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Regional aspects of the sustainable management of wetland resources

(REGWET)

Project homepage: http://www.exa.unicen.edu.ar/~wetland/regwet/

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Tools for wetland ecosystem resource management in Eastern Africa

CSGI University Of Siena, Department of Chemical and Biosystem Sciences, Via Aldo Moro 1, 53100 Siena	PROF. CLAUDIO ROSSI E-M : rossi@unisi.it TEL : +39 0577 234355 FAX : +39 0577 234177
UNICEN Universidad Nacional del Centro Campus Paraje Arroyo Seco (7000) Tandil, Argentina.	PROF. GRACIELA CANZIANI canziani@exa.unicen.edu.ar Tel. +54-2293-447104 Fax +54-2293-444431
USVID, USAL - VRID Dirección de Investigación - IMAE Universidad del Salvador Rodriguez Peña 770 – 2°Piso 1020 Buenos Aires, Argentina	PROF. GENOVEVA DE MAHIEU uds-inve@salvador.edu.ar Tel .+54 11 48130631 Fax +54 11 48131381

Final scientific report – summary

The INCO Accompanying measure entitled Regional aspects of the sustainable management of wetland resources (REGWET) began in March 2003 and was completed in February 2004. The project was aimed at extending and further developing the wetland management instruments that were developed in a preceding INCO project entitled The Sustainable Management of Wetland Resources in Mercosur" (IC18 CT98 0262). The project increased the collaboration on a regional basis by including the participation of wetland researchers and policy makers from Paraguay and Brazil in the measure as well as Argentine and European partners. Further scientific developments were made related to the development of wetland management indexes and water optical quality studies in neotropical wetlands. Two regional meetings were held in Paraguay, in which a large number of scientific and non-scientific stakeholders participated. The first meeting was dedicated to exploring and extending the results from the first INCO project in similar ecosystems in Paraguay while the second workshop reviewed the results of the application of several of the approaches developed to a specific wetland in Paraguay, in collaboration with Paraguayan colleagues.

The basic goal of REGWET was to extend the wetland resource management network of Mercosur scientists and to explore the use of instruments developed in the original INCO project in wetland resource management in Paraguay. Specifically, the researchers from Mercosur and Europe aimed to

- increase the dissemination of the wetland management and analysis instruments tools and methodologies developed in the original INCO project,
- extend the network of research institutions dedicated to the sustainable management of wetland resources in the Mercosur,
- identify the baseline data requirements and apply some of the approaches of previously developed to other Mercosur wetlands and favour their further development.
- initiate a regional dialogue related to the sustainable management of wetland resources

This was achieved through the following activities:

- Meeting between researchers in Paraguay, set up of dissemination activities and REGWET web site
- An exchange of ecological and socio-economic data between researchers, a collaborative research activities aimed at a specific wetland in Paraguay
- Satellite data analysis
- A wetland management workshop

The first wetland meeting was held in Asuncion and Pilar Paraguay in March 2003. The first section of the meeting was held in Assuncion and was organised by the Universidad Nacional de Asuncion – Facultad de Igegneria during the period 14 – 17 of March 2003. The four day general meeting in Asuncion consisted of an open panel discussion with researchers of different expertises from University faculties, European and Argentine research institutes and private companies regarding the results of the original INCO Project. This was followed by a field visit and data gathering in wetland sites of the Ñeembucù wetland. The second part of the meeting was held in Pilar and organized by the Universidad Nacional de Pilar – Facultad de Ciencias Aplicadas from March 18-21. The Pilar activities were split in to field activities with the Univ. of Pilar scientists and scientific meetings with the University researchers with the aim of an exchange of ideas and the creation of a closer collaboration on wetland research in the Parana basin. The results of the meeting are described in the annex. Participants in the panel discussion and scientific workshop are listed in the annex. The public meeting was covered in the national media and attended by a large number of local persons.

The REGWET web site was created by the UNICEN partner and is acting as a dissemination and information gathering site for the project and after. The address is http://www.exa.unicen.edu.ar/~wetland/regwet/

Scientific activities following the first meeting consisted in data gathering and analysis examining the natural and social characteristics of a major Paraguay wetland. Each partner analysed the information obtained and collaborated with the Paraguayan colleagues to apply and extend the instruments and experiences gained in the first INCO project to the REGWET study areas. These consisted in

- Analysis of landscape changes within the wetland using satellite data and possible relationships to economic activities and natural causes.
- Analysis of the socio-economic situation of the Ñeembucù wetland area and comparison to other wetland areas using specific indicators
- Analysis of water quality variations within the wetland area with respect to other wetland areas in the Mercosur.

These activities were performed in collaboration with a number of important regional institutions, in particular, the Comisión Nacional de Actividades Espaciales de la Argentina (CONAE), the Universities of Asunción and Pilar in Paraguay, the University of Cadiz and the University of Campo Grande (BR).

The wetland workshop was held in December 2003 in Asuncion and Pilar. The workshop was dedicated to presenting the results of the preliminary and competed analysis performed as part of the REGWET project and related wetland projects in the basin. Participants in the wetland workshop were from both the research and public policy areas and included also the general public.

Management report.
The REGWET project followed the expected timetable of activities, proposed in the technical annex and reported below:

Act.	Date	Description of event
1	March 2003	Meeting between researchers in Paraguay
2	April-Feb 2004	Baseline data determination on wetland resource uses and ecological data
3	April-Feb 2004	Satellite data analysis
4	December 2003	Wetland management workshop

The deliverables of the project are listed below:

1. Web page of the accompanying measure, containing information on the measure, data available and results of the preliminary satellite based analysis.
   http://www.exa.unicen.edu.ar/~wetland/regwet/

2. Workshop of exchange between INCO researchers and Paraguay wetlands researchers (see annex).

3. Wetland management workshop for the dissemination of the results of the accompanying measure and of the tools and methodologies developed in the INCO project. (see annex).

4. A final report of the results of the study, requirements for resource monitoring and extension of the results from the INCO project to Paraguay ecosystem management.

The results of the project were well disseminated on the regional scale. However, as the REGWET project was limited in time, the research that was performed during the project has not been published to date. Publications are being developed related to each aspect of the research activities. The coordination of these activities as well as the wetland meetings and workshops was performed by partner CSGI, with the close collaboration of UNICEN, USAL, Univ. of Asuncion and Univ. of Pilar.

Scientific report

This report briefly describes the research activities REGWET project related to:

- Analysis of landscape changes within the wetland using satellite data and possible relationships to economic activities and natural causes.
- Analysis of the socio-economic situation of the Ñeembucù wetland area and comparison to other wetland areas using specific indicators
- Analysis of water quality variations within the wetland area with respect to other wetland areas in the Mercosur.

Other activities include the dissemination activities that consist of two scientific and public meetings and the project web page. The description of the workshops and meeting is present in the annex.

Landscape analysis with satellite data

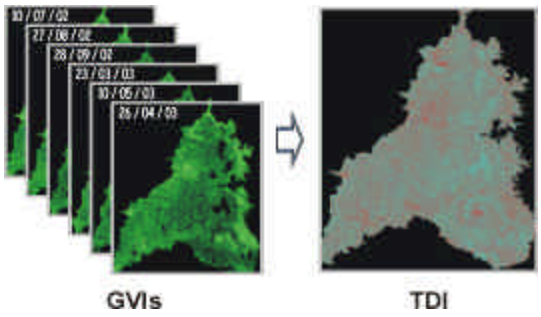
These activities were coordinated by the UNICEN partner in collaboration with COANE, CSGI, Univ of Cadiz and Univ. of Pilar. The development of satellite data tools for the mathematical modelling of the landscape dynamics were developed in the preceding INCO project (ERB IC18 - CT98 – 0262) while new developments were made in the present accompanying measure where they were applied to wetlands in Paraguay. Spatially extensive wetland analysis and management instruments are essential in the study of the vast wetlands that characterise the Del Plata basin, because they allow the possibility of studying the area in a integral manner.

The analysis was aimed at the Ypoa Wetlands located in Paraguay, where the researchers of the REGWET project focused their attention, together with a number of scientists in Argentina, Paraguay and Europe. The results of this analysis and development were demonstrated at a series of meetings with wetland scientists from the Mercosur countries within the REGWET project and several international meetings.

UNICEN researchers collaborated with local and international researchers in the scientific activities of the REGWET project and are continuing to work together with the team of researchers that has been developed. The growing importance of wetlands in the Del Plata basin, in combination with the increasing pressure to use these areas and the water that characterises them has made the use of these approached to analysis and management very important. UNICEN researchers participated in both the scientific and public meetings that were held on two occasions as part of the REGWET accompanying measure.

The new developments in the analysis approach were based on the different conditions of the particular region. The newly developed models use different techniques to optimise landscape classification and the calculus of vegetation indexes. Also a model to estimate tendencies was developed, which improves the capacity of monitoring the temporal evolution of the vegetation. Finally, coupling the exploration of changes in time and the results of indexes models, makes possible to detect potential anomalies and landscape and cover variations.

For the REGWET project, a Temporal Difference Index (TDI) was developed by comparing vegetation indices data from several images of the same geographic sector taken in different dates.



TDI definition

The method was applied using data obtained from a specific vegetation index on several images from one sector, in a temporal succession. These methods were applied simultaneously with the GVI band of the Tasselled Cap Transformation. For each pixel, this Cartesian representation will have as many points as images that are being analysed. The slope of the linear regression that fits the data furnished is taken as the value for the variation in each pixel. The least-squares fitting criteria is that which minimises the expression:

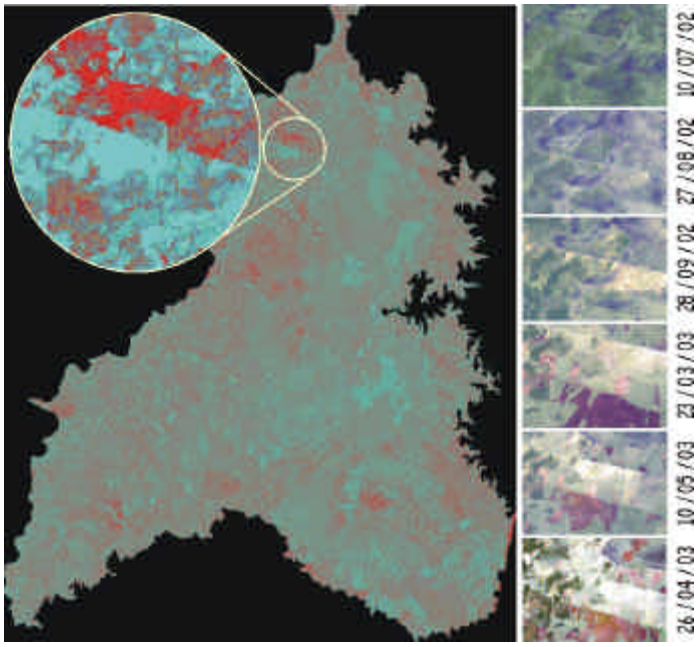
$$S = \sum_{1}^{n} (y_i - (ax_i + b))^2$$

where *a* is the slope of the line and *b* is the *y*-intercept.

The slope value determines how each pixel varies in time, increasing (positive slope) or decreasing (negative slope) its brightness. The slope is obtained when the derivative of *S* with respect to *a* and to *b* are zero. So, an equation system in two unknowns is solved to find the value of *a* and *b*.

$$a = \frac{N\sum x_i y_i - \sum x_i \sum y_i}{N\sum x_i^2 - (\sum x_i)^2}$$

A new image is generated with a value for each calculated slope *a* for each one of the pixels. The resulting image of the study wetland shows darker points where the slope values are negative, ie. where the vegetation index is decreasing , and it has brighter pixels where the vegetation intensity is increasing. Once the classification and the TDI index was performed, the necessary information for detecting areas that exhibit general variations and anomalies, and particularly vegetation intensity variation can be made. The analysis was done by identifying the areas of extreme values (very positive or very negative) and focusing on these zones to study these changes. Several zones of the Ypoa Wetlands exhibit variations of some kind that can be seen in the red zones below. In this example, the green regions show zones without change, while the shades of red indicate that the vegetation has undergone a major variation, in this case, an increase in the vegetation.



TDI Results

Performing the NDVI and TC transforms on the same images allowed the UNICEN researchers to retrieve more information which lead to the hypothesis that these areas are subjected to man induced fires for vegetation clearing. NDVI shows that the zones exhibit a remarkable absence of brightness. A search on fire foci detected in the wetland region between these dates was performed in order to define if the observed area was affected by fire was made. The information was acquired from the Queimadas Group (INPE/CPTEC) in Brazil. They monitor the zone with NOAA 12, NOAA 16, TERRA 01, AQUA 01 and GOES 12 satellites. It was possible to confirm that there was a fire focus in the spot where the anomaly was detected.

The proposed methodology allowed the further development and application of the satellite based wetland analysis that was developed in the original INCO project. The collaboration with CONAE and with the Paraguay collaborators in REGWET allowed for the extension and validation of the approaches developed. In particular, soil brightness, burn severity, and vegetation intensity are identified as important aspects for the definition of wetland vegetation indexes. The anomalies detected in the Ypoa wetlands include vegetation increments due to agricultural activities, as well as vegetation reduction due to land clearing and marks of possibly burnt areas. The methodology can be applied to the to other wetlands in Mercosur and worldwide. Regionally, these results were presented to the research community and public of several Paraguay wetland areas

Socio-economic analysis of the Ñeembucù wetland area

Various activities were carried out by the USAL researchers in collaboration with Paraguayan colleagues in order apply some of the analysis indicators used in the Esteros del Iberá study to the Esteros de Ñeembucú area, in particular, the tools and methodologies necessary to make socio-economic and cultural diagnosis regarding the relationship between society and nature:

The indicators with environmental implications were used for the study of Ñeembucú area, where local and national statistics were available and the UNDP Human Development Atlas 2003. These

were used to examine the socio-economic situation in the wetland dominated areas and compare those to national and regional conditions. A brief summary of the results follow.

The Ñeembucú Department has characteristics that make it different form other Departments in Paraguay. It has an strategic location between the two main rivers of the region, the Paraná and the Paraguay, which make wetland a main aspect of the Department resources and resource management. Due to these characteristics it has an important role in the context of a regional integration process, becoming the first port of entry (for imports) and the last of departure (for exports). The area offers a number of developmental possibilities, as of yet undeveloped that could promote the social and economic development of the region, which would also benefit the rest of the country. Ñeembucú has been a neglected Department, it was for a long time the only Department of Paraguay lacking paved routes, but that situation is changing nowadays.
This Department has big wetlands, and its area has a big number of wetlands, lagoons and small watering places that in some parts of the year hinder the agricultural development. Besides this, there are recurring floods in the southern zone of Yacyretá dam, that continuously damage the low-lying regions. The capital city of Ñeembucú, Pilar, was totally flooded in 1983, and its surrounding neighborhoods suffer recurring floods because they don not have definite defence walls.

Ñeembucú has an area of 12.147 sq km. It has been the only Department that showed a negative growth rate in the Census of 1992. It is divided into 16 districts, as follows: Pilar (capital), Isla Umbú, Mayor Martínez, Desmochados, Gral. Díaz, Paso de Patria, Humaitá, Laureles, Villalbin, Villa Oliva, San Juan del Ñeembucú, Cerrito, Tacuaras, Alberdi, Villa Franca and Guazu Cuá.
The Department has a population of 87.873 inhabitants, and it is estimated to reach 88.285 inhabitants in year 2000, with a growth of 0,4%. In the Department there are more men than women in the Economically Active Population, and a bigger number of men work in the rural area than in the urban area. This can be shown as follows:

Urban area 70%
Rural area 80,4%

The participation rate of women is much lower than the one correspondent to men. The relation between the population out of the working age and the population that is in the working age, known as ratio of dependence, was 81,03 in 1990. In year 2000 it had fallen, reaching 72,76%.

Ñeembucú is a Department whose main economic activities are agriculture and livestock breeding. Only the 0,24% of the total area of the Department is farmed with products that can be sold in the national market, such as: garlic, rice, pea, sugar cane, strawberry, manioc, peanut, tomato, potato, soybeans, tobacco, carrot. Ñeembucú only has 22 industrial companies with more than seven workers per zone, with its main office in the Department. They are exclusively located in the urban area, none of them are in surrounding or rural areas. In the city of Pilar it is located one of the most important textile companies of Paraguay, with approximately a thousand workers.

According to the information about hospital services of public institutions provided by the Statistical Yearbook of Paraguay 1997, in Ñeembucú there are only 86 available beds. This means that there are only 9,7 beds per 10.000 inhabitants.

In Ñeembucú, 27,3% of the population has drinking water supply services, either supplied by CORPOSANA, by SENASA, or by private system, 51,4% of the population has safe water (wells with and without pump), and 21,3% has not got drinking water. This means that 17.500 inhabitants obtain water from springs, rivers, streams, etc.

A total of 16.259 housing units were taken into account in the census, and the results indicate that 37,7% of them have electricity supply services, and 28,3% have water supply services. But this

situation varies considerably between urban and rural areas. Only 5,4% of the units have electricity supply services in the rural area, whereas in the urban area 74,9% of the units have them. Only 0,3% have water supply services in the rural area, whereas in the urban area the correspondent percentage is 60,5%.

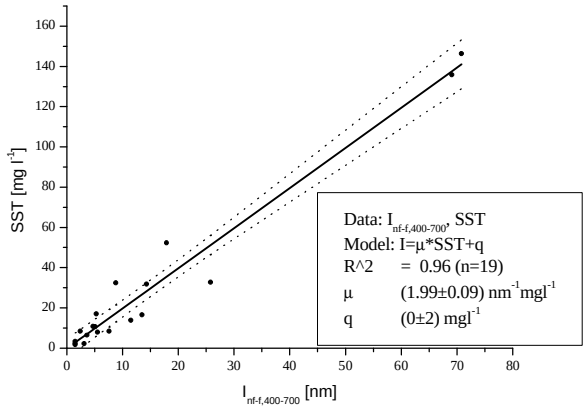
Unsatisfied Basic Needs (UBN)
In Ñeembucú 75,93% of the households have at least one UBN, which is a percentage that exceeds in 11,75 points the national average. There is a big difference between the poorest and the richest districts in terms of UBN: Gauzucuá has 95,39% of the households with at least one UBN whereas Alberdi has 63,69% of the households with at least one UBN. The difference is 31,7 points. The rural areas have 4 out of 5 households with deficiencies (79,94%), whereas urban areas have a lower percentage (71,37%). Tacuaras, Villa Franca y Guazucuá are the districts at the end of the scale according to the high percentage of households with unsatisfied basic needs, and they are the ones with the worst results in terms of socio-demographic indicators related to deficiencies. The percentage of illiterate population in Tacuaras (24,8%) and Guazucuá (23%) is higher than the departmental average, while the percentage in Villa Franca (14,9%) is closer to it. Regarding indicators related to housing issues, only Tacuaras has part of its housing units (6,2%) with electricity supply services. In Ñeembucù, 48,49% of the housing units lack sanitary infrastructure, 29,3% of its households have deficiencies related to the access to education, and 18,57% of its households with deficiencies are in a situation of subsistence capacity, what means that in this UBN the district is in the third level of the departmental scale. Regarding the variables analysed, there are some special points to mention:
Guazucuá has got only 251 households according to the census of 1992, it appears in the 216º position in the whole of the country, and if we take into account the four UBN it is below other districts such as Tacuaras or San Juan de Ñeembucú.
With respect to education, there is a high desertion rate from schools, basically because of the rural culture which makes the help that a child can bring in rural or domestic activities more appreciable for their parents than the school education that he/she can get, in important production areas. Besides this, there is also a big distance between educational centres and family houses. We should also mention the continuous emigration of families that live in riverside areas affected by floods, that many times make it necessary to close the educational centre and to move people towards higher areas where there are no educational centres.
Regarding this point, we have to mention that the department has got 8 neighborhoods and 38 riverside towns threatened by floods, in the areas of Pilar, Villa Oliva, Alberdi, Villa Franca, Humaitá, Paso de Patria, Gral. Díaz, Mayor Martínez, Villalbin, and Cerrito, in whose housing units the deficiencies become more evident.

Water quality analysis of different wetlands in the Mercosur.

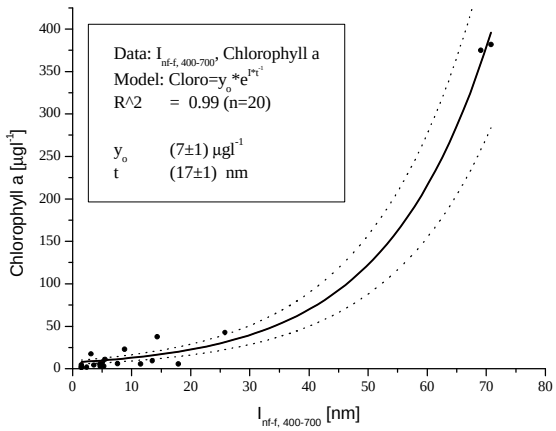
As part of the field sampling of the REGWET project, researchers from CSGI. Univ of Pilar (PG) and Universidad Federal de Campo Grande (BR) obtained samples from12 water bodies in the Ypoà, Ñeembucu and Pantanal wetlands for a comparison of the optical and biological qualities. Phyto- and zooplankton samples were also collected trawling a plankton net (80µ mesh). The analysis were performed to determine dissolved organic matter (DOM), total suspended solids (TSS), organic suspended solids (OSS), inorganic suspended solids (ISS,), chlorophyll *a* (*chl a*) and the spectrophotometric extinction between 250-700 nm. This latter extinction data was used to determine the differences in the optical qualities of the different ecosystems sampled. Correlations between the biological and optical characteristics of the ecosystems were studied, to permit the continued sampling and spatial characterization of these open water bodies in the future. The spatial and temporal evolution of the optical properties of these inland water bodies is very sensitive to

changes in the hydrological and meteorological conditions of the surrounding environment. This was demonstrated in the first INCO project and has been further developed in the present accompanying measure. In particular, a number of new analysis approaches were developed and tested on the samples from these 12 water bodies. The results demonstrate significant differences between the quality of the water bodies with respect to the presence of ultraviolet and visible light, as well as the role of dissolved and particulate matter in changing the water quality.

The ultraviolet and visible extinction spectrums were analyzed using filtered and unfiltered water samples obtained in 12 sampling sites in two distinct periods. The influence of particulate matter dominated in the extinction of the wavelengths higher than 400 nm. The integral of the extinction curve in the visible wavelengths (400-700 nm) was found to relate with the concentrations of particulate matter such that significant correlations with the total suspended solids and chlorophyll concentrations were determined. These are presented in the following graph.

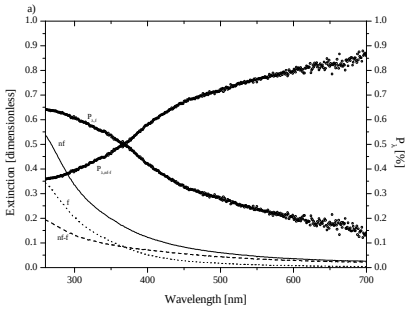


Linear correlation between *I* (Eq. 1) and the measured concentration of *TSS*. The dot lines indicate the 95%-confidence limits

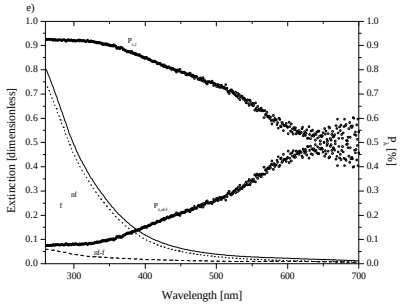


Exponential correlation between *I* (Eq. 1) and the measured concentration of *chl a*. The dot lines indicate the 95%-confidence limits

The spectra of the extinction percentages was obtained for each sample, both filtered and unfiltered. The spectra were analyzed to assess the role of specific water components in the optical conditions of the wetland lakes studied and in particular to the penetration depth of the UV radiation. Two of the spectra, as well as the calculated percentage of total extinction for each wavelength due to dissolved and particulate fractions of the water body are presented below.



Optical characteristics of water sample 1. Measured extinctions in the non-filtered (nf, solid line) and filtered samples (f, dot line). Calculated extinction of suspended matter (nf-f, dash line) and P_1 curve of dissolved ($P_{1,f}$) and

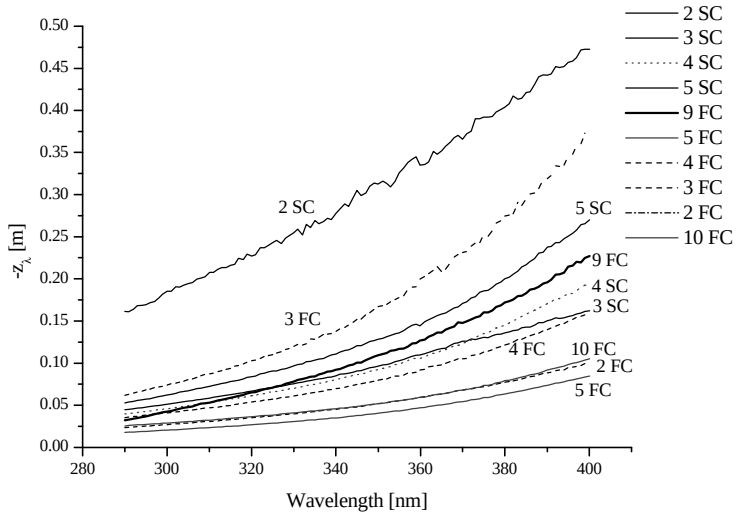


Optical characteristics of water sample 5. Measured extinctions in the non-filtered (nf, solid line) and filtered samples (f, dot line). Calculated extinction of suspended matter (nf-f, dash line) and P_1 curve of dissolved ($P_{1,f}$)

suspended matter ($P_{1,nf\text{-}f}$)	and suspended matter ($P_{1,nf\text{-}f}$)

The differences in DOM concentrations explained the main pattern of UV extinction. Nevertheless, second-level differences between the studied lakes depended also on the molecular weight of DOM. The degree of photodegradation and photobleaching of DOM was found to negatively influence the extinction of UV radiation in these humic environments.

Overall penetration of ultraviolet radiation was found to vary significantly in these ecosystems. The presence of modifications in incident light field, as well as any changes in the hydrological conditions or inflow of materials could influence the presence and growth of numerous aquatic organisms in these areas of high insolation. The estimated penetration of 10% of incident solar UV radiation for each study site is described in the figure below.



Even though off site optical characterization of filtered and unfiltered samples of the of natural waters cannot replace the direct on-site measurements of light attenuation, the preliminary research performed in collaboration with Mercosur partners showed that a number of important properties of the aquatic ecosystems can be studied. The optically determined properties of the water samples gave fundamental information about light environment of the study ecosystems and was correlated with other water column components (TSS, chlorophyll a concentrations). Further development is continuing, in particular to relating specific wavelengths or wave bands of the directly measured spectral extinction curves or indirectly measured to other water column properties.

Annex A

Regional Aspects of the Sustainable Management of Wetland Resources
REGWET

First wetlands meeting of the REGWET AM

The first general meeting concerning the Accompanying Measures to the INCO Project *The Sustainable Management of Wetland Resources in Mercosur* (SMWRM) was organised by the Universidad Nacional de Asuncion, Facultad de Igegneria of the *Regional Aspects of the Sustainable Management of Wetland Resources* (REGWET) Project. The first section of the meeting was held initially in Assuncion during the period 14 – 17 of March 2003. The second section of the meeting was held in Pilar with the support of the Universidad Nacional de Pilar – Facultad de Ciencias Aplicadas from March the 18th to the 21st.

In Asuncion the following researchers were the central promoters:

Alejandro B. Centurion	Decano de la Universidad Nacional de Asuncion – Facultad de Igegneria	
Ramon E. Pistilli	Dir. Financero de la Universidad Nacional de Asuncion – Facultad de Igegneria	
Margherita Falcucci	CGSI- Laboratorio Centrale di Idrobiologia di Roma	Italy
Vincent Hull	CGSI- Laboratorio Centrale di Idrobiologia di Roma	Italy
Genoveva de Mathieu	Universidad del Salvador	Argentina
Graziela Canziani	Universidad Nacional del Centro de la Prov. BsAs	Argentina
Diego Ruiz Moreno	Universidad Nacional del Centro de la Prov. BsAs	Argentina
Emilio Buongermini	Paraguay	

A large number of other researchers and professors of the Universidad Nacional de Asuncion.

In Pilar the following researchers were present:

Dr.Reinaldo C. Franco Ibañez	Rector of the Universidad Nacional de Pilar	
Rafael G. Bordon	Director Inst. Ciencias Ambientales - Universidad Nacional de Pilar	
Margherita Falcucci	CGSI- Laboratorio Centrale di Idrobiologia di Roma	Italy
Vincent Hull	CGSI- Laboratorio Centrale di Idrobiologia di Roma	Italy
Cesar M. Pfanni	Inst. Ciencias Ambientales - Universidad Nacional de Pilar	
Josè M. Gomez	Inst. Ciencias Ambientales - Universidad Nacional de Pilar	

In Asuncion

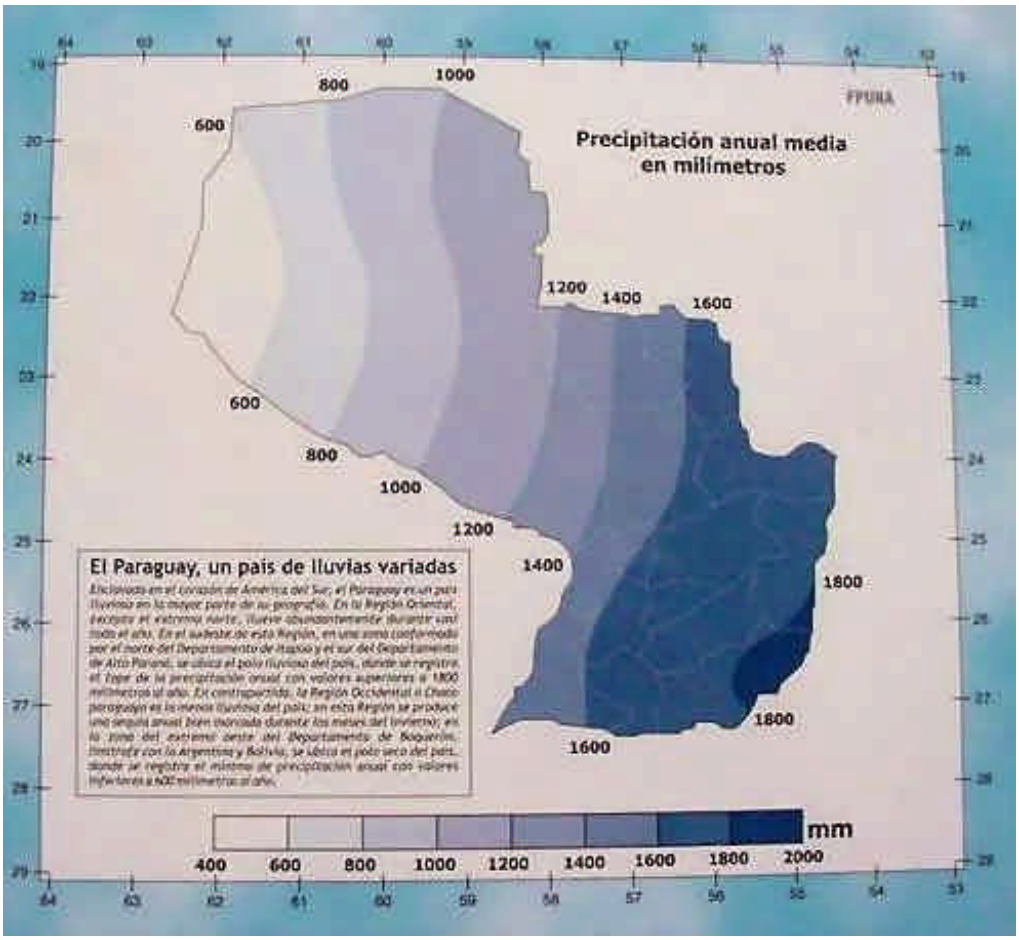
The four days general meeting in Asuncion was split in two distinctive activities:

- Visit to the lake and Esteros of Ypoà and to different wetland sites in the most northern area of Neembucu;
- A Panel Discussion with researchers of different expertises from University faculties and private companies regarding the results of the preceeding INCO Project The Sustainable Management of Wetland Resources in Mercosur at Iberà (Argentina) in relation to regional wetlands.

The Decano de la Universidad Nacional de Asuncion – Facultad de Igegneria organized in the early morning of the 14th of March a very preliminary meeting to have the opportunity to know each other and to discuss the organization of the general meeting to be held the next Monday. After this, a group of 9 people moved south of the city of Asuncion for a visit the lake of Ypoà and to the Esteros de Ypoà. The territory of the Ypoà lake is a Ramsar site but does not evidence borders of any kind. During this first visit (140 km) to the Ypoà wetland region water samples were taken at the following sites. These samples were later analysed in Europe by CSGI –LabRoma, CSGI-Siena and Univ. de Cadiz researchers.

During the field trip around the esteros area, information and exchange was made between the new Paraguayan UNA colleagues and the researchers in the original Ibera study. In particular an interesting map of the rain fall regime in Paraguay that is reported in figure below.

Rainfall regime in Paraguay



On Monday morning, an open public meeting and Discussion was held at the Instituto Paraguayo de Telecomunicaciones from 9:30 a.m. to 5:15 p.m. (attachment n. 1). Over 150 people attended the meeting. After the opening of the Decano of the University, Professor Centurion, the first part of the meeting was dedicated to a presentation of the most relevant results of the INCO Project SMWRM. The actors of this section were G. de Mathieu, G. Canziani and V. Hull. The second part saw the platea making several questions to the speakers and a wide discussion was initiated on the possibility/necessity for making similar experiences on the Ypoà and Neembucu regions and about possible funding sources. After a break for lunch the discussion went deeper into the problems, also

thanks to the division of all the attendants into three working groups aimed to analyse and propose specific research activities for the Paraguayan wetland regions:

1. social and economical problems
2. environmental problems
3. sustainable use of territory and resources

The meeting closed with the proposition to define a protocol of methodologies for the sustainable use of the wetlands in Paraguay, where one of most complex problems remain the fact that 93% of all the Paraguayan territory is private property, including the Ramsar site of Lake Ypoà.

At Pilar

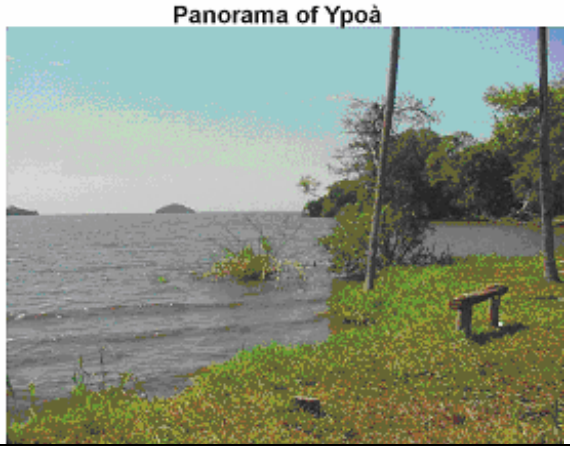
The three days meeting in Pilar was also split in to field activities and meetings with the rector of the university and his collaborators.
The European researchers were accompanied to visit wetlands and lagoons of the southern area of Ñeembucù. This territory is covered of more than 500 lakes and lagoons, most of them are very small, but some are large water bodies. The census of all the water bodies of the province of Pilar was a work performed by GIS studies of the Institute de Ciencias Ambientales (ICA) of the University.

Partners to the REGWET Project

Attending the Meeting

Prof. Centurion - Decano

Panorama of Ypoà



Neotropical Depressed Vegetation

Transportations in the wetlands

Annex B

Regional Aspects of the Sustainable Management of Wetland Resources
REGWET

Second and Final wetlands meeting of the REGWET AM

The final general meeting of the REGWET Accompanying Measures to the INCO Project The Sustainable Management of Wetland Resources in Mercosur (SMWRM) was organised by the Universidad Nacional de Asuncion – Facultad de Igegneria in Asuncion Paraguay. The wetland workshop, held in Pilar, was organized by the Universidad Nacional de Pilar – Facultad de Ciencias Aplicadas.

At the meeting the following researchers of the original the INCO Project were present:

Claudio Rossi (Project Leader) CGSI - Dip. Scienze e Tecnol. Chimiche e dei Biostistemi Università di Siena, Italy
Margherita Falcucci CGSI- Laboratorio Centrale di Idrobiologia di Roma, Italy
Vincent Hull CGSI- Laboratorio Centrale di Idrobiologia di Roma, Italy
Genoveva de Mathieu Universidad del Salvador, Buenos Aires, Argentina
Graziela Canziani Univ. Nacional del Centro de la Prov. BsAs, Tandil, Argentina
Federico Dukatz Univ. Nacional del Centro de la Prov. BsAs, Tandil, Argentina
Manuel Vargas Russo Univ. Nacional del Centro de la Prov. BsAs, Tandil, Argentina

Together with the Paraguayan partners:

Alejandro C. Blanco Decano de la Univ. Nacional de Asuncion – Fac. de Igegneria
Ramon E. Pistilli Dir. Financero de la Univ. Nacional de Asuncion – Fac.de Igegneria
Javier S. Spinzi Universidad Nacional de Asuncion – Facultad de Igegneria
Dr. Reinaldo C. Ibañez Rector of the Universidad Nacional de Pilar
Rafael Gonzales Director Inst. Ciencias Ambientales – Univ.Nacional de Pilar
Josè M. Gomez Inst. Ciencias Ambientales – Univ.Nacional de Pilar
Carolina Fossati Inst. Ciencias Ambientales – Univ.Nacional de Pilar
Victor Portillo Inst. Ciencias Ambientales – Univ.Nacional de Pilar
Miguel A. Delpino Inst. Ciencias Ambientales – Univ.Nacional de Pilar
Luis Recalde Inst. Ciencias Ambientales – Univ.Nacional de Pilar

and many professionals of the University of Pilar and of the Office of the Governor of the Province of Ñeembucù.

Two researchers (Giancarlo La Storia – hydrogeologist, and Kennedy Roche - planktonologist) of the Universidad Federal de Campo Grande (Mato Grosso do Sul – Brazil) were also invited, but unfortunately were unable to attend. However, both sent messages of participation and will continue contact with the people of the network.

The three day meeting was held at the head quarters of the Governors Office in a room able to receive over 150 people. The event was announced in Asuncion on the most important city newspaper and in Pilar by a local radio network.

The aim of the meeting was to have the opportunity to show to a wide platea the objectives and the results of the AM project, the INCO project and other projects in the area, and discuss them with the scientists and public assembled.

After the first welcome talks of the Governor of the Province of Ñeembucù, that of the representative of the two hosting Universities of Asuncion and Pilar, a series of scientific talks were given by the scientific participants to the project. Each presented the developments and results of the preliminary studies performed as part of the REGWET project and the comparison of these results with those obtained in the original INCO project or related projects.

Rafael Gonzales (Univ. Pilar – Pilar Paraguay)
Genoveva de Mathieu (Univ. del Salvador – Buenos Aires, Argentina)
Graziela Canziani (Univ. Nacional del Centro de la Prov. de Buenos Aires - Tandil, Argentina)
Vincent Hull & Margherita Falcucci (CGSI - Laboratorio Centrale di Idrobiologia – Rome, Italy)
Jose Maria Gomez (Univ. Pilar – Pilar Paraguay)
Claudio Rossi (CGSI - Laboratorio Centrale di Idrobiologia – Rome, Italy)

A discussion followed regarding the historical and actual approaches toward wetland management, as well as the future perspectives for the sustainable management of wetland resources in Paraguay, in particular integrating experiences obtained in the wetlands of Iberá, Ñeembucù and Pantanal.

Region LAM
Research area INCO A4 DEV ICFP 599A4AM01

EU Contract number ICA4-CT-2002-50027

Individual Partner reports

Regional aspects of the sustainable management of wetland resources

(REGWET)

Project homepage: http://www.exa.unicen.edu.ar/~wetland/regwet/

Keywords:
Mercosur, wetland management, ecosystem indicators, ecological modelling

Partner Summary Report – PARTNER 1 CSGI

Scientific coordinator: Claudio Rossi
Researchers:
Vincent Hull, CGSI- Laboratorio Centrale di Idrobiologia di Roma, Italy
Andres Cozar, Facultad de Ciencias del Mar y Ambientales, Universidad de Cadiz
Margherita Falcucci, CGSI- Laboratorio Centrale di Idrobiologia di Roma, Italy
Steven Loiselle, CSGI . Università degli Studi di Siena
Luca Bracchini, CSGI . Università degli Studi di Siena

Objectives

The CSGI research team participated in the sampling, analysis and dissemination activities throughout the research project. CSGI researchers worked with both local researchers and with research partners from the original INCO project. CSGI also acted as coordinator of the REGWET project. The objectives of the research were:

- increase the dissemination of the tools and methodologies developed in the original INCO project and extend them to new wetland areas in collaboration with regional partners
- participate in a regional dialogue related to the sustainable management of wetland resources in Mercosur, in particular in the two REGWET conferences held in Paraguay.
- application of and further development of the optical analysis of the humic waters that dominate the inland aquatic ecosystems of the Paraná basin.

CSGI researchers collaborated with scientists from the Univ of Pilar (PG), Univ. Nacional de Asuncion (PG) and Universidad Federal de Campo Grande (BR) in the discussion and analysis of wetland management and analysis. A collaborative preliminary analysis of a number of water bodies was performed.

The focus was on the analysis wetlands in Paraguay and Brasil, using methods that were first developed in the original INCO project entitled The Sustainable Management of Wetland Resources in Mercosur" (IC18 CT98 0262). The results of this analysis were demonstrated at a series of meetings with wetland scientists in Paraguay and are being assembled for collaborative publication to be submitted to scientific journal Chemosphere.

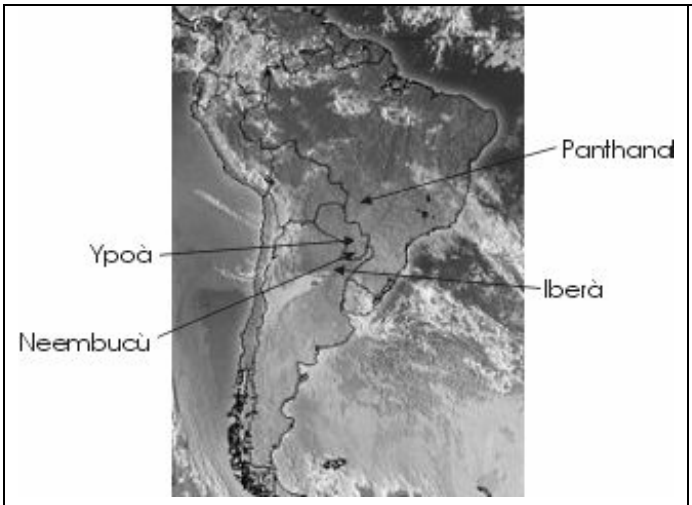
CSGI researchers participated in both meetings in Paraguay and have developed a collaboration with other wetland scientists in Paraguay and Brazil.

Activities

A. Dissemination activities in the two REGWET meetings, held in March and December 2003. Researchers from CSGI included Claudio Rossi, Vincent Hull and Margherita Falcucci. Each participated in both the presentation and discussion of the research and information exchange.

B. Research to examine the biological and optical characteristics of different wetland water bodies. Extension and development of analysis approaches developed in the original INCO project, in collaboration with researchers from University of Pilar (Paraguay),Institute Ciencias Ambientales, of Asuncion (Paraguay), Faculty of Engineering and the Federal University of Mato Grosso do Sul.

The sites chosen for study were situated in the Ypoà and Ñeembucù region in Paraguay and different areas of the Pantanal wetland in both Brazil and Paraguay. These sites are reported below.



Map of measuring areas

Table 1. Coordinates of measuring sites

Site	Region	Coordinates	
		South	West
Ypoa	P	25.94528	57.44581
Arroyo Surubi'y	P	25.65445	57.61948
Arroyo Paray	P	25.81526	57.74413
Arroyo Hondo	P	27.04663	58.30375
Laguna Paso Vega	P	27.01039	58.29568
Laguna Guazu Gua	P	26.88078	57.96551
Isla Umbu Ovest	P	26.97901	58.27056
Isla Umbu Est	P	200 m from above	
Lago Salato	PB	19.56289	56.1009
Rio Negro	PB	19.58782	56.08693
Rio Miranda	PB	19.57708	57.01824
Baia de Medalha	PB	800 m east Rio MIranda	
Rio Blanco	PP	21.00171	57.80803
Rio Navileque	PP	20.92315	57.83277
Laguna Soo Kangue	PP	20.93591	57.84022
Rio Apa	PP	22.09035	57.97256
Rio Paraguay	PP	22.12974	57.95714

P Paraguay
PB Pantanal Brazialian side
PP Pantanal Paraguayan side

.

Sampling involved the determination of water temperature, dissolved oxygen and saturation, chlorophyll *a* and degraded pigments and suspended matter. Plankton samples were obtained for analysis. Filtered and unfiltered water samples were analysed for optical measurements to determine the extinction coefficients in different wavelengths.

The analysis of the ultraviolet (UV, 260-400 nm) and visible (Vis, 400-700 nm) extinction was demonstrated to be a suitable surveying method to study the optical characteristics in humic aquatic ecosystems. The analysis of the solar extinction along the water column is related to several major ecosystem processes, light limitation of primary production and UV induced inhibition events. The biological community can be negatively affected by the UV radiation. In particular, UVB radiation (290 - 320 nm) is the most damaging portion of the solar spectrum but is usually extinguished quickly in freshwater ecosystems. In clear aquatic ecosystems (e.g. ocean), the solar UVB may penetrate tens of meters, but in the humic lakes that dominate subtropical and tropical latitudes, a significant UVB attenuation may occur in the first centimeters. In these aquatic ecosystems the measured spectral attenuation coefficient in UVB (A_1, m^{-1}) can approximate the attenuation determined by the dissolved organic substances present in the water. From information about the incident radiation and the extinction coefficient at specific wavelengths, it is possible to estimate the exposition of living systems to solar UVB radiation. Due to the importance of the UVA bands (320-400 nm) and Vis spectra in the repairing the damages of UVB radiation and their control of the primary production, a wide solar spectrum should be considered in the biological characterization of natural solar radiation in the aquatic ecosystems. From extinction measurements, it is possible to determine chemical and photochemical characteristics of the dissolved substances. It is also possible to determine the degree of photobleaching (loss of spectral absorbance of DOM) connected to the time of permanence in the aquatic ecosystems and the exposure dose. The processes of photodegradation (formation of lower molecular weight particles) and photobleaching of the dissolved organic matter in the water column influence UV extinction. The increasing dose of UV radiation on the dissolved substances and a subsequent photodegradation imply a smaller adsorption of UV radiation.
Tropical and subtropical wetlands of the Mercosur are both ecologically (due to their generally high biodiversity) and economically important, as major storage areas for freshwater. The complex trophic structures of these ecosystems are often threatened by local and global perturbations in the aquatic or atmospheric environments. The solar radiation flux at lower latitudes is relatively high compared with the middle and higher latitudes. Many of these open water bodies are characterized by their shallowness, which may permit a strong interaction of the aquatic community with the incident solar UV radiation. On the other hand, the surrounding wetland vegetation releases high quantities of dissolved organic matter into the water column, which strongly influenced the light environment of the water bodies. The study of the effects of dissolved and suspended particulate matter on the light environment in tropical and subtropical lakes presents an area of importance in the study of these important ecosystems. The inland water bodies examined as part of the REGWET project were located in the Ñeembucu wetland in Paraguay and in the southern area of the Pantanal wetland in southestern Brazil. The study was performed in water samples of 12 water bodies during two well-differentiated seasons (March 2003 and September 2003). The optical analyses were based on the comparison of the extinction spectrum of 0.22 μm-filtered and non-filtered samples. The extinction spectrum was built from 260 nm to 700 nm with a spectrum resolution of 1 nm.

The concentrations of dissolved organic matter (DOM, mg l^{-1}) of the filtered samples were estimated from the 272 nm-extinction by using an appropriate calibration curve. In addition to the extinction spectrum for each sample, non-filtered water samples were also analyzed to determine the concentrations of suspended matter (total suspended solids, TSS; organic suspended solids, OSS; and inorganic suspended solids, ISS) and chlorophyll *a* (*chl a*). Particulate suspended matter, both inorganic and organic fractions, were measured by gravimetry after filtration. Chlorophyll *a* were measured by spectrophotometry following to Strickland and Parsons (1972). Using the extinction measurements in the non-filtered (total extinction, $a_{1,nf}$) and filtered samples ($a_{1,f}$), the contribution of the particulate matter (> 0.22 μm) to the total water column extinction was determined for each wavelength ($a_{1,nf-f}$, dimensionless) as:

$$a_{l,nf-f} = a_{l,nf} - a_{l,f}$$

By determining the area under the $a_{l,nf-f}$ curve between 400 and 700 nm (I, nm), the correlation between the particulate related extinction and the measured particulate quantities can be examined (*chl a* and *TSS)*

$$I = \int_{400}^{700} a_{l,nf-f}\, dl \qquad \text{(Equation 1)}$$

$$TSS = m \cdot I + q$$

$$chla = y_o e^{\left(\frac{I}{t}\right)}$$

where m, q, y_0 and t were determined using a least square method. Likewise, the percentage of the dissolved fraction to the total extinction can be determined ($P_{l,f}$, dimensionless):

$$P_{l,f} = \frac{a_{l,f}}{a_{l,nf}} = 1 - \frac{a_{l,nf-f}}{a_{l,nf}} = 1 - P_{l,nf-f} \Rightarrow P_{l,nf-f} = 1 - P_{l,f}$$

On the other hand, the coefficient of the solar UV band attenuation for the dissolved fraction (A_l, m^{-1}) was calculated as:

$$A_l = \frac{2.3 \cdot a_{l,f}}{10^{-2}} \qquad \text{(Equation 2)}$$

where 10^{-2} m is the linear pathlength of the cuvette, 2.3 is the conversion constant of the base 10-logarithm to the Neper logarithm, and $a_{l,f}$ is the extinction measured by spectrophotometry.

The depth where 10% of incident solar UV radiation just below the surface is present can be roughly estimated from the A_l (assumed as total attenuation) through the following equation:

$$z_l = z_0 + \frac{1}{A_l} \cdot \ln\left[\frac{I(z)}{I(z_0)}\right] = z_0 + \frac{1}{A_l} \cdot \ln[0.1] \qquad \text{(Equation 3)}$$

where z_0 it represents the depth just below the water column (z_0=0.00 m).

The degree of photodegradation of the dissolved fraction is related to the inverse relative molecular weight ($(MW_r)^{-1}$, dimensionless) of the measured DOM and was estimated through the extinction ratio of the filtered samples at 250 nm and 365 nm as

$$(MW_r)^{-1} = \frac{a_{250,f}}{a_{365,f}} \qquad \text{(Equation 4)}$$

The degree of photobleaching of DOM can be estimated from the slope of the filtered extinction sample, which was calculated with the best exponential fitting:

$$a(l)_f = a(l_0)_f e^{s(l-l_0)} \qquad \text{(Equation 5)}$$

where $a(l_0)_f$ is the extinction of the filtered samples measured at the wavelength l_0, and s (slope, nm^{-1}) is estimated with the least square method. The analysis was developed between 260 and 700 nm. Thus, $a(l_0)_f$ corresponds to extinction measured at 260 nm.

The results of the measurements in each field campaign of each sampled site are presented in Table 1, as well as the differences between the values measured in the each period. The estimated DOM concentrations from the adjusted model varied from 6.90 ±0.07 mg l^{-1} to 25.6 ±0.2 mg l^{-1} during the first survey and from 2.4±0.1 mg l^{-1} and 17.8 ±0.1 mg l^{-1} during the second survey. The average concentration of DOM and standard deviation was 15±6 mg l^{-1} for the first survey and 10±5 mg L^{-1} for the second survey.

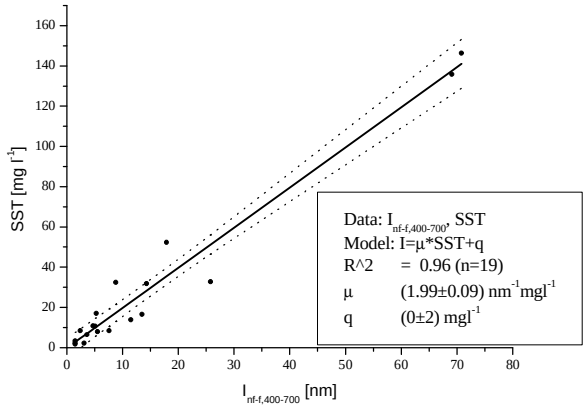
sample (FC)	**Lat South**	**Long West**	**a_{272}**	**DOM [mgl^{-1}]**	**±D**DOM [mgl^{-1}]	***chl a*** **[mgl^{-1}]**	**TSS [mgl^{-1}]**	**OSS [mgl^{-1}]**	**ISS [mgl^{-1}]**	**I [nm]**
1	25.94	57.44	0.303	12.7	0.1	5.6	13.9	11.4	2.5	11.5
2	25.65	57.61	0.463	19.4	0.1	2.8	17.1	14.2	3.0	5.2
3	25.81	57.74	0.205	8.57	0.08	1.4	1.8	0.5	1.3	1.5
4	27.04	58.30	0.311	13.0	0.1	2.8	10.8	9.5	1.3	4.7
5	27.01	58.29	0.661	27.6	0.2	17.4	2.3	0.0	2.3	3.1
6	26.88	57.96	0.165	6.90	0.07	11.1	7.9	0.0	7.9	5.5
7	26.97	58.27	0.310	13.0	0.1	37.7	31.8	10.1	21.7	14.3
8			0.321	13.4	0.1	42.7	32.7	11.3	21.4	25.8
9	19.56	56.10	0.434	18.1	0.1	4.2	6.5	0.8	5.6	3.6
10	19.58	56.08	0.402	16.8	0.1	5.6				4.6
sample (SC)	**Lat South**	**Long West**	**a_{272}**	**DOM [mgl^{-1}]**	**±D**DOM [mgl^{-1}]	***chl a*** **[mgl^{-1}]**	**TSS [mgl^{-1}]**	**OSS [mgl^{-1}]**	**ISS [mgl^{-1}]**	**I [nm]**
1	25.94	57.44	0.297	12.4	0.1	6.0	8.4	6.8	1.6	7.6
2	25.65	57.61	0.081	3.4	0.1	2.3	3.4	1.8	1.6	1.5
3	25.81	57.74	0.290	12.1	0.1	7.9	10.7	8.2	2.6	5.1
4	27.04	58.30	0.327	13.7	0.1	1.9	8.4	6.9	1.5	2.4
5	27.01	58.29	0.247	10.3	0.1	4.5	2.4	0.9	1.5	1.5
6	26.88	57.96	0.159	6.65	0.07	22.9	32.4	1.2	31.2	8.8
7	26.97	58.27	0.426	17.8	0.1	374.9	135.9	34.7	101.1	69.1
8			0.427	17.8	0.1	381.8	146.3	41.3	105.0	70.8
9			0.057	2.4	0.1	5.6	52.3	45.8	6.5	17.9
10			0.178	7.4	0.1	9.5	16.6	12.1	4.6	13.5
DDq				DD**DOM**		DD***Chl a***	DD**TSS**	DD**OSS**	DD**ISS**	DD**I**
1				1.02		-0.92	1.65	1.69	1.50	1.51
2				5.72		1.20	5.01	7.70	1.90	3.53
3				-0.71		-0.18	-0.16	-0.06	-0.51	-0.29
4				-0.95		1.43	1.29	1.39	-0.84	1.96
5				2.68		3.85	-0.98		1.50	2.07
6				1.04		-0.48	-0.24		-0.25	-0.63
7				-0.73		-0.10	-0.23	-0.29	-0.21	-0.63
8				-0.75		-0.11	-0.22	-0.27	-0.20	-0.21

The results demonstrate the relatively high concentrations of DOM typical of subtropical wetland lakes. The measured *chl a* concentrations showed a wide range of trophic conditions, especially during the second survey. The *chl a* concentrations varied from 1.4 μgl^{-1} to 381.8 μgl^{-1}. During the

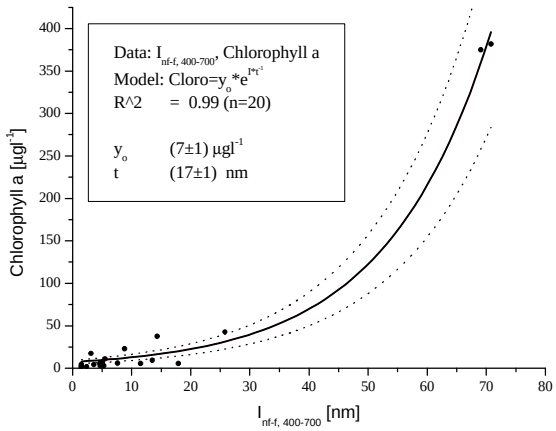
second survey, the samples 7 and 8 had high concentration of all measured parameters. The relative variation of the measurements between the two surveys is shown in the *DDq* parameter:

$$\Delta\Delta J = \frac{J_{FC}}{J_{SC}} \cdot Sign\left(J_{FC} - J_{SC}\right) \text{ with } Sign\left(J_{FC} - J_{SC}\right) \equiv 1 \text{ when } q_{FC} = q_{SC} \qquad \text{(Equation 6)}$$

where q is every measured parameter. When $DDq = 1$, there was no variation between the measurements of the two surveys. The least-squares regression between I (Eq. 1) and the measured TSS as well as the *chl a* concentrations showed good fittings, $R^2 = 0.96$ (Fig. 2) and $R^2 = 0.99$. The relationship of I and *DDI* plotted against TSS and *chl a* supported the definition of $a_{1,nf\text{-}f}$. The results demonstrated that the optical characterization of the studied wetlands lakes allows a suitable estimation of the concentrations of these water components.

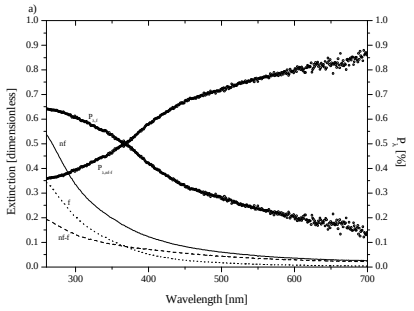


Linear correlation between I (Eq. 1) and the measured concentration of *TSS*. The dot lines indicate the 95%-confidence limits

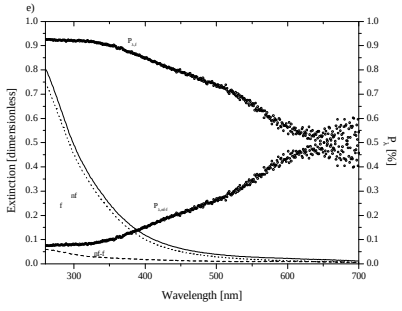


Exponential correlation between I (Eq. 1) and the measured concentration of *chl a*. The dot lines indicate the 95%-confidence limits

The influence of the different water compositions (dissolved and particulate components) was reflected in the extinction curves of the filtered and nonfiltered samples. Each of the studied lakes showed well-differentiated patterns in the P_1 curves.



Optical characteristics of water sample 1. Measured extinctions in the non-filtered (nf, solid line) and filtered samples (f, dot line). Calculated extinction of suspended matter (nf-f, dash line) and P_1 curve of dissolved ($P_{1,f}$) and suspended matter ($P_{1,nf\text{-}f}$)

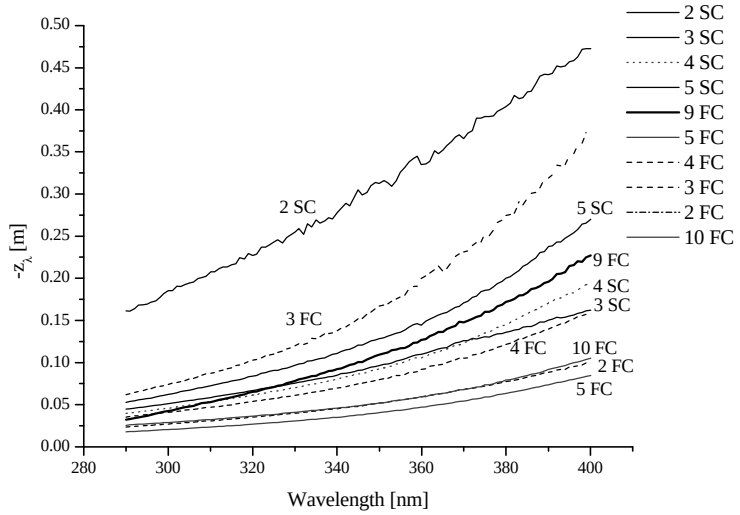


Optical characteristics of water sample 5. Measured extinctions in the non-filtered (nf, solid line) and filtered samples (f, dot line). Calculated extinction of suspended matter (nf-f, dash line) and P_1 curve of dissolved ($P_{1,f}$) and suspended matter ($P_{1,nf\text{-}f}$)

The intersection of the $P_{l,f}$ and $P_{l,nf\text{-}f}$ curves indicates the wavelength where the contribution of the dissolved and particulate components to the radiation extinction is equivalent. These intersections were usually registered in the UV A and Vis regions of the spectrum. However, a number of samples strayed from this general pattern, indicating a different level of "humic-ness" that strongly influences the amount of visible and UV radiation present in the water column.

The classification of lake as "humic" is often considered in relation to the concentration of DOM. However, these results would indicate that the overall influence of the DOM in UV extinction will be effected by the concentrations of all substances in the water column, including suspended particulate matter. The use of the P_l curves allows a more comprehensive assessment of the role of the DOM in the optical conditions of the lakes. From a strictly optical viewpoint, dissolved matter has a dominant role in the UV attenuation when $P_{l,f}$ is greater than 0.5 in the UV waveband. In these 12 water bodies, we used this criterion to distinguish between an "optically humic lake" and a "optically non-humic lake" and to examine the relative weight of dissolved and particulate components in the total attenuation. The contribution of particulate matter to UV extinction appears rather limited.

The depth related to 10% of the surface irradiance was calculated for the wavelengths between 290 nm and 400 nm ($-z_{l,}$). This depth depends on the wavelength of interest, the DOM concentrations and the quality of the dissolved substances (slopes of the extinction spectra of the filtered samples). The values of $-z_l$ varied from 0.02 m (at 290 nm) to 0.47 m (at 400 nm). The high DOM concentrations of the samples 2, 5 and 10 of the first survey can be explained the minimum values of the $-z_l$. Likewise, the high $-z_l$ obtained for the sample 2 of the second survey can be related with the minimum concentration of DOM.



The determination of $-z_l$ is also linked to the slope (calculated between 260 nm and 700 nm) and the inverse relative molecular weight (calculated with the ratio between $a_{250,f}$ and $a_{365,f}$, $(MW_r)^{-1}$, of DOM. Important differences between the average values of the slope and $(MW_r)^{-1}$ of the two surveys were not observed.

The chemical quality (molecular weight) of the DOM was significantly different in the studied lakes as estimated using the slope and $(MW_r)^{-1}$ values. This characteristic helps to explain some of the differences in the overall extinction coefficients. The DOM concentration of the sample 9 in the

first survey was 18 mg l^{-1}, but the slope was minimum (-0.0216 ±0.0001 nm^{-1}). The lower slope and molecular weight of the DOM of this sample determined a higher penetration of the irradiance than other samples (*e.g.*, samples 10 and 2 of the first survey) with similar DOM concentration but lower $(MW_r)^{-1}$. Likewise, the differences between the $-z_1$ curve of the samples 4 and 3 of the second survey may also be linked to the differences of DOM composition (the $(MW_r)^{-1}$ of sample 3 was higher than that for sample 4 SC). The $-z_1$ curve of the sample 3 was lower than the curve of sample 4 beyond 373 nm despite the differences of DOM concentrations.

The differences of DOM concentrations explained the main pattern of UV extinction. Nevertheless, second-level differences between the studied lakes depended also on the molecular weight of DOM. Thus, the UV extinction depended on the DOM concentrations and composition. The molecular weight of DOM in a lake may depend on the origin and nature of the organic matter and the different degrees of photodegradation and photobleaching (linked to solar radiation dose). Lower molecular weight (MW_r^{-1}), due to higher photodegradation will have a lower respective UV extinction compared to similar DOM concentrations of high molecular weight. Modifications to the DOM quantity and quality due to changes in the hydrological or pluvial regime (or chemistry) will alter the radiation transfer in the water column. Such an alteration will have effects on the structure and functioning of wetland ecosystems.

Even though off site optical characterization of filtered and unfiltered samples of the of natural waters cannot replace the direct on-site measurements of light attenuation, the present study has shown that a number of important properties of the aquatic ecosystems can be studied. The optically determined properties ($a_{\lambda,nf\text{-}f}$, I, $P_{\lambda,f}$, z_λ, MW_r^{-1}, S) of the water samples give fundamental information about light environment of the study ecosystems and can be correlated with other water column components (TSS, chlorophyll a concentrations). Further development is possible, in particular to relating specific wavelengths or wave bands of the directly measured spectral extinction curves ($a_{\lambda,f}$, $a_{\lambda,nf}$) or indirectly measured ($a_{\lambda,,nf\text{-}f}$) to other water column properties. Finally, the identification of “optical humic lakes” or lake areas may be utilized to examine differences in the potential exposure of aquatic organisms in these areas of high insolation.

Conclusion

The activities of the CSGI team within the REGWET project were directed at both collaborative research and dissemination. In both cases, these activities were found to be fruitful. In the case of dissemination and exchange, CSGI researchers were able to exchange information and knowledge with a new group of wetland scientists, principally those from the Univ. of Pilar and Asuncion. Researchers continued to work together with the partners from the original project, in particular with Genevieve de Mahieu from USAL, Andres Cozar from Univ. de Cadiz, Graciela Canziani and Diego Ruiz Moreno from UNICEN. These collaborative efforts resulted in an enlarged and reinforced network of wetland scientists dedicated to the study of wetlands in Mercosur.

The analysis methodologies developed in the original INCO project were further studied and developed. These are described in a scientific article that will soon be submitted.

Presentations in Scientific Meetings

Luca Bracchini: UV and visible extinction analysis of the lakes of Ñeembucu (Paraguay) and Pantanal (Brazil) wetlands, to be presented at the all'VIII Congresso Nazionale di Chimica dell'Ambiente e dei Beni Culturali in June 2004.

Vincent Hull, Margherita Falcucci, Claudio Rossi made several presentations at the Wetland workshop held in Pilar and Asuncion, Paraguay.

Partner Summary Report – PARTNER 2 UNICEN

Scientific coordinator: Graciela Canziani
Researchers:
Manuel David Vargas Russo, Federico Dukatz, Rosana Ferrati, Diego Ruiz Moreno,

Instituto Multidisciplinario sobre Ecosistemas y Desarrollo Sustentable
Facultad de Ciencias Exactas
Universidad Nacional del Centro de la Provincia de Buenos Aires
Paraje Arroyo Seco – 7000 Tandil – Argentina.

Objectives

The UNICEN research teams activities within the REGWET accompanying measure were focused on the following activities:

- increase the dissemination of the tools and methodologies developed in the original INCO project, creation of a specific REGWET web site http://www.exa.unicen.edu.ar/~wetland/regwet/
- participate in a regional dialogue related to the sustainable management of wetland resources in Mercosur, in particular in the two REGWET conferences held in Paraguay.
- application of and further development of the satellite based analysis and management instruments in the wetland area in Paraguay in collaboration with researchers and local actors

The web site was created and is functioning as a dissemination site as well as a means to document the continuing dialogue between actors in the region. The development of satellite data tools for the mathematical modelling in the analysis of the landscape dynamics for the conservation was the main objective of the UNICEN research team. Some of these instruments were developed in the preceding INCO project (ERB IC18 - CT98 – 0262) while others were specifically developed for the present accompanying measure where they were applied to wetlands in Paraguay. Spatially extensive wetland analysis and management instruments are essential in the study of the vast wetlands that characterise the Del Plata basin, because they allow the possibility of studying the area in a integral manner.

The focus was on the analysis of the Ypoa Wetlands located in Paraguay, where the researchers of the REGWET project focused their attention, together with a number of scientists in Argentina, Paraguay and Europe. The results of this analysis and development were demonstrated at a series of meetings with wetland scientists from the Mercosur countries within the REGWET project and several international meetings.

UNICEN researchers collaborated with local and international researchers in the scientific activities of the REGWET project and are continuing to work together with the team of researchers that has been developed. The growing importance of wetlands in the Del Plata basin, in combination with the increasing pressure to use these areas and the water that characterises them has made the use of these approached to analysis and management very important. UNICEN researchers participated in

both the scientific and public meetings that were held on two occasions as part of the REGWET accompanying measure.

Considering the framework of the methodology developed in the INCO project "*The Sustainable Management of Wetland Resources in MERCOSUR*" (ERB IC18 - CT98 – 0262) for the study of the Ibera wetlands, the REGWET project was oriented to adapt and extend this methodology to the neighbouring Paraguayan wetlands. This means the introduction of refinements based on the different conditions of the particular region. The newly developed models use different techniques to optimise landscape classification and the calculus of vegetation indexes. Also a model to estimate tendencies was developed, which improves the capacity of monitoring the temporal evolution of the vegetation. Finally, coupling the exploration of changes in time and the results of indexes models, makes possible to detect potential anomalies and landscape and cover variations

Activities

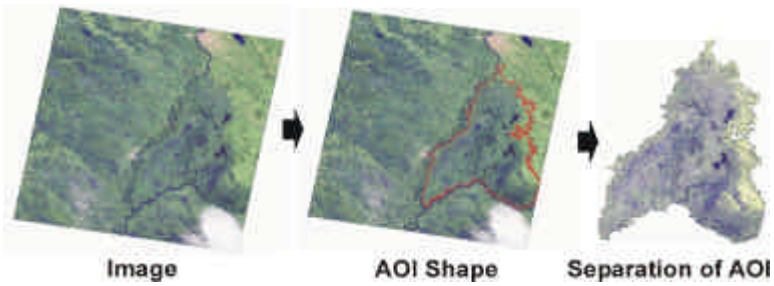
A. Dissemination web site: see http://www.exa.unicen.edu.ar/~wetland/regwet/

B. REGWET meetings were held in March and December 2003. Researchers from UNICEN (Diego Ruiz Moreno and Graciela Canziani) participated in both the presentation and discussion of the research and information exchange.

C. Satellite based analysis and instrument development for Paraguay wetlands. The main scientific activities of this area of the project were performed in collaboration with the other partners in the project and in collaboration with the Argentine Space agency (CONAE), in relation to the use of the SAC-C satellite system. Multipurpose satellite SAC-C, is oriented to the study of the terrestrial surface. This satellite is equipped with a special sensor (Multispectral Medium Resolution Scanner - MMRS) with the capability of analysing crops, forest as well as coast and continental water monitoring.

In addition to SAC-C data, Landsat images were also used in the analysis, the next table shows the images list from the Landsat 7 and 5 satellites, provided by CONAE. All the analyses were performed over 10 scenes. Acquisition dates for those scenes range from 2001 to 2003. The first step was the selection of the satellite images. The next step was the image rectification and a geo-correction. This procedure involves the selection of discernible ground control points (GCP's) in the images. These points are then assigned to an appropriate reference information from a determined geographic referencing system, zone 21 UTM co-ordinates in our case. This reference data is obtained from topographic sheets. Prior to analysis, a sub-image of the region was extracted based on topographic and hydrologic knowledge.

Once the images were corrected and referenced, an Area of Interest was defined according to some criteria. From here on, only the area contained in this zone of interest will be processed, allowing a major certainty in results.



AOI definition

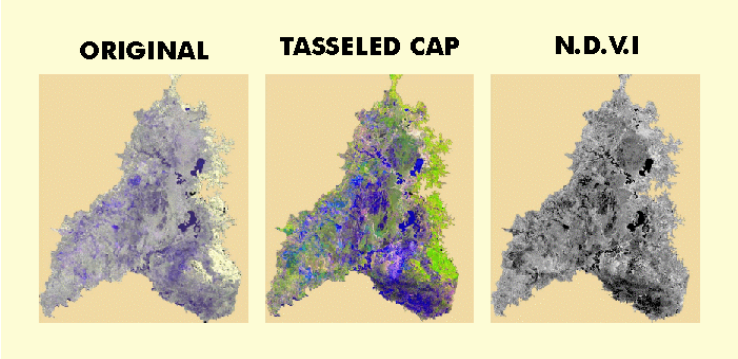
In order to define the cutting of the area, the following limits were taken into account:

- to the South the limit was set to be the Tebicuary River's flooding plane;
- to the Northwest the contour was defined by the Paraguay River's flooding plane.
- to the Northeast the limit was chosen to be the 100m contour line.

Both valleys were defined through satellite image exploration and topographic sheets. The criteria are based on hydrological and topographic information. Besides it was taken into account the satellite images boundaries. All the indexes and models were obtained by applying the methodology over the resulting area only. It is important to note that for the detection of anomalies, smaller sub-areas were separated and later analysed individually.

Index development

We applied vegetation indexes to the images to simplify and make specific their visualisation by reducing the quantity of image layers according different criteria of composition. The two images used and applied to the wetland area were NDVI (Normalised Difference Vegetation Index, a ratio-based index) and a Tasselled Cap Transformation. The NDVI index has the advantage of being simple, and with a good dynamic range and sensitivity to changes in vegetation cover. The Tasselled Cap Transformation attempts to transform the original n-multispectral bands into a new n-dimensional space. The Tasselled Cap index measures of vegetation (***greenness***, GVI index), soil (***brightness***, SBI), and the interrelationship of soil and canopy moisture (***wetness***). Originally the Tasselled Cap transformation is proposed for Landsat images. But since the SAC-C MMRS sensor doesn't provide the band 7, the model was modified to solve the index with only 5 bands in collaboration with the colleagues of the University of Siena.

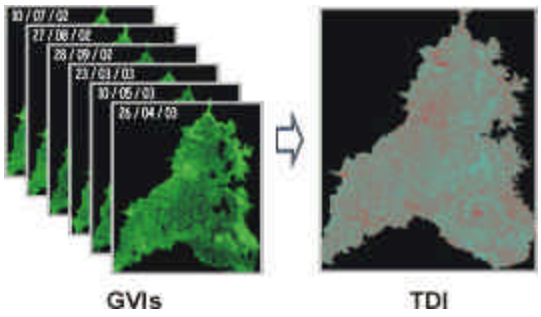


Samples of TC and NDVI indexes

A classification of the indexed images was performed using an unsupervised approach The classification algorithm was the ISODATA algorithm. Regarding the parameters, a configuration in 10 classes, 24 iterations, and a convergence threshold of 0,95 were chosen. Since the algorithm was applied to the Tasselled Cap Transformation output, the Unsupervised Classification algorithm input is a three band image (SBI, GVI, Wetness). The resulting output image is a single band with ten classes. The first class corresponds to free water and the last one to bare soil. Lower-middle classes correspond to water and vegetation, while upper-middle ones to soil and vegetation.

One way to detect changes in wetland ecosystems is the development of indexes that consider the temporal evolution of the vegetation intensity. For the REGWET project, we

developed a Temporal Difference Index (TDI). This index is defined by means of a linear regression. This method is performed simultaneously over the vegetation index data from several images of the same geographic sector taken in different dates.



TDI definition

The method is applied using data obtained from any chosen vegetation index on several images from one sector, in a temporal succession. These methods may be applied simultaneously with the unsupervised classification, because it needs the same input data, in our case the GVI band of the Tasselled Cap Transformation. Each input pixel represents a vegetation index value, for example, for the GVI layer, this value is between 0 and 255. Each pixel value can be represented with respect to time on a Cartesian axis system (on the *y*-axis), time being represented on the *x*-axis, in this case the day number, zero being the first day.

For each pixel, this Cartesian representation will have as many points as images that are being analysed. The slope of the linear regression that fits the data furnished is taken as the value for the variation in each pixel. The least-squares fitting criteria is that which minimises the expression:

$$S = \sum_{1}^{n} (y_i - (ax_i + b))^2$$

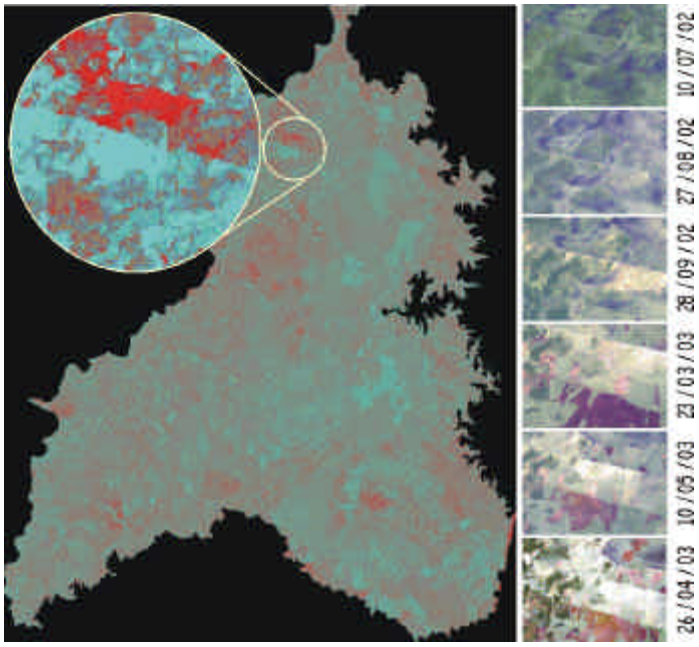
where *a* is the slope of the line and *b* is the *y*-intercept.

In this case, only the slope value is relevant, because it determines how each pixel varies in time, increasing (positive slope) or decreasing (negative slope) its brightness. The slope is obtained when the derivative of *S* with respect to *a* and to *b* are zero. So, an equation system in two unknowns is solved to find the value of *a* and *b*. In our case, we obtain

$$a = \frac{N \sum x_i y_i - \sum x_i \sum y_i}{N \sum x_i^2 - (\sum x_i)^2}$$

The final step is that of generating a new image with the value of each calculated slope *a* for each one of the pixels. The resulting image shows darker points where the slope values are negative, this is where the vegetation index is decreasing , and it has brighter pixels where the vegetation intensity is increasing. Once the classification and the TDI index is performed, the necessary information for detecting areas that exhibit general variations and anomalies, and particularly vegetation intensity variations, is at hand. In order to detect anomalies, zones where TDI has extreme values (very positive or very negative) must be identified. Then, the analysis is done by returning to the original images and focusing on these zones to study these changes. Another way to detect changes is to look for differences in the specific zones of the classification images.

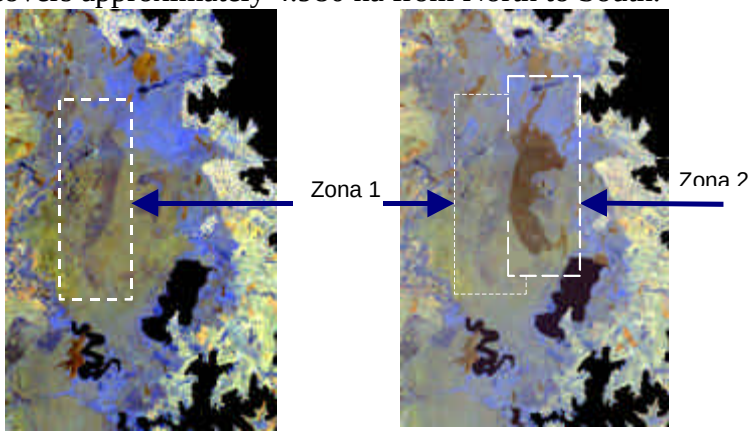
Several zones of the Ypoa Wetlands that exhibit variations of some kind can be seen in the red zones in Figure below. In this example, the green regions show zones without change, while the shades of red indicate that the vegetation has undergone a major variation, in this case, an increase in the vegetation.



TDI Results

In the above **Figure**, the resulting scene shows a large anthropogenically caused variations (specific geometry) in the vegetation. The unprocessed images are shown at the right, each one with its date. Although it is easy to see the vegetation variation in these close-ups, it was detected only by the TDI transformation in the complete satellite image.

This anomaly was so extensive that could be detected even before processing the images. On bands 4, 5, and 6 it is possible to observe a shadow at the North side of Ypoa lake. This anomaly has a reflectance pattern associated with a lack of brightness on the NDVI index, as well as the TC GVI index. Its area covers approximately 4.980 ha from North to South.



Second Anomaly view

The first image where this anomaly can be seen was taken on 26/5/2003. When this image is contrasted with the scene from 10/5/2003, we can see that this shadow is absent.

Observing the images, it is possible discover the dynamics of many zones with the same behaviour. As first hypothesis, the origin of that anomaly may be fire. Besides, when a TDI Transformation is applied, this area shows a negative variation on greenness. Even more, the same pattern repeats itself in other places of Ypoa.

Performing the NDVI and TC transforms allows retrieving more information from this situation. NDVI shows that the zones exhibit a remarkable absence of brightness. It means less leaf vegetation, similar to that of water bodies. TC Transformation confirms the previous result, not only through a low response on GVI index, but from low values in Wetness and SBI.

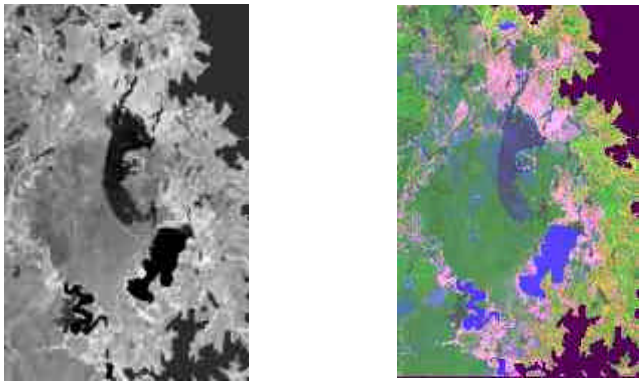


Image acquired on 26/5/2003. at left: NDVI, at right: TC transformation.

Since both results are consistent with the consequences of fire, a search on fire foci detected in the wetland region between these dates was performed in order to define if the observed area was affected by fire. The information was acquired from the Queimadas Group (INPE/CPTEC) in Brazil. They monitor the zone with NOAA 12, NOAA 16, TERRA 01, AQUA 01 and GOES 12 satellites. It was possible to confirm that there was a fire focus in the spot where the anomaly was detected.

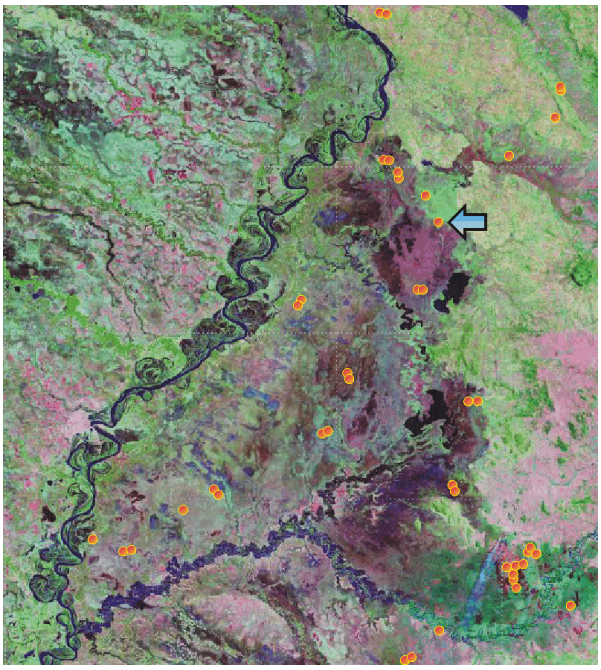


Figure 10. Fire foci in the zone
From 2003-05-10 to 2003-05-26

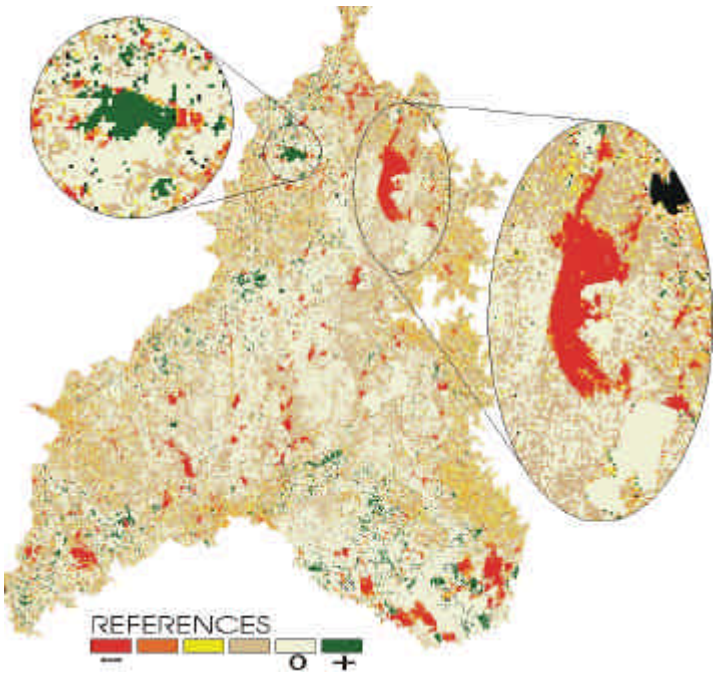
At this point, it was possible to study this anomaly caused by fire. In order to execute this operation, the Normalised Burn Ratio, NBR, was used. The ratio evaluation was performed by calculating the length of the index and the difference between dates, specifically before and after the fire event.

The process has the same inconvenient than NDVI, and the GVI of TC, namely the same responses to water bodies and fire effects. Both water bodies and fires are very important in this kind of wetlands.

On a second stage of the process, the NBR difference is performed with two images of zone 2, the invariant zones look dark grey, and the damaged areas show a light grey or white colour.

Then, we separated the burnt area and perform an unsupervised classification. This classification has a parameter of 10 clusters. We make this classification in order to quantify the damage on classes and relate them to particular locations.

We used TDI to identify zones where the vegetation rapidly changed. If we performed a TDI on several images, we found areas where the vegetation had a great increase/decrease in a short period. Then, an Unsupervised Classification was performed on this TDI Transformation (six classes on three TDI images); so that a classification of variation levels could be obtained. A wide red zone can be clearly seen, indicating a sharp reduction in vegetation, as well as a region with vegetation increase due to anthropic activities.



Unsupervised Classification on a TDI Transformation

At this point, the analysis can be continued in two additional steps. The first step is exploring the area of interest searching for same patterns. Then, a new iteration of the methodology over the new area can be performed.

The following figures show other possible locations of the same phenomena:

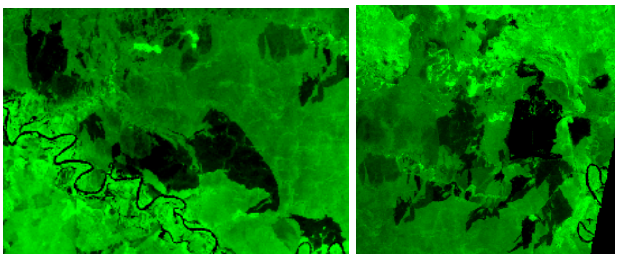


Figure 13. Other zones with possible burned areas

Right image: Villa Florida, Sheet: 5468, latitude 26º 25´ y 26º 32´, longitude 57º 37´ y 57º 13´.
Left image: Villa Florida, Sheet: 5448, latitude 26º 28´ y 26º 35´, longitude 57º 33´ y 57º 21´.
The zones show less reflectance on the GVI index.

These zones show a decrease on the vegetation index (black colour) and a negative slope in the regression model.

Conclusion

The proposed methodology allowed the further development and application of the satellite based wetland analysis that was developed in the original INCO project. The collaboration with CONAE and with the Paraguay collaborators in REGWET allowed for the extension and validation of the approaches developed. In particular, soil brightness, burn severity, and vegetation intensity are identified as important aspects for the definition of wetland vegetation indexes. The anomalies detected in the Ypoa wetlands include vegetation increments due to agricultural activities, as well as vegetation reduction due to land clearing and marks of possibly burnt areas. The methodology can be applied to the to other wetlands in Mercosur and worldwide. Regionally, it was presented to the research community and public of several Paraguay wetland areas.

Presentations in Scientific Meetings

"Sensores Remotos para la Conservación de humedales del Mercosur"
Graciela Canziani, Diego Ruiz Moreno, Manuel Vargas Russo, Federico Dukatz, Rosana Ferrati. Seminario de la Constelación Matutina. CONAE - NASA.
Buenos Aires, Argentina. 3-5 de Diciembre de 2003.

"Temporal evolution in wetland features"
Diego Ruiz Moreno, Federico Dukatz, Manuel Vargas Russo, Rosana Ferrati, Graciela Canziani. Seminario de la Constelación Matutina. CONAE - NASA.
Buenos Aires, Argentina. 3-5 de Diciembre de 2003.

"Satellite Data Analisis"
Aplicación de los Sensores Remotos en los Humedales del Mercosur, Yberá y Ñembucú
Federico Dukatz, Manuel Vargas Russo, Graciela Canziani.
Taller sobre Manejo de Humedales en Mercosur. Universidad Nacional de Pilar,
Pilar, Paraguay, Diciembre de 2003.

"The Sustainable Management of Wetland Resources in Mercosur"
Graciela Canziani, Rosana Ferrati, Diego Ruiz Moreno, Paula Federico, Florencia Castets.
Taller sobre Manejo de Humedales en Mercosur. Universidad Nacional de Pilar, Paraguay. Diciembre de 2003.

"Need of an Original Approach to the Management of Wetlands and
Lagoons of the Pampas Region in Argentina",
Graciela Canziani, Rosana Ferrati, Fabián Grosman, Pablo Sanzano, Fernando Milano, Diego Ruiz Moreno
Taller sobre Manejo de Humedales en Mercosur. Universidad Nacional de Pilar, Paraguay. Diciembre de 2003

Publications

Canziani, G.; C. Rossi; S. Loiselle; R. Ferrati (Eds) 2003. *Los Esteros del Iberá. Informe del Proyecto "El Manejo Sustentable de Humedales en el Mercosur"*. Fundación Vida Silvestre Argentina, Buenos Aires, Argentina. 258 pp.

Partner Summary Report – PARTNER 3 USAL-IMAE

Scientific Coordinator: Genevieve de Mahieu
Researchers: Julieta Mazzola
Alejandra Ríos
Claudia Toselli
María Martha Lucano
Adriana ten Hoeve
Ramiro Calafell Carranza
María Paz Aduriz
Administrative Area: Magdalena Salleras
Acknowledgments: Lilian Hreljac and María Elena Rizza

Vicerrectorado de Investigación y Desarrollo
Instituto de Medio Ambiente y Ecología
Rodríguez Peña 770 2º piso
1020 – Buenos Aires, Argentina

Various activities were carried on in order to analyse the possibility of transferring, from the case of Esteros del Iberá to the case of Esteros de Ñeembucú, the tools and methodologies necessary to make socio-economic and cultural diagnosis regarding the relationship between society and nature:
Two workshops (February and December 2003) where the facts related to socio-economic and cultural aspects of the Esteros del Iberá were discussed
Exchange of information and experiences between researchers of the Universidad Nacional de Asunción and of del Pilar engaged in related thematic areas
Bibliographic research of material referred to both wetlands, focused on socio-economic, cultural, and legal aspects
Preliminary compilation of socio-economic statistical information of the Department of Ñeembucú and its districts, showed in Annex, with the purpose of analysing the possibility of methodological transference
According to this background, the thematic and conceptual basis on which the INCO-Iberá experience could be transferred to the case of Esteros de Ñeembucú were established. The following points arose:
The need of a follow-up of the environmental perturbations produced as a consequence of economic development, taking into account aspects concerning biogeography and the belonging to characteristic eco-regions. In the future, useful comparisons of the sensitiveness to natural and antrophic disturbances of the ecosystems, in a temporal and spatial context, could be made considering that Ñeembucú and Iberá wetlands belong to shared eco-regions with common biogeographic aspects.
The need of a visualization, through life quality indicators, of the environmental pressures upon the wetlands that could appear due to an increase of the population and inadequate infrastructure.
The need of a study of the trends of economic development using economic indicators. Most production activities do not take into account natural conditions; in practice, environmental aspects are not included in patrimonial accounts, and thus no costs are assigned to matters of environmental variables. That is why it is important to analyse to what extent economic accounts include social repercussions that could derive from exceeding the carrying capacity of water, land and air, having short term additional income but threatening future income. Since wetlands are one of the most productive environments on Earth, they are suitable for many alternative uses. Nevertheless, not all crops favour the sustainability of wetlands, and the production activities that generate the most employment are not necessarily the most adequate for the conservation of these ecosystems.

The level of development of legal aspects for the better protection of wetland resources.
The importance of nature in the historical, cultural and economic development of the inhabitants. The cultural component as an affirmation of the identity and of the local and regional development.
From the point of view of its biogeographic characteristics, nowadays the Argentine Secretaria de Medio Ambiente de la Nacion considers that the area of the Ibera wetlands is an eco-region itself, but many authors consider it as a part of the Humid Chaco. It can not be denied that there are evident landscape similarities between both areas.
Many indicators with environmental implications were developed in the study performed for the INCO project regarding life quality in the Departments close to Esteros del Iberá. These indicators could also be used for the study of Ñeembucú area, because there are available statistics and the UNDP has recently developed a Human Development Atlas 2003 that could be useful as well.
The base for their application is to see which are the environmental implications of the main indicators, and in which way they can be combined in order to identify the most affected places. In this sense, the following subjects were developed in the report:
The environmental implications of the life quality indicators that were used in the INCO project.
A comparative analysis of some life quality indicators of the Departments close to Esteros del Iberá, and the application of GIS tool for a spatial visualization, as a quick method for the detection of areas with different levels of vulnerability

In any kind of analysis, the way in which economic activities are evaluated depends on the development model that is assumed. The statistics reflect a certain model. With respect to this point, it is important to bear in mind that both in the case of the Esteros del Iberá and in the case of the Esteros de Ñeembucú, National Accounts provide economic data without taking into account neither the degradation of the habitat and of the energy sources due to the use of resources because of economic activities, nor the waste of natural capital. The effects of economic activities on the population are not estimated either by National Accounts.
USAL researchers examined some of the available economic indicators used for the study performed in the Province of Corrientes, that could be used for the analysis of the Department of Neembucú in order to visualize which production activities may have impacts on the wetlands, regarding environmental sustainability:
Gross Geographical Product (GGP) in 1995: 2.795 million U$S
Direct and indirect jobs in the main branches of activity of the Province of Corrientes. 1999
Gross Value Added of the main economic products - Relative importance (in percentage) over the total production of the selected Departments, and its situation in relation to the provincial total production – 1998
Total area under crops in the selected Departments, and Significance of each type of crop as a percentage of the departmental gross value - 1998
Soil use
Growth of the number of hotels and other type of lodgings in the period 1997-2001 - (expressed as a percentage)
Growth of the number of beds in hotels and other type of lodgings in the period 1997-2001 - (expressed as a percentage)
Environmental perturbations produced as a consequence of economic development, such as the ones listed below, are expounded in the report:
Problems regarding the development of adequate infrastructure: main impacts of the municipal sewage on the aquatic ecosystem.
Development of rice production: demand for wetland water, use of pesticides and fertilizers, modification of the natural habitat.
Development of tourism: impacts of tourism on protected natural areas, impacts of this activity in wetlands.

The socio-economic assessment approach of the "Esteros del Iberá" can be perfectly used in the case of the "Esteros de Neembucú", what would allow a potential estimation of the effects caused in the latter region by the use of its resources, assuming different scenarios of natural heritage management.
Even if the indicators available for both wetlands derive from the national accounts, it is important to bear in mind that some kind of systematisation of the statistical information available is needed. The information needed with respect to indicators will depend on the specific features of the "Esteros de Neembucú" and on their productive development. As a consequence of the impact of the latter, an estimate of the environmental costs involving research and development study should be included in order to: protect air and weather; protect water; collect, transport and dispose of waste properly; prevent an inadequate disposal of it; protect the soil and the phreatic waters; provide sanitation and similar services.
As shown by the studies done in the "Esteros del Iberá", it is important to take into account that much of the productive development in the wetlands alters the quality of water and air, and affects the natural functioning of the ecosystems. For instance, landscape alteration, loss of biodiversity, and impacts on the soil, are possible effects of forestal activities.
Moreover, even if tourism is an important development factor, this main source of local income can be lost in the short term if it does not take place together with research and studies on the possible impacts produced on the natural resources by this activity.
Regarding other subjects, it is necessary to consider that the natural environment, shared in terms of landscape similarities together with cultural expressions, constitutes a heritage resource whose protection is not fostered in a comprehensive manner in the cases of both areas of moist soils. The Guarani ethnic group, the pathway taken by Jesuit missionaries during their the expeditions and travels, where proof of their stay was left in both regions (archaeological fields and ruins), the Spanish colonization, and the contribution of the immigration, represent common grounds between both areas.
In addition to the points already mentioned, from the review on environmental legislation applied to the moist soils in both sites done in this study and according to the review of the South American legislation for moist soils compiled by Solano (1997), the report also concludes that:
There is a trend to institutionalise environmental management.
The environmental institutions of both countries have different levels of autonomy as well as of political and economic decision power.
The outlining of national policies concerning the moist soils is almost always in charge of the environmental institutions of both countries. Either the same institution or any other sector of the government may be in charge of laying down such policies.
Argentina and Paraguay have subscribed the Convention on Wetlands of International Importance especially as Waterfowl Habitat ("Ramsar").
Neither country has yet elaborated domestic legislation which rules the ecosystems of the moist soils in a global manner.
Until now, the legal mechanism mostly used to protect certain moist soils of great importance for the country or for the region has been the declaration of such zones as protected natural areas. The category assigned to each case varies according to the system of protected areas of each country and to the permitted uses that derive from the declaration.
The environmental impact assessment processes are mechanisms incorporated in both countries for projects that involve environmental risk or that are developed in fragile ecosystems. Any project or activity that may affect a moist soil should be subject to a study of environmental impact prior to carrying it out.

An Annex is included: Statistical facts of the Department of Ñeembucú; indicators concerning population, housing and households, health and education; as well as Topographic Charts (Hydrographical system. Scale 1:50.000. Military Geographic Service Directorate, Paraguay).

Annex 1 – Socio-economic analysis of the Department of Ñeembucú

Ñeembucú has got characteristics that make it different form other Departments. It has an strategic location between the two main rivers of the region, the Paraná and the Paraguay, and due to this characteristic it can play an important role in the context of a regional integration process, becoming the first port of entry (for imports) and the last of departure (for exports). It is important to mention that in 1983 it was impossible to operate in the port of Asunción because of a flood that affected it; whereas in the south of Ñeembucú there are areas which are not threatened by floods and thus can be suitable for a deepwater port that would enable the establishment of a free zone, or that can be an alternative for the consolidation of the regional integration. With respect to this, it is important to take into account that in front of the port of Itapirú and/or Humaitá it is located the port of Las Palmas Argentina, with a railway station in the route of the bi-oceanic corridor. We consider that this combination of alternatives could promote the social and economic development of the region, which would also benefit the rest of the country.
Ñeembucú has been a neglected Department, it was for a long time the only Department of Paraguay lacking paved routes, but that situation is changing nowadays.
This Department has big wetlands, and its area has a big number of wetlands, lagoons and small watering places that in some parts of the year hinder the agricultural development. Besides this, there are recurring floods in the southern zone of Yaciretá dam, that continuously damage the low-lying regions.
The capital city of Ñeembucú, Pilar, was totally flooded in 1983, and its surrounding neighborhoods suffer recurring floods because they don not have definite defense walls.

Demographic characteristics
Ñeembucú has an area of 12.147 sq km. It has been the only Department that showed a negative growth rate in the Census of 1992. It is divided into 16 districts, as follows: Pilar (capital), Isla Umbú, Mayor Martínez, Desmochados, Gral. Díaz, Paso de Patria, Humaitá, Laureles, Villalbin, Villa Oliva, San Juan del Ñeembucú, Cerrito, Tacuaras, Alberdi, Villa Franca and Guazu Cuá.
The Department has a population of 87.873 inhabitants, and it is estimated to reach 88.285 inhabitants in year 2000, with a growth of 0,4%. In the following table we show, for each district, the growth rate of 1995/2000, the percentage of the population in year 2000, and the estimation for year 2005.

District	Total population '92	Population density 1995/2000	Growth rate 1995/2000	% of the population 2000	Population in 2005
Ñeembucu	69.770	7.27	0.54	1.61	88.285
Pilar	22.103	84.64	1.38	33.97	31.717
Alberdi	5.618	41.70	0.60	8.22	7.440
Cerrito	4.682	8.88	0.03	6.46	5.712
Desmochado	1.817	9.39	-0.01	2.46	2.171
General Diaz	3.520	15.55	0.14	4.83	4.288
Guazucua	2.291	1.89	0.23	3.21	2.863
Humaita	2.884	8.28	0.01	3.98	3.517
Isla Umbu	3.349	6.12	-0.03	4.52	3.985
Laureles	3.367	4.04	0.27	4.70	4.193
M. Martinez	3.585	14.14	0.23	5.03	4.483
Paso de Patria	1.577	10.22	-0.31	2.09	1.823
S. J. Ñeembucu	5.982	6.99	-0.01	8.20	7.242
Tacuaras	3.256	4.88	0.01	4.55	4.021
Villa Franca	772	0.53	-0.46	1.01	876
Villa Oliva	2.786	2.30	-0.10	3.76	3.306
Villalbin	2.181	4.91	0.15	3.02	2.686

With respect to what is showed in the tables, it is important to mention that the districts of Desmochados, Isla Umbú, Paso de Patria, San Juan del Ñeembucú, Villa Franca and Villa Oliiva show a negative growth, while the districts of Tacuarás and Villalbín have an slight growth as a consequence of the emigration of a big part of their population.
Regarding the population structure, in terms o sex and age, the facts provided by the Estimation and Projection of the National Population of 1996, by the DGEEC, are the following:

Groups of Age	Year 2000
Total	88.285
0-14 years old	31.992
15-64 years old	51.101
65 and over	5.192

In the Department there are more men than women in the Economically Active Population, and a bigger number of men work in the rural area than in the urban area. This can be shown as follows:
Urban area 70%
Rural area 80,4%
The participation rate of women is greatly slower than the one correspondent to men.
The relation between the population out of the age adequate to work and the population that is in the age adequate to work, known as ratio of dependence, was 81,03 in 1990. In year 2000 it had a slight fall , reaching 72,76%.
Ñeembucú is a Department whose main economic activities are agriculture and livestock breeding. It is significant then to note that only the 0,24% of the total area of the Department is under crops that can be greatly sold in the national market, such as: garlic, rice, pea, sugar cane, strawberry, manioc, peanut, tomato, potato, soybeans, tobacco, carrot.
Ñeembucú only has 22 industrial companies with more than seven workers per zone, with its main office in the Department. They are exclusively located in the urban area, none of them are in surrounding or rural areas.
In the city of Pilar it is located one of the most important textile companies of Paraguay, with approximately a thousand workers.

Health

According to the information about hospital services of public institutions provided by the Statistical Yearbook of Paraguay 1997, in Ñeembucú there are only 86 available beds.
This means that there are only 9,7 beds per 10.000 inhabitants.
In Ñeembucú, 27,3% of the population has drinking water supply services, either supplied by CORPOSANA, by SENASA, or by private system, 51,4% of the population has safe water (wells with and without pump), and 21,3% has not got drinking water. This means that 17.500 inhabitants obtain water from springs, rivers, streams, etc.

Housing

A total of 16.259 housing units were taken into account in the census, and the results indicate that 37,7% of them have electricity supply services, and 28,3% have water supply services. But this situation varies considerably between urban and rural areas.
Only 5,4% of the units have electricity supply services in the rural area, whereas in the urban area 74,9% of the units have them.
Only 0,3% have water supply services in the rural area, whereas in the urban area the correspondent percentage is 60,5%.

Unsatisfied Basic Needs (UBN)

In Ñeembucú 75,93% of the households have at least one UBN, which is a percentage that exceeds in 11,75 points the national average. There is a big difference between the poorest and the richest districts in terms of UBN: Gauzucuá has 95,39% of the households with at least one UBN whereas Alberdi has 63,69% of the households with at least one UBN. The difference is 31,7 points.
The rural areas have 4 out of 5 households with deficiencies (79,94%), whereas urban areas have a lower percentage (71,37%).
Tacuaras, Villa Franca y Guazucuá are the districts at the end of the scale according to the high percentage of households with unsatisfied basic needs, and they are the ones with the worst results in terms of socio-demographic indicators related to deficiencies.
The percentage of illiterate population in Tacuaras (24,8%) and Guazucuá (23%) is higher than the departmental average, while the percentage in Villa Franca (14,9%) is closer to it.
Regarding indicators related to housing issues, only Tacuaras has part of its housing units (6,2%) with electricity supply services.
In Ñeenmbucú 48,49% of the housing units lack sanitary infrastructure, 29,3% of its households have deficiencies related to the access to education, and 18,57% of its households with deficiencies are in a situation of subsistence capacity, what means that in this UBN the district is in the third level of the departmental scale.
Regarding the variables analysed, there are some special points to mention:
Guazucuá has got only 251 households according to the census of 1992, it appears in the 216º position in the whole of the country, and if we take into account the four UBN it is below other districts such as Tacuaras or San Juan de Ñeembucú.
With respect to education, there is a big desertion form school, basically because of the rural culture which makes the help that a child can bring in rural or domestic activities more appreciable for their parents than the school education that he/she can get, in important production areas. Besides this, there is also a big distance between educational centers and family houses. We should also mention the continuous emigration of families that live in riverside areas affected by floods, that many times make it necessary to close the educational center and to move people towards higher areas where there are no educational centers.
Regarding this point, we have to mention that the department has got 8 neighborhoods and 38 riverside towns threatened by floods, in the areas of Pilar, Villa Oliva, Alberdi, Villa Franca, Humaitá, Paso de Patria, Gral. Díaz, Mayor Martínez, Villalbin, and Cerrito, in whose housing units the deficiencies become more evident.