SEQUENTIAL SEASONAL CHANGE DETECTION USING AIR-SPACE RECORDINGS AND FIELD MEASUREMENTS, BASIS FOR MONITORING OF DANUBE DELTA IN THE FRAME OF LISI-DD (LAND INFORMATION SYSTEM BASED ON IMAGES FOR DANUBE DELTA)

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ABSTRACT: Concisely are presented: the characteristics of the area, as well as the need to implement LISI-DD, the main objectives, ideas concerning its conception, architecture, configuration, implementation. Using existing sequential historical airborne and space recordings and radiometric measurements, selected on seasons, are performed: (a) radiometric internal and external corrections using histogram normalization and manipulation, thus as to adjust the sequential recordings for each phenological period in the frame of the season are to be brought at a standard situation, and are able to be introduced into a data bank; (b) absolute geometric registration of the most representative recording for each period, and afterwards the relative registration with this image of the all ante and post data recordings; (c) change detection by processing the set of recordings using analogical conventional methods as well as digital one, for each deltaic, ecosystem, ecotype and ecotope on the basis of Δ image values. A case study for Dunăvăţ field laboratory is approached.

Introduction

1.1 The Danube Delta covering about 400,000 ha and the Black Sea coastal zone are areas of special interest as regards their partial and integral management, related to their ecology ;in this way, a proper LIS was required and must to be implemented to monitor the deltaic resources situation in any season, considering various stages of project or variant evaluations, i.e.designing, implementation, monitoring, and also post project evaluation.The remote sensing data allow to monitor situations and to approach them holistic. LISI-DD can be proper and efficient tool to monitor the deltaic natural resources and landscape: natural vegetation, crop and soil, hydrology, environmental landscape, using thematic sampling on intensive test sites and holistic evaluation on the other areas; some other extrapolation control zones are used, as well.

1.2 LISI-DD is briefly developed as a system for: (a) the present-day situation in the field; (b) data collection for system completion and updating; (c) data analysis and (d) the quick access to the processed information required by users.

The main purposes of this LISI-DD are: (a) the objective partial or integral management measure establishments on holistic units; (b) efficient data for the three management stages: studies-designing, implementation and monitoring, consequence evaluations included for reed, agricultural, forestry, fishery,hydrological,

hydrological- engineering projects on environmental landscape-ecology.
In addition we can mention the scientific-technological aims: (a) LISI-DD basic concept development; (b) information structures provision; (c) special technical equipment and method selections; (d) mathematic and computation bases; (e) mapping methods; (f) geomodel in decision-making development; (g) recommendations and proposals for specialized LISI-DD versions; (h) special subject study development and proposals for LISI-DD improvement.
The various basic models to be used within LISI-DD are:
-seasonal resource dynamics monitoring on different types;(a)resource dynamics analysis, crop and soil development; (b) the general water resource analysis and hydrology; (c) prognosis on unfavorable vegetation soil and hydrology processes;
- complex ecology monitoring over a long period of time on: (a) various engineering and management projects influences;(b)forestry ecology; (c) proper hydrological resource uses and management; (d) conflicting ecological situations.

2.Among LISI-DD principles, ideas, and solving possibilities, the followings are worth to be mentioned:(a)care selection of users requirements;classification data levels;
-their uniformity not to be too general, that is analytical, their permanent improvement;
-(b)hybrid digital, analogic, vector, raster, conventional-traditional system development;it will become only a digital one in

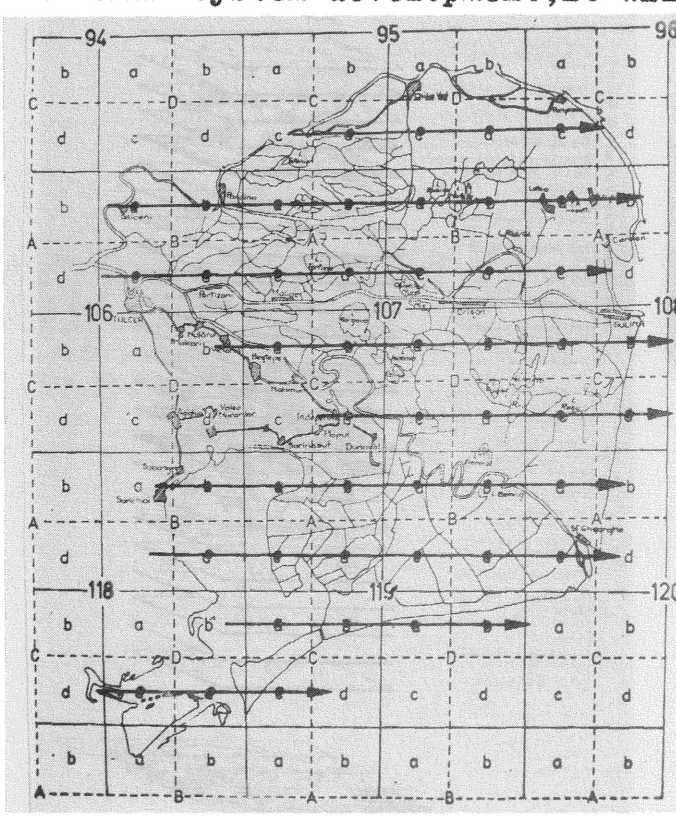


Fig.1 Flight lines for aerial multitemporal photographs using RC-9 camera considering 10x10 km.working units within LISI-DD

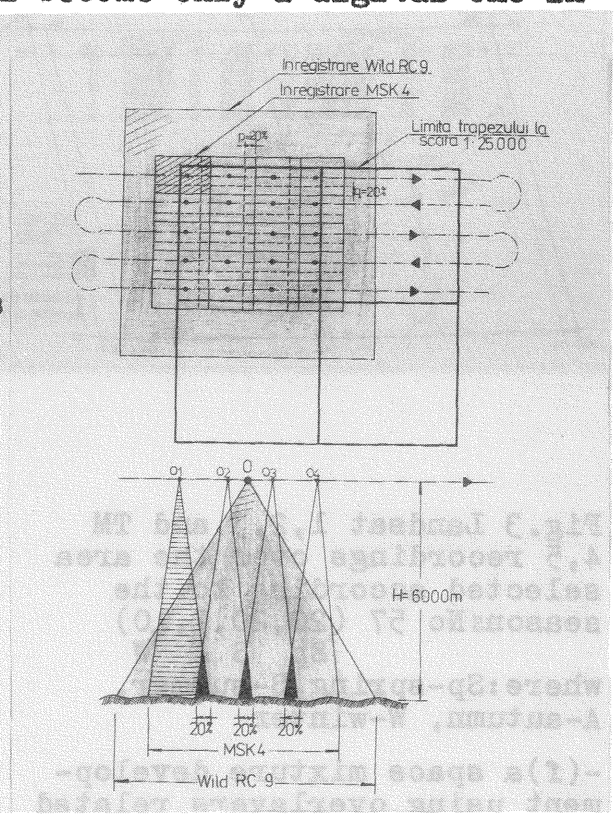


Fig.2 Aerial multispectral photography with MSK-4 camera concurrently with aerial photography using RC-9 camera

the future; because nowadays microcomputers are used in digital processings and Landsat CCT data windows are stored on floppy disks, a great digitizing effort is required;

-(c)the main information sources are: aerial and space recordings and historical and present-day available samplings in the field that is: repetitive aerial photographs for about 40 years, Landsat recordings for 16 years, LFC-recordings made by G-41 Space Shuttle Mission, SIR-B recordings, MKF-6M recordings, as well as, airborne multispectral MSK-4 camera imagery over the deltaic test sites;

-(d) cartographic products as photomaps are photogeodetically compiled employing panchromatic, IR and colour IR photographs, on which stable premarkings are to be found. Aerial triangulation based on photographs having simple overlapping /11/,using inclusion method, is used. The working unit covers a 10x10 km area. The flight lines are in a central position within these working units (Fig.1). The airborne multispectral images are placed within the working units, according to fig.2 diagram;

-(e) a relative reference system is used. An image having good geometric and/or radiometric qualities is selected as a basic plane; any other topographic, photogrammetric, cartographic, thematic data are adjusted to make this registration over the basic plane;a reference plane for each season, especially spring-summer images are suitable for the Danube Delta;the situation of some Landsat 1,2,3 and TM 4,5 images according to the seasons are given in fig.3.

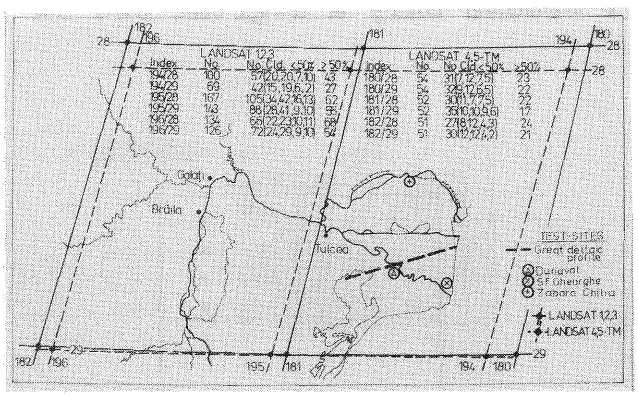


Fig.3 Landsat 1,2,3 and TM 4,5 recordings over the area selected according to the seasons No 57 (20,20,7,10)
Sp S A W
where:Sp-spring,S-summer, A-autumn, W-winter

-(f)a space mixture development using overlayers related to problem and thematic sets fig.4.

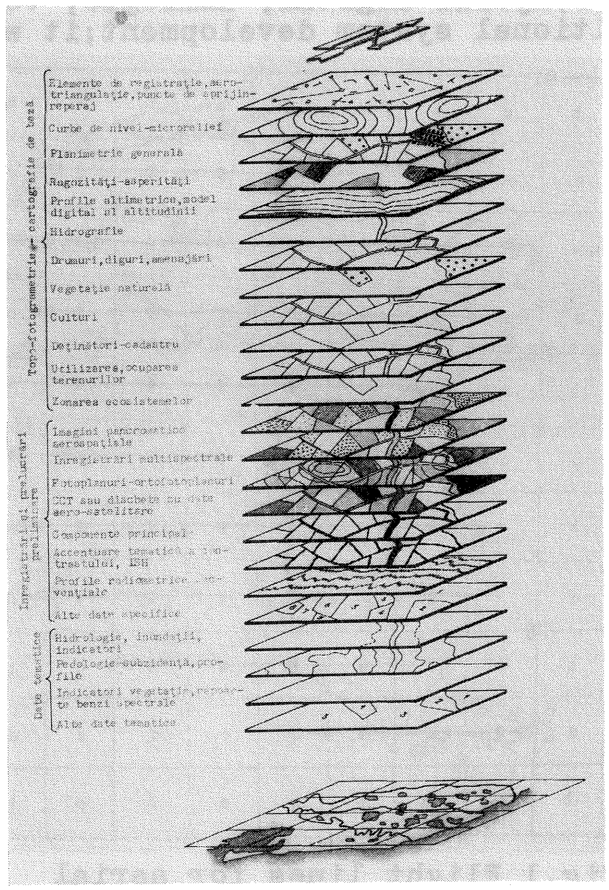


Fig.4 Space mixture concept using overlay related to problem and thematic sets,correlation and interdependences included.

-cartographic-photogrammetric basis,satellite recordings radiometric measure-

ments, i.e. photogeodesy, aerial photographs, ground control, inclusion, photomaps, orthophotomaps, contour lines, microrelief, roughness, heightprofiles and DEM, digital map elements, multispectral recordings, main elements, thematic contrast enhancement, sequential radiometric profiles, seasonal standard reference recordings, cadastre, management, dams, a.s.o.;
-data base for natural vegetation and crops (reed, dub rush, forests,crops, LAI-vegetation indicators, modelling,prognosis);
-pedological data base:-soil units,physical and morphological properties, agrochemistry, hydrophysical features, subsidence, erosion structure prognosis;
-data base for hydrologys:aquatic vegetation, bathymetry,eutrophication control, water quality, turbidity, sediments,floods, modelling,prognosis;
-environmental landscape situation:ecosystems and their zoning, thematic ecosystem element analysis,ecosystem, classification, improvement, ecotopes, modelling,prognosis.
A pluri-inter and trans-disciplinary work of the specialist team is to be noted to monitor objects - phenomena quickly, slowly, steady variable in the course of time.
-(g)an integrated approach for sampling zones and a holistic approach one for the other zones were conceived. The integrated approach means survey of landelements (components) separately and subsequent combined and integrated; holistic approach means that the object is primarly considered and studied as a unit as a whole in itself;holistic means constant attention to integration. The basic data are structured on holistic land units(the main landscape, land system, land unit, ecotopes).
Various thematic ecosystem mappings suitable for the Danube Delta are given in Fig.5 :

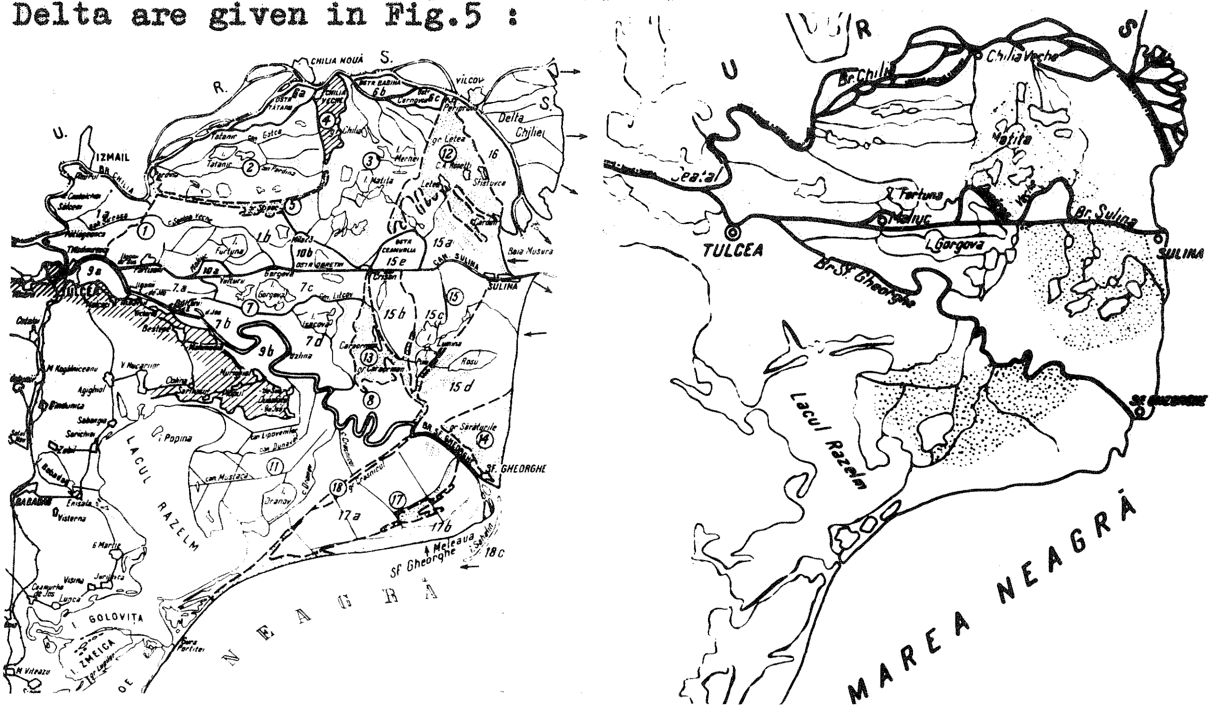


Fig. 5 Various thematic ecosystems mappings for the Danube Delta.

-(h) in order to explain the complex process of implementation of any project within the territory we will report to fig.6 that represent a scheme of land classification and resources evaluation in integrated and holistic landsurvey of natural environment in connection with different stages of project implementation.

3. Aerial and satellite recordings processings to be integrated within LISI-DD to change detection.

Aerial, satellite imagery and CCT digital recordings were at our disposal.

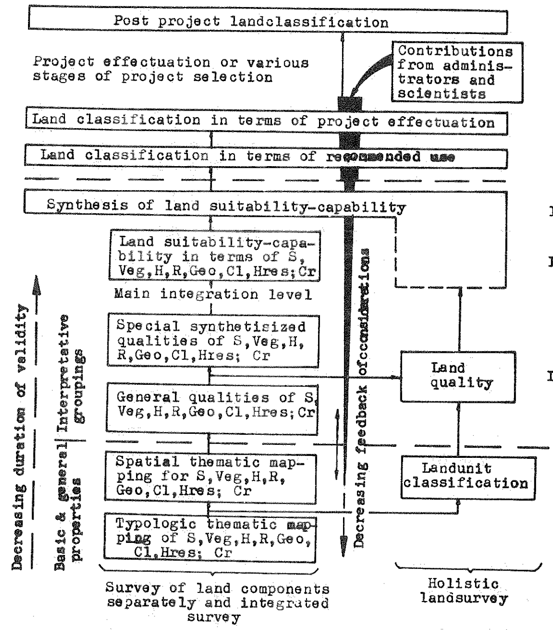
3.1 Among the photographic like recordings for change detection we can mention:

-pseudoscopy using sequential photographs;

-addition, substraction, ratio, binary imagery, enhancement, filtering, solarisation;

-combinations black-and-white, color, true colour and false color, equidensities.

The above mentioned operations are photographically made, using MSP-4 multispectral projector, A/D and D/A conversion system equipped with a closed TV configuration. The results are interesting and important presenting a global view of the changes observed; internal and external photograph calibrations sould be taken into account, thus assuring the test site control.



Abridges: S-soil; Veg-vegetation; H-hydrography-hydrology; Geo-geomorphology-geology; Cl-climate; H-res-human resources, etc; Cr-correlated

Fig. 6 Scheme of landclassification and resources evaluation in integrated and holistic landsurvey of natural environment, in connection with different stages of project implementation (adapted from Zonneveld I.S.,1968)

3.2 Segments ("windows") of Landsat image are used in digital processing, considering test sites, in which case, preliminary corrections are made.

3.2.1 Internal sensor radiometric calibrations are made (when they have not be made at the data dissemination centres) using cumulative histogram fitting method of each uncalibrated sensor to cumulative histogram of a medium sensor /1,2/; such an example is given in fig. 7 :

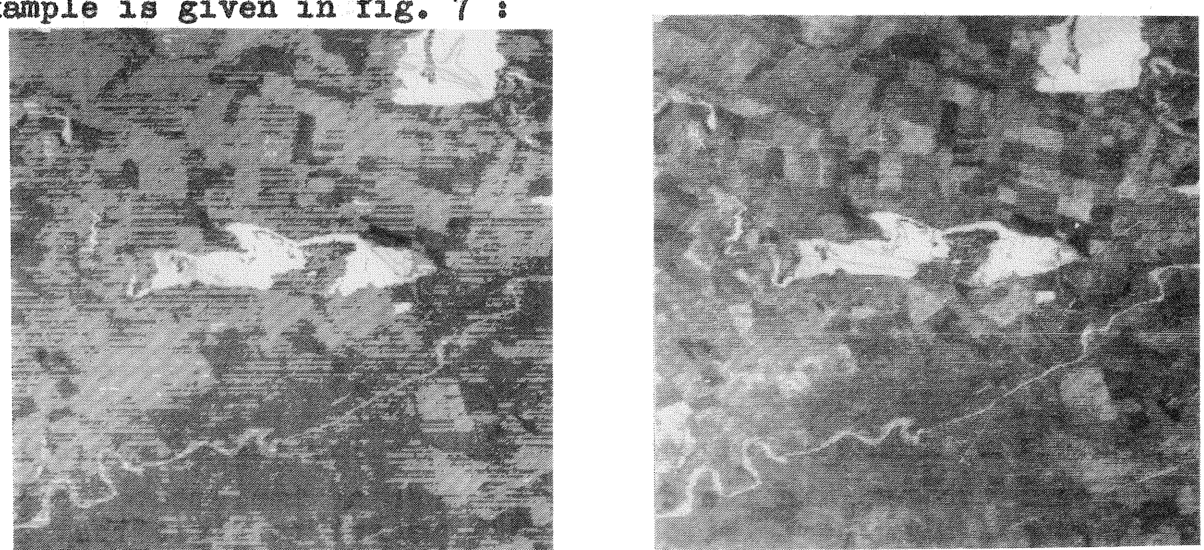


Fig. 7 Landsat image segment with internal radiometric correction left-uncorrected, right-corrected image); band 7 from June 4,1978.

3.2.2 The relative external radiometric calibration to reduce the atmosphere influence is made based on the ground measurements,using Exotech 100AX radiometer. The computed reflectance values based on satellite sensor answer are corrected using histogram modification shifted and expanded within the brightness range is used /9/.
3.2.3 Multitemporal Landsat recordings are calibrated to eliminate the sun elevation and azimuth variation effects, thus transforming into the same reference system /4/.
3.3 Data compression, using the main components, entails data analysis reduction, and computation time reduction, as well.
3.4 The absolute reference image registration is made using control points and checking points identified on the map,aerial triangulation points, pre-markings. The III order polynomial transformation coefficients /13/ contains all deformations affecting dynamic images /5/, and are computed using the least square method; the eroneously points are identified and selected based on 3σ test, the general model being improved based on weight $w=1/|v|$. Depending on the unit weight error required in projection plane, $v=\pm 1$ pixel, the minimum number of control points necessary for transformation parameters calculation are given by relation $m \approx 3n$, where "n" is a number of terms of transformation polinom adopted. Analysing space point distributions and deformation area we can evaluate parameters computed - fig.8 :

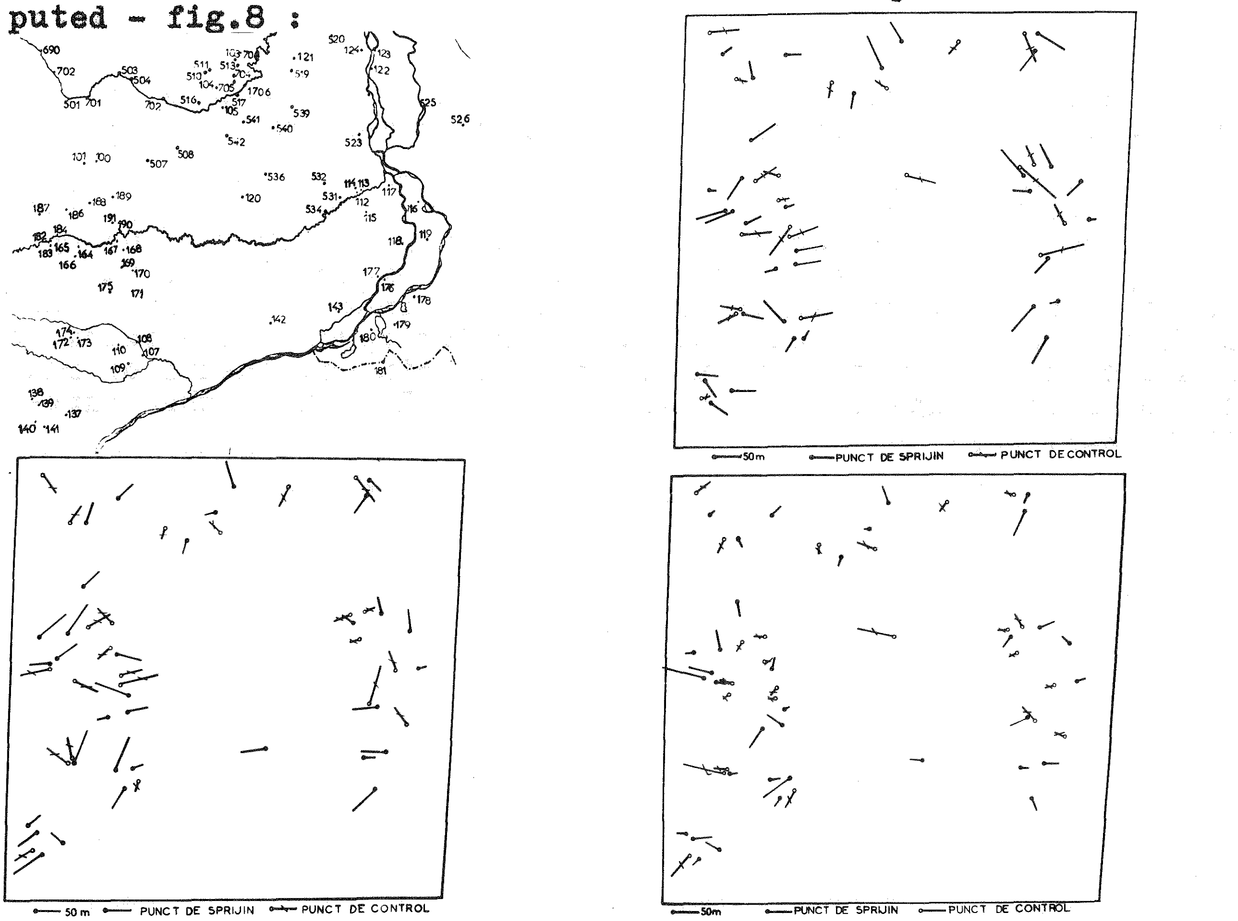


Fig. 8 Absolute registration:(a) ground control and checking point distribution,(b) residual errors corresponding when polynomial having 5 terms in x and y coordinates, (c) the same as above having 8 terms in x coordinate and 6 terms in y coordinates, (d) the same as above having 15 terms in x and y coordinates.

The absolute registration is made in two stages: (a) a preliminary transformation in which an image oversampling is required and a $\pm$ 10 pixels accuracy is obtained; (b) a precision transformation, in which resampling is made, using the cubic spline function /2,10/, fig.9.

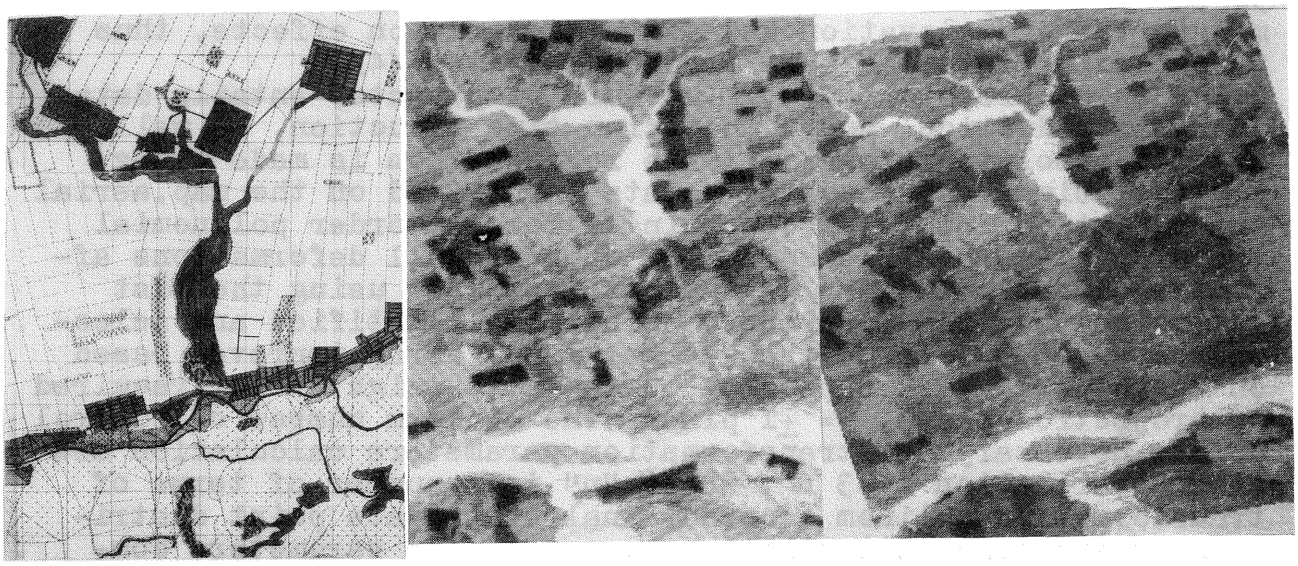


Fig. 9 Absolute registration; left-reference map; middle-untransformed Landsat images; right - transformed Landsat images.

3.5 The relative registration of the other multitemporal images is made considering the absolute registered reference image.The control points being identified by image correlation /7/ using the algorithm described in /1/, fitted for binary images.Having this end in view, the registered images is enhanced using Söbel and Kirch convolution operators /8/. Better results are obtained when the same operators are used for the main components or ratio images;binary image is made using T threshold established experimentally, fig. 10.

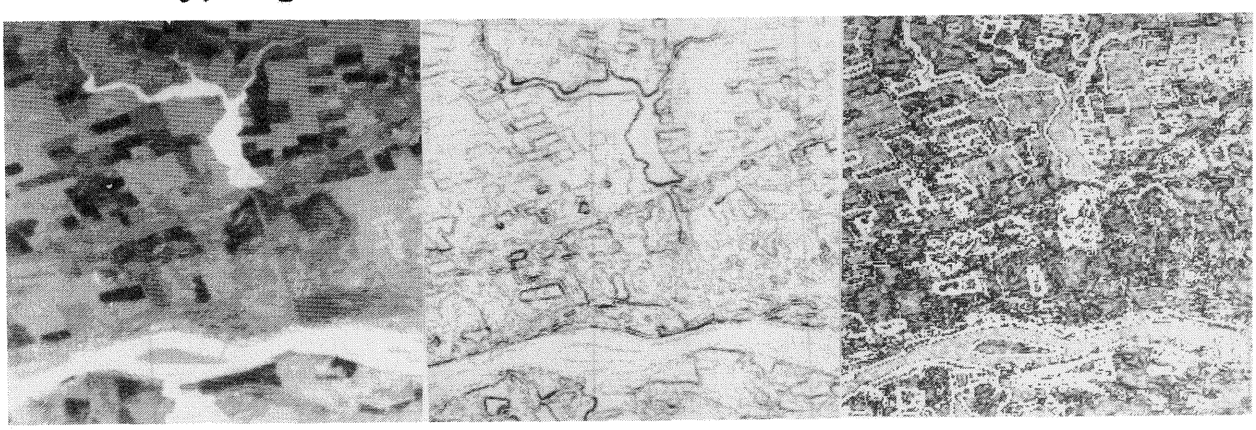


Fig. 10 Image limit enhancement: a) original image; b) image obtained after using Söbel operator; c) image obtained after using Kirch operator.

Computation time reduction considering correlation was made analysing information contents for each pair of windows from correlated image. As usual transformation parameters have been computed based on the least square method and plane projection transformation and the control points having an accuracy lower than one pixel were identified based on weights and eliminated.
3.6 Temporal changes and their representation are illustrated by "Δ" difference image analysis and classification fig. 11.

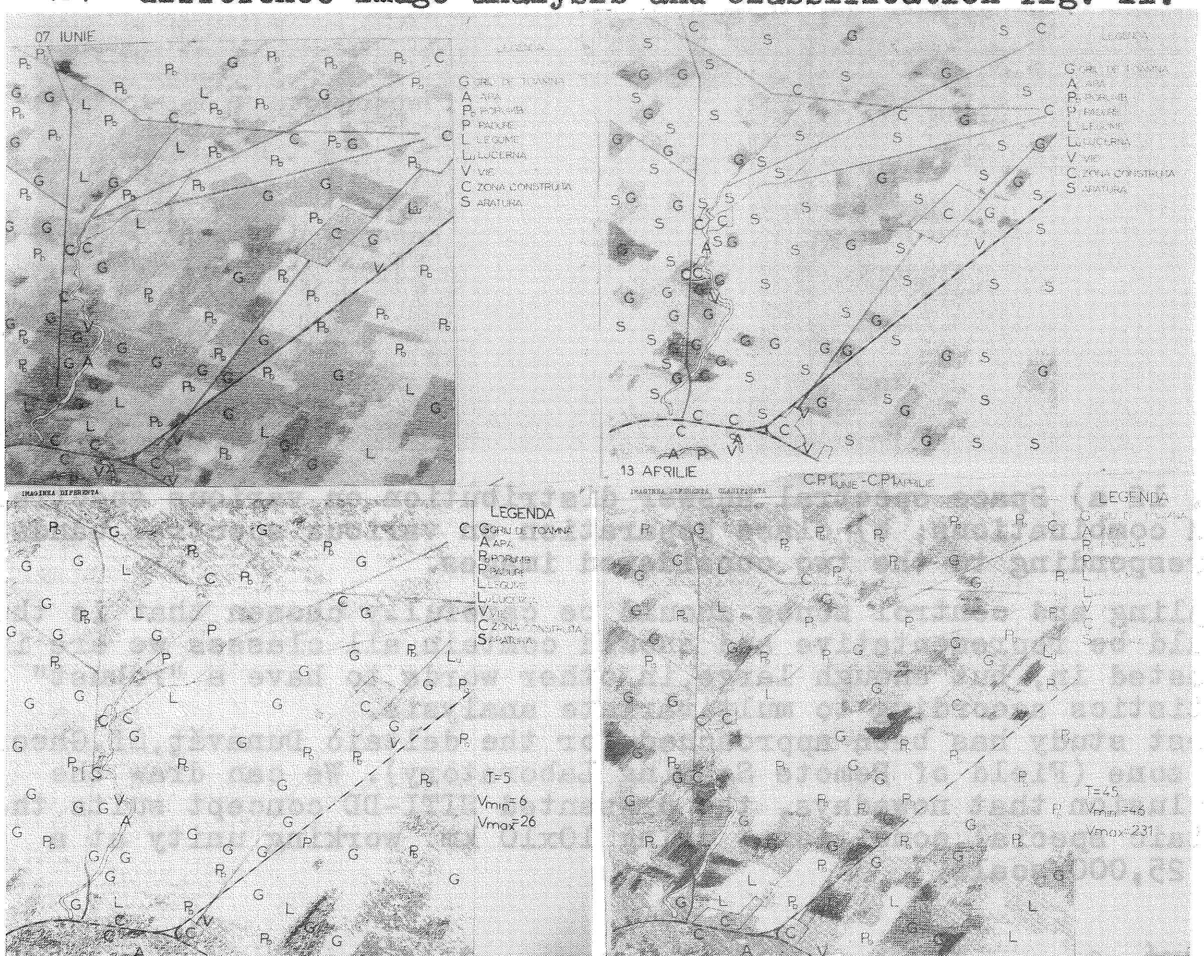


Fig. 11 Multitemporal change detection and representations:a)crop plane Landsat image from april, 13, 1981; b) the same - Landsat image from june, 7, 1981; c) difference image; d) difference image for the two main components, classified.

The threshold T establishing important changes was experimentally developed considering the statistic image qualities. Supervised classification was based on ground-truth data either for sampling zones or for selected checking ones.
The space sensor answer distribution and the class separation analysis,fig. 12, on several spectral band combinations allow to establish OIF (Optimum Index Factor) for our purpose.

4. Conclusions

Preliminary remote sensing data processing stages related to internal and external relative radiometric calibration and multitemporal data radiometric sampling have a great importance when changes are analysed.

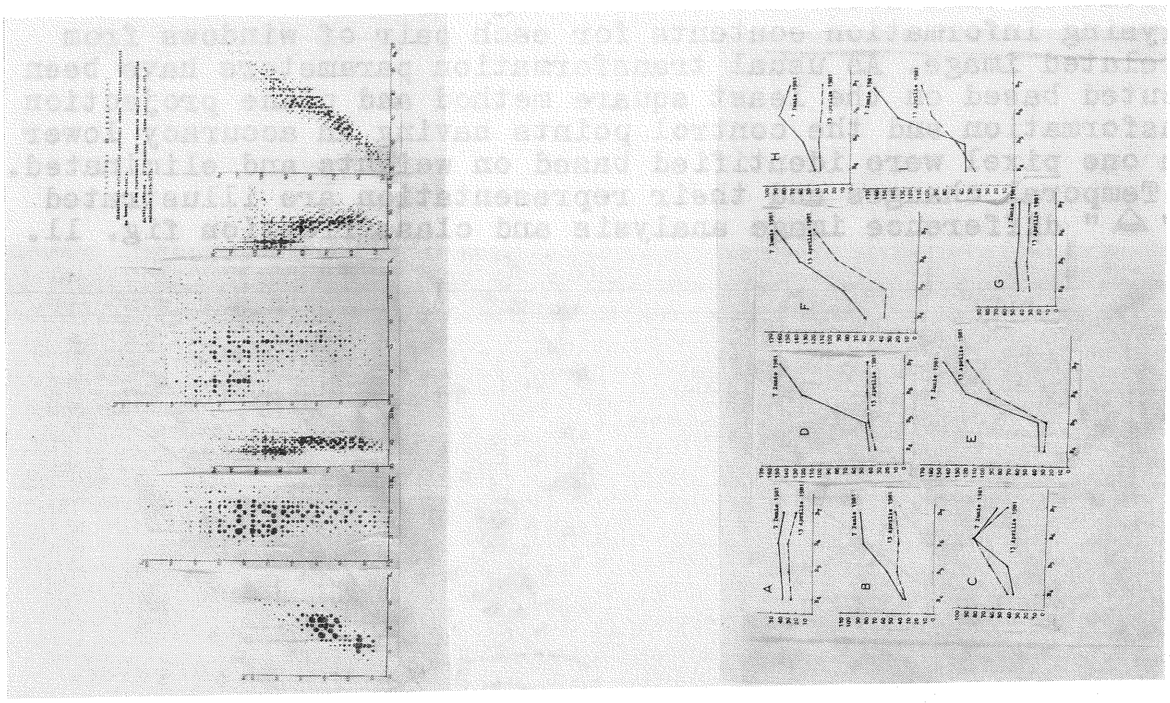


Fig. 12 a) Space spectral answer distribution on various spectral band combinations; b) class separation on various spectral bands corresponding to the two considered images.

Sampling and control zones should be carefully chosen that is they should be representative and should contain all classes we are interested in, but enough large, in other words to have a "robust" statistics according to multivariate analysis.
A test study has been approached for the deltaic Dunavăţ, Sf.Gheorghe Arm zone (Field of Remote Sensing Laboratory). We can draw the conclusion that nowadays, the presented SITI-DD concept suits the deltaic special conditions, using 10x10 km. working unity at a 1 : 25,000 scale.

RÉSUMÉ: On y présente brièvement les caractéristiques de la zone, la nécessité d'implanter le LISI-DD, les objectifs principaux ainsi que les idées de base concernant la conception, l'architecture, la configuration et l'implantation de celui-ci.
En utilisant des couvertures aéro-spatiales "historiques", ainsi que des déterminations radiométriques de terrain sélectionnées par saisons, on réalise;(a) des corrections radiométriques internes et externes des enregistrements en utilisant la normalisation et la manipulation des histogrammes de sorte que les enregistrements multidatés soient ajustés pour chaque période phénologique d'une saison, amenés à une situation standard et, par consequent, susceptibles d'être introduits dans la banque de données;(b) la registration géométrique absolue de l'image la plus représentative de chaque période et ensuite sur la base de cette image, la registration relative de tous les enregistrements ante-et post-datés; (c) la détection des changements par le traitement de séries d'enregistrements, en utilisant des méthodes conventionnelles analogiques et numériques pour chaque écosystème, ecotype, ecotope deltaïque en s'appuyant sur les images △ . On y aborde également une étude de cas pour le territoire du Laboratoire de terrain de Dunavăţ, sur le Bras Sf. Gheorghe.

ZUSAMMENFASSUNG: Es werden noch kurz, die Charakteristiken des Gebietes und die Notwendigkeit für die Einführung des LISI-DD, die verfolgten Ziele,Konturierung der Arhitektur und die Grundideen für seine Auffassung und Realisierung um Beschlüsse ziehen zu können, dargestellt. Durch Anwendung der "historischen" secventiellen Luft-Fernerkundungsaufnahmen mit den auf Jahreszeiten angeordneten und gegenwärtigen radiometrischen Bestimmungen wird folgendes realisiert:(a) radiometrische innere und äussere Korektionen durch Normalisierung und Behandlung der Histogramme, so dass die phenologisch abhängenden, secventiellen Aufnahmen zu einer standard Lage gebracht werden und ihre Aufspeicherung in einer Datenbank;(b) die absolute geometrische Registration für die repräsentativste Aufnahme und nachfolgend die Bestimmung im Bezug auf diese, der relativen Registration der Aufnahmen die vor und nach diesem Zeitpunkt durchgeführt wurden;(c) Detektierung der Veränderungen durch konventionelle analogische Methoden, sowie auch die digitale Verarbeitung der Spektralbandersets für jede Objektklasse aus demselben Ecosystem, Ecotyp, Ecotop, jahreszeitabhängend gruppiert, wodurch dann die Werte für das Differenzbild Δ erhalten wird. Von den gegenwärtigen Bedingungen abhängig, wird ein Kasus-Studium für ein deltaisches Gebiet angefasst das, des Fernerkundungslabors Dunavăţ am Sf. Gheorghe Arm.

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