION

The northeast part of Brazil comprises of nine states and covered by various physiological relief features and morphological forms. The area generally has leveled to slightly undulating and mountainous topography. At some locations the area is also covered by natural pastures and waste lands, forest patches, and a network of of rivers, many of which run only during the rainy seasons. The approach for natural resources development and management varies from one type of environment to another, The soil and land management in semi-arid region is totally different from the soil and land management in humid areas. Nowadays, there is a tremendous pressure on the availability of soil and land resources due to increasing population and grow consumption of land for constructing houses and buildings in major cities. In such a situation we must make an optimum planning and management of our land through remote sensing and GIS technology. These two technologies are the major tools for solving of our complex natural resources planning problems.

The purpose of our research using remote sensing and GIS technologies and ERDAS Software is to apply image processing and pattern recognition techniques to Satellite Data, such as LANDSAT-TM and SPOT HRV to drive various earth resources information for the land development and management of the region. Also, provide information about the land use/land cover classification, Soil classification, land capability classification, soil slope and relief features, which are used for the resources management and regional planning of semi-arid regions of northeastern Brazil. The aim of this research was to know the realistic assessment of the extent to which SPOT and LANDSAT data can be used for the survey of the study area, and to provide basic information on the nature of the digital remote sensing data and how they can be used for different applications.

2. BACKGROUND DISCUSSIONS:

Various types of remote sensing data, such as, **SAR**, **MSS**, **TM**, **ETM**, **MOMS**, **AVHRR** and **SPOT** etc. lave been used for earth resources management and development of semi-arid regions by various governmental agencies, institutions, and universities of the world. For example: **Kennard et al**. (**1988**) have worked on a GIS system for land use planning and management of semi-arid regions of northeastern Brazil, using digital image processing on Landsat-TM and SPOT data. **LaBash et al (1989)** conducted a digital image analysis of Landat-TM data in eastern Connecticut for regional land use and land cover classification. The results were found most satisfactory for regional planning in the sate of Connecticut.. U**lbricht et al.** (**1992** used the supervised classification for the soil and land use studies for a part of semi-arid regions of Brazil. **Teotia et al.** (**1996**) did a very comprehensive work for land use planning in semi-arid regions of NE Brazil, usiusing SPOT HRV data. According to **Silva Junior (2003)** the remote sensing and gIS are economic and adequate for the land survey and land use classification of semi-arid regions of Paraiba state of Brazil. **Ribeiro G. do N** (**2006**) studied some remotely sensed data and found that the ERDAS Imagine Software and SPOT data is a good combination for land use and land cover mapping in order to develop the Agreste region of the Paraiba sate of Brazil.

STUDY AREA: (Figures-1 and 2); (Photos 1, 2, 3 & 4):

The study area falls in the states of Paraiba, Ceara, and Piaui, which is mainly semi-arid. The area has various types of dry lands and altitudes varying from 200 to 900 meters. Various types of physiological relief features and geomorphologic forms are encountered in the study area. Hydrologically, the area is covered by a network of rivers, many of which are intermittent. Soils derived from recent streams sediments are rich, whereas others are poor to moderate in fertility. The major soil groups of the area

are: Entisols, Alfisols, Inceptisols, Ultisols, and Lithic Sub-Groups of various orders and rock outcrops. The study area also has extensive areas of various drought-resistant trees and shrubs; mainly Caatinga Hipoxerofila, Caatinga Hiperxerofila and Xerophytic Forests. The Climate of the region is semi-arid and has a rainfall of 300 to 700 mm per annum and temperatures from 30 to 40 ºC in the summer.

Figure-1: Composition of northeastern part from 9 States of Brazil

Figure-2: Study Area in three northeastern States of Brazil (Paraiba, Piaui and Ceara)

P Photo 1 (Part of Semi-Arid Region of Paraiba State)

Photo 2 (Part of Semi-Arid Region of Paraiba State)

Photo 3 (Part of Semi-Arid Region of Ceara State)

Photo 4 (Part of Semi-Arid Region of Piaui State)

Geographic Information Required

Data about various components required for this research have been gathered from various, Federal, State, and Municipality Agencies, such as, Land Use, Soil, Soil Conservation, Slope and Elevation, Drought and Flood, Climate (Precipitation, Temperature and Humidity), Geology and Hydrology, Vegetation and Forest, Irrigation and Drainage, Socio-Economic, Municipality and State boundaries etc.

Programs of ERDAS used for study

Following programs of ERDAS Software in systematic sequence were used for unsupervised, supervised classification & accuracy assessment.

For Unsupervised Classification:
READ-CLUSTR-DISPLAY-COLORMOD-CLASNAM-RECODE-COLORMOD-CLASNAM-ANNOTAT-CLASOVR-BSTATS-LISTIT

For Supervised Classification:
READ-SEED-SIGDIST-SIGMAN-ELLIPSE-CLASNAM-MAXCLAS-DISPLAY-COLORMOD-CLASNAM-ANNOTAT-CLASOVR-RECODE-INDEX-RECODE-INDEX-COLORMOD-CLASNAM-ANNOTAT-SCAN-BSTATS-LISTIT.

For Accuracy Assessment:
READ-DISPOL-DIGSCRN-GRDPOL-CLASOVR-CLASNAM-SUMMARY.

Criteria used for land use classification

For our study of semi-arid regions of NE Brazil, the land use and cover classification system (**Anderson et al., 1976**) is modified in accordance with the local climate, local needs and existing conditions. During the conduct of our project, we used the following important criteria:
1. The interpretation accuracies in the identification of land use and land cover categories from remote sensor data should be 85% or greater.

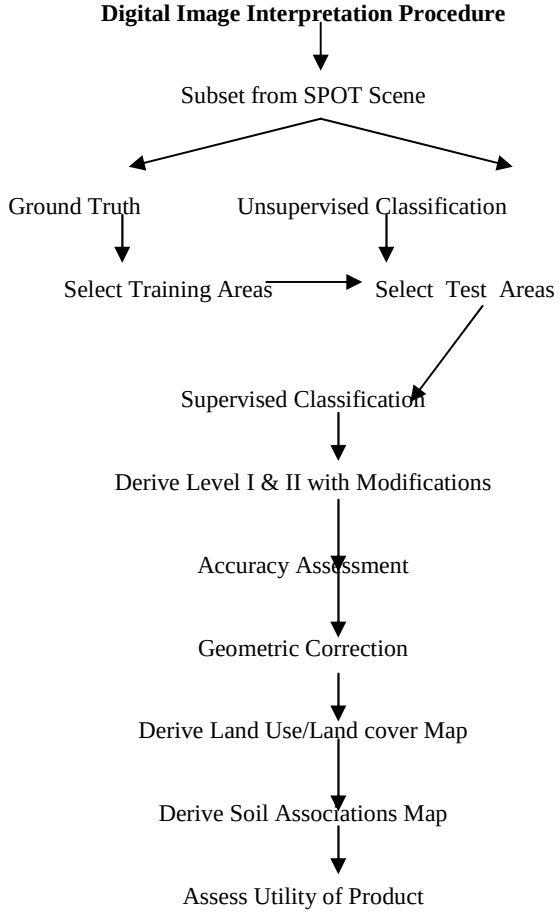
2. The multiple use of land should be recognized where possible.

3. 3. Individual land use and cover classifications should be
4. customized to facilitate interpretations of digital images with different resolutions.

Image Processing

A 1000 by 1000 pixel sub-scene of LANDSAT-TM and SPOT multi-spectral data (band 3,4, 5 & 1,2,3) were used for image analysis. More than 40 sites were visited in the study area, and reference data, such as soil, vegetation, geology, topography, climate and others are made to assist in **supervised classification (Maximum Likelihood Classification-MAXCLAS)**. Various field trips served as a basis for accuracy assessment to derive various earth resources information. The digital interpretation was checked by three field trips. The relevant statistics, such as mean, mode, medium, standard deviation, variance and co-variance matrices wwere applied for our study. After inspection of the digital classification combined with the field work, finally resulted into 15, 17 and 12 categories of land use/land cover classification in **Paraiba, Piaui and Ceara** states at the Level II. **(Anderson et al., 1976).** The accuracy assessments of the transformed and no-transformed LANDSAT-TM and SPOT image were concluded to compare the best areas of known reference data with the same areas on Level II land use and land cover classification on a pixel by pixel base produced by supervised classification. The over all accuracy was found more than 85% in all the three areas. By using RECODE program of **ERDAS** Software on land use/land cover information resulted into 11,11 and 6 categories of soil associations in each area. Re-coding was possible because of the high degree of correlation of land use and land cover with the features of other maps. Field observations conducted at the sites confirmed this relationship.

Digital Image Interpretation Procedure



Results and Discussions (Tables-1 to 6 and Images 1 to 6)

The tables 1, 3 and 5 present a summary for the maximum likelihood classification results of the three regions of northeastern Brazil. The overall classification accuracy for all the areas was found always more than 85%, which is good with respect to the classification categories used for this study. The classification shows that the percentage accuracy decreases as the level of detailed is increased. The more spectrally heterogenous areas also reduce the accuracy percentage of the classifications. The results of computer classification (Supervised Classification) of LANDSAT-TM and SPOT-2 Satellite data gained through various programs of ERDAS software into 15,17 and 12 mapping units.

Table 1: Paraiba Land Use/Land Cover

V1 Deep to very deep water
V2 Moderately deep to deep water
V3 Very shallow to shallow water
U1 Dense Urban area
U2 Sparse Urban and barren rocky land
CF1 Cotton cultivated and fallow land
MF1 Mixed cultivated and fallow land
CP1 Mixed cultivated and Pasture
A1 Alluvial land with dense shrubs/trees
A2 Alluvial cultivated and eroded land
F1 Sparse Caatinga forest and rocky land
F2 Sparse to moderate Caatinga forest and rocky land
F3 Moderate to dense Caatinga forest
F4 Dense Caatinga forest on undulating land
F5 Dense Caatinga forest on hills

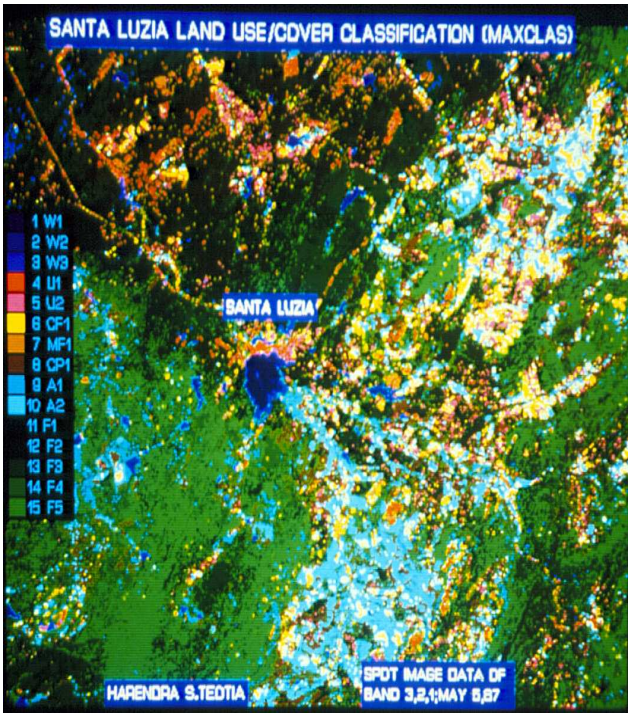


Figure 3 Paraiba Land Use/Land Cover Map

Table-2: Piaui Land Use/Land Cover

W0: Deep clean water
W1: Moderately deep water
W2: Shallow silted water
W3: Very shallow water or moist area
SFA: Swampy flooded area
UO: Urban area with barren rocky land
EFA: Eroded flooded area
PDC: Poor drained cultivated with eroded land
PDC1: Poor drained cultivated
AMC: Alluvial mixed cultivated
CRB: Cultivated river bed
CRB: Cultivated river bed with dense shrubs/vege.
SCD; Saline cultivated depression
WERM: Weathered eroded rocky and moist land
DCF : Dense Caatinga Forest
MDCF: Mode. Caatinga forest on undulating relief
SPC: Sparse Caatinga forest on undulating relief

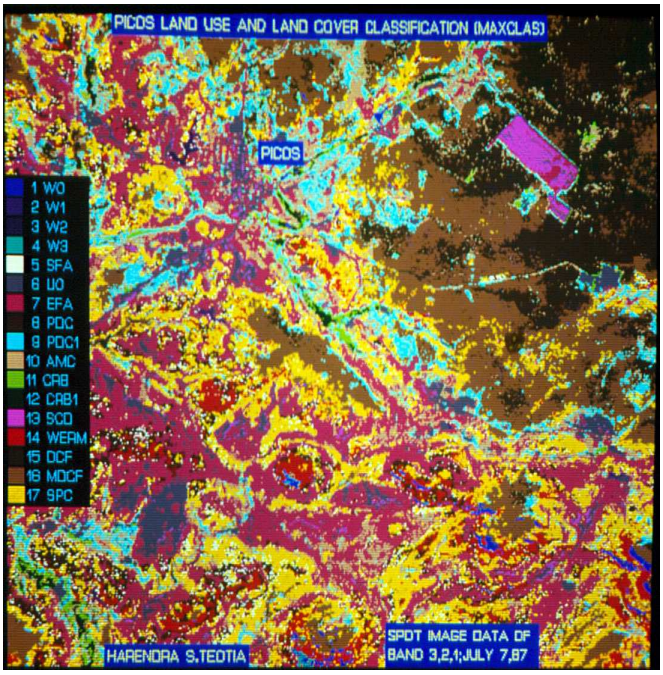


Figure 4 Piaui Land Use/Land Cover Map

Table-3: Ceara Land Use/Land Cover

W1 Deep to very deep water
W2 Moderately deep to deep water
W3 Shallow silted water
W4 Shallow and polluted water
U1 Urban area with rock outcrops
C1 Cultivated nearly leveled land
C2 Sparse to moderately cultivated undu. land
A1 Alluvial moderately to dense cultivated land
A2 Alluvial mode. culti.& eroded undu. land
F1 Dense Caatinga forest on hills
F2 Mode.denseCaatinga forest on undu. relief
F3 Sparse Caatinga forest on eroded undulating

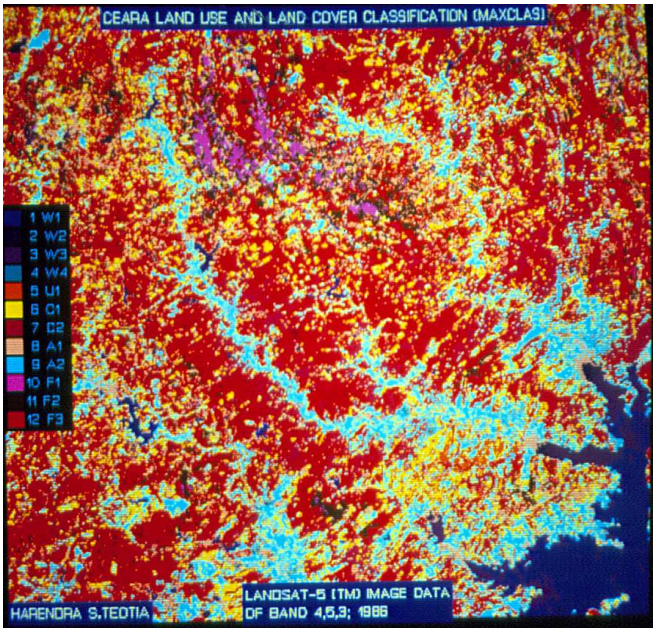


Figure 5 Ceara Land Use /Land Cover Map

Table-4: Paraiba Soil Associations

Water
. Urban
. LS-RO : Lithic Subgroup-rock outcrops
.UP-UO-UC: Ustipsa.-Ustorthents-Ustochrepts
.UO-HU-LS: Ustorthents-Haplustalfs-LithicSubgr
.UF-UP-UC: Ustifluvents-Ustipsa.- Ustochrepts.
.UF-UP-UO: Ustiflu.-Ustipsaments-Ustorthents
.LS-RO-UO: Lithic SubGr, Rock outcrops –Ustorthents
.LS-HU-UO:: Lithicsubgr-Haplustalfs-Ustorthents
0.LS-HU-RO: LithicSubgr-Haplustalfs-Rock Outc
1.S-RO-HU: Lithic Subgroup-Rock Outcrops- Haplustalfs

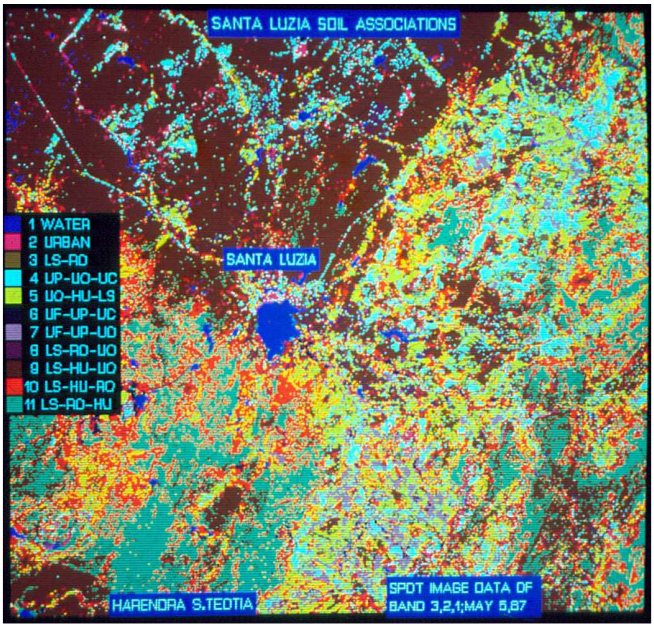


Figure 6 Paraiba Soil Associations Map

Table-5: Piaui Soil Associations

.Water
.E-L-R: Entisols-Lithic Subgr.-Rock outcrops
.E-I: Entisols-Inceptisols
.E-I-L: Entisols-Inceptisols-Lithic Subgroup
.I-E: Inceptisols-Entisols
.I-E-A: Inceptisols-Entisols-Alfisols
.I-E-L: Inceptisols-Entisols-Lithic subgroups
.I-A: Inceptisols-Alfisols
. L-R-E: Lithic subgr.-Rock Outcrops-entisols
0. L-A: Lithic Subgr.-alfisols
1. L-R-A: Lithic Subgr.Rock Outcrops-Alfisols

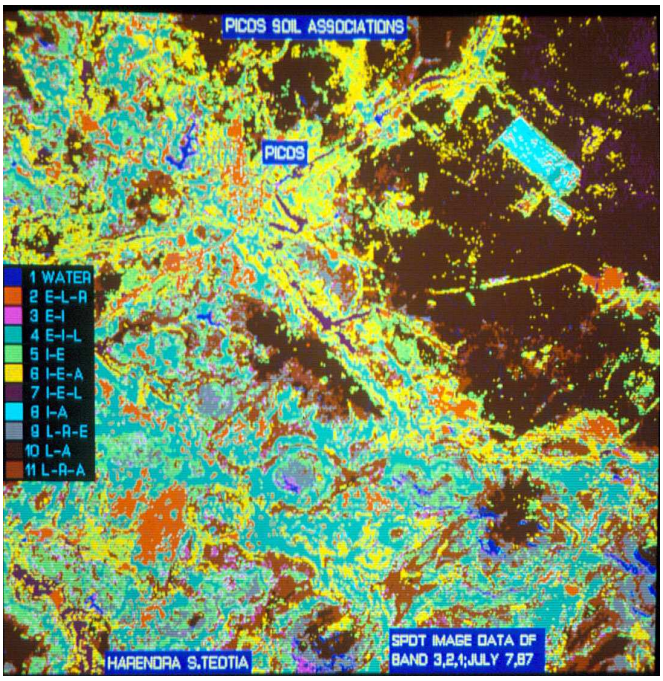


Figure 7 Piaui Soil Associations Map

Table-6: Ceara Soil Associations

Water
Urban/Barren
V(HU)FA-CU:Vertisols-Haplustalfs-Ustochrepts-Ustorthents
UF-UP-UO: Ustifluvents-Ustipsaments-Ustorthents
.LSGR-RO-UO: Lithic Sub Groups-Rock-Outcrops-Ustorthents
LSGR-HU(V)-RO: Lithic Sub-groups-Haplustalfs-Vertisols-Rock-Outcrops

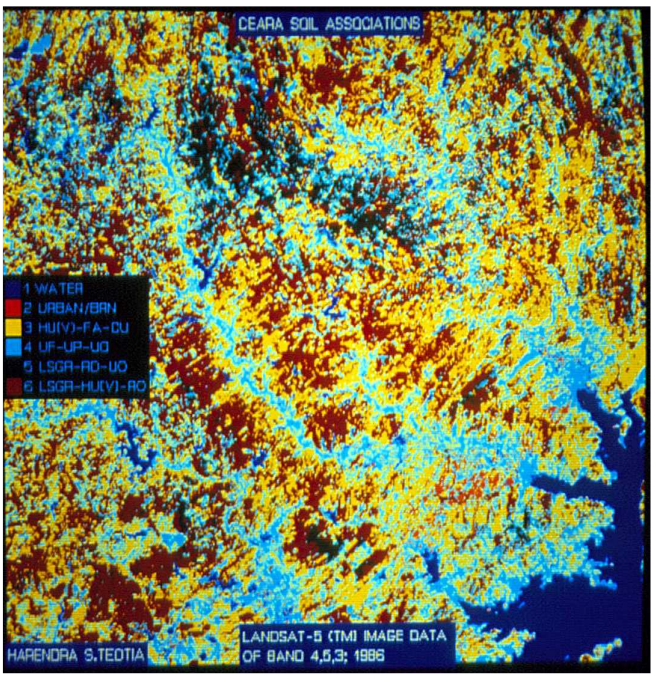


Figure 8 Ceara Soil Associations Map

3. GENERAL RECOMMENDATION

1) The LANDSAT-TM and SPOT imagery are found more reliable for land use/land cover and major soil associations mapping and could be used effectively for any part of semi-arid regions of Brazil in order to submit the natural, ecological and environmental resources information for the development and management of the study area.

2) The orbital images proved to be an extremely useful source of data for the purpose of detailed regional, local and rural planning and management and development of our natural resources.

3) The supervised classification of SPOT and LANDSAT-TM data for Land Use/Land Cover mapping and accuracy assessment provided satisfactory results. In terms of operational reliability, the per pixel maximum likelihood classification of SPOT and LANDSAT-TM images offered the most satisfactory results in comparison to other classification systems.

4) Accuracy assessment of the digital classification showed that some categories such as water, forest and alluvial land were identified more accurately than other categories. The more accurately identified categories may be used as framework for the addition of residual classes through a more conventional approach, such as aerial photo-interpretation. The comparison of digital interpretation with reference information indicated that digital interpretation, closely resembled to

field observation and the overall classification accuracy was observed always more than 85% except the urban and rock outcrops mapping units..

5) Maps of soil associations prepared using the RECODE program and other information may be used for detailed planning and development and management of semi-arid regions of northeastern Brazil.

ACKNOWLEDGEMENT

The authors wish to thank the Federal University of Paraiba (UFPB, Brazil and the DLR, Oberpfaffenhofen of Germany to supply all the Remotely sensed data (Landsat-TM and SPOT) and other necessary material in order to conclude this project.

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