RADAR AND TM DATA: TOOLS FOR DESERTIFICATION MONITORING IN CALCHAQUIES VALLEYS (Argentina)

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There was 75 % of arid and semiarid lands in the Argentine Republic. Desertification/ land degradation increases ,according to the government 650000 hectareas per year . (PNUMA,1996)

The region of the Arid Valleys in Argentine , has an approximate area of 14,000,000 ha. The Calchaquies Valley, in Catamarca, is within this system. Agriculture in the region is concentrated in irrigated oases. From the physiographic and climatic viewpoints, the studied valley is similar to other northwest valleys like Fiambalá; Tinogasta and Chilecito . However, while in those valleys desertification has been galloping during the last thirty years (Igarzábal, 1974; Navone et al, 1996), turning it almost into a vast desert, the Calchaquies valley presents the first symptoms of the process.

A management plan for this valley should be made on the basis of a proper description and diagnosis of the different levels of desertification present in the basin. The use of preventive measures is very important in the areas not yet affected by degradation processes or showing a minimum degree. The **objective** of this research was to find an enhacement to discriminate the earlier stages of desertification through radar and Landsat Thematic Mapper images in this valley

A diagnosis of the desertification degree was done using through observations and transects aplying FAO (1984) methodology . In desertification research ,human and biophisics aspects should be integrated. (FAO, PNUMA, Secretariat for Natural Resources and Human Environment, 1995.)

A dry season radar image was choosen for this study. The filters Flee;Fmode;Fsharp and Fgamma were applied .
The best enhaced radar image obtained by this way was merge with Landsat TM 3,4,5 from dry season image .Different methods of combining radar and VIS/IR imagery were proved
➢ RGB to IHS transforms,
➢ Principal component transform and
➢ Multiplicative

Visual and statistical analysis has been done to determine the accuracy level of the different products . For that purpose the desertification map done in the field has been overlapped with the enhanced images.

Besides,we originated a scale (value) in order to determine the coincidence level.
The best enhaced radar image used to merge with optical image was obtained with Gamma-MAP filter
Visual comparison obtained by overlapping between field map and the four enhanced images shows that the image generated aplying Principal Components in an image with 3 bands : radar, near infrared and middle infrared band,then Fourier transformation and low pass used has the highest coincidence

Then we obtained the correlation to know the efficiency between the different products and the map obtained in the field and ground truth and IHS/radar .

The r2 value shows that statistically the best product to discriminate the earlier stages of desertification in Calchaquies valleys is principal components/radar/inverse fourier

The whole valley of the Santa Maria river has been subjected to some degree of dessertification. In fact, 70% the valley falls evenly either into moderate to severe or the severe category.

The useful image obtained to identificate different desertification map units was principal component transform with radar and reverse transform. This product highlight moderate to severe degree. The merge of optical and radar data convey both chemical and physical information and could prove more useful than either image alone.

Introduction

Desertification increases in 650000 hectareas year by year in Argentine Republic .(Regional Workshops on Desertification - Program of National Action to Fight against Desertification (FAO, PNUMA, Secretariat for Natural Resources and Human Environment, 1995.)

According to the FAO-UNEP definition (1984) "desertification is the general expression of the economic and social problems,in conjuction with natural and induced processes,that lead to the destruction of the balance of the environment"thus ,the need of an integrated approach of socio-economic and biophysical factors for a proper assesment.

Vegetation cover , water and wind erosion ,salinization,animal and human pressure (FAO,1984) were studied

There are several similar valleys in the Northwest region .while in some of them desertification has been galloping during the last thirty years (Igarzábal, 1974; Navone et al, 1996), turning them into vast deserts, Santa María valley presents the first symptoms of the processes.To avoid this problem it is very important to make a proper diagnosis of actual status of desertification in order to allow the monitoring of processes. In this region is logistical difficulty in obtaining ground data quickly,cheaply,and with an appropriate level of accuracy.That's why we need a tool like remote sensing data.The usefulness of the integration of optical and radar data was demostrated by Kierein Young (1997) in geology and Shimabukuro et al.(1998)in land cover.

The objective of this research was to determine how useful could be the integration of radar and Landsat Thematic Mapper images mapping the earlier stages of desertification .

Study area description:

The region of the Arid Valleys of the Argentine Northwest, considering its basins, has an approximate area of 14,000,000 ha. It is characterized by its valleys and "bolsones" (*) found between high mountain ranges. Agricultural systems are exclusively under irrigation and cattle rearing is generally extensive, even in mountain slopes.

The Santa María Valley, in Catamarca, is inside this system. This region is located between 25 and 26 15 Southern latitude and 65 to 66 Western longitude The climate is semi-arid (Thornwaite,1948) showing wide temperature fluctuations between day and night. Winter is the cold and almost dry season, with a mean rainfall of 10 mm; while summer is relatively warm and rainy (290 mm) The floor of the Valley is between 1000 and 1500 m. and various microclimates can be observed therein.

The Torriorthent are the predominant soils in the alluvial fans and in the highest section of the upper terraces.The soils of the lower terrace of the Santa Maria river and its flood plain are Torrifluvents ,and Torrifluvents, associated with Torripsament.(Navone et al, 1995). Flora is typical of the " Monte" formation .It is a shrub formation of 1 to 1.8 m height.Agriculture in the region is concentrated in irrigated oases The 66% of forest has been cut or has been overgrazing.

RADARSat data

.Three RADARSAT Standard mode images from wet season (January) and dry season (august) were used in this study. RADARSAT sensor has been described in detail by Luscombe et al (1993) and their products by Denyer et al (1993)
The images were obtained in the ascending pass from January 17th,1998 and August 10th,1997 and May 20th,1998.

Landsat Themathic mapper data:

Three sets of Landsat Thematic Mapper (TM) data with six bands each were used in this study .Two of them from rainy season (March,1993 and January,1998) and one for dry season (august,1997)
Three bands (3,4 and 5) with full resolution (30 metres) were considered for the digital analysis.

METHODOLOGY:

Analysis Of Optical And Radar Images

The RADARSAT standard mode and Landsat TM images were registered to the study area .

The selected bands were used as input data for the indexes and for deriving the Principal components statistics (PCA).

We tried on the following methods of combining radar with VIS/IR images:.

❇ **Co-displaying in a viewer** The simplest and most frequently used method of combining radar with VIS/IR imagery is co-displaying on an RGB color monitor. In this technique the radar image is displayed with one (typically the red) gun while the green and blue guns display VIS/IR bands or band ratios. This technique follows from no logical model and does not truly merge the two data sets.

❇ **RGB to IHS transforms:** RGB (red,green,blue)color composite of bands (or band derivatives)such as ratios is transformed into intensity,hue,saturation color space. The intensity component is replaced by the radar imageThis technique integrally merges the two data types.

❇ **Principal componentes transform** :A similar image merge involves utilizing the principal components (PC)transformation of the VIS/IR image.. These are converted to a series of principal components. The first principal component, PC-1,is generally accepted to correlate with overall scene brightness. This value is replaced by the radar image and the reverse transform is applied.

❇ **Multiplicative** :A final method to consider is the multiplicative technique. This requires several chromatic components and a multiplicative component which is radar data. Assigned to the image intensity. In practice,the chromatic components are usually band ratios or PCs' ,the radar image is input multiplicatively as intensity (Holcomb 1993).

The two sensor merge models using transforms to integrate the two data sets (Principal Components and RGB to IHS) are based on the assumption that the radar intensity that the transform derives from the data inputs.

 A simple approach was used to correlate radar backscatter values with real ground feature types.This involved working from the ground to the image.

The visual and statistical analysis of the enhaced products were made on the basis of the ground truth, on a existing semi-detailed map.(Navone et al,1997). . For that purpose the maps originated from the different products has been overlapped with the map units obtained with the field survey.

An statistical analysis has been done to determine the accuracy level..The better enhaced images were choosen to make a correlation analysis.

Collection and analysis of field data:

In desertification research socioeconomics and biophisics aspects should be integrated. (FAO, PNUMA, Secretariat for Natural Resources and Human Environment, 1995.) In desertification research ,human and biophisics aspects should be integrated. (FAO, PNUMA, Secretariat for Natural Resources and Human Environment, 1995.)

The following processes involved in the biophisical area were studied:

a)Vegetation cover (Mueller,Dombois,1965)

b) Water erosion (Wischmeir y Smith, 1978) González del Tanago(1991)y Vich(1985).

c) Wind erosion (Woodruff y Sidoway, 1965)

d) Salinitation(FAO,1984)

Animal pressure and human pressure were estimated to evaluate socioeconomic area. FAO(1984)

.Vegetation cover ;water and wind erosion ;salinization;animal pressure and human pressure were measure in the field through observations and transects aplying FAO (1984) methodology within sample areas This methodology was employed too for the status of each one of the desertification processes with some adjustments for the application in this region.

For mapping precision selected points in the field were measured with GPS.

Results and Discussion:

The results of field measurements (water and wind erosion,vegetation cover,salinization and human and animal pressure) were described in each landform.

The upper part from the alluvial cones have moderate to severe level of water erosion cause in the low vegetation cover and the steep slope , slight wind erosion, no salinization, moderate animal pressure and slight human pressure, according to FAO we have moderate degree of desertification in this unit.

The forests in the high terraces present moderate degree of water erosion due to the vegetation and the soils ;moderate salinization ;severe degree of wind erosion;moderate degree of human pressure and severe degree of animal pressure According to this factors the desertification in the high terraces is moderate

East pediments in their lower part present very severe degree of desertification .They show very severe water and wind erosion,low vegetation cover,no salinitation,moderate human and animal pressure.

Agriculture under irrigation were done in lower terraces They present moderate desertification degree due to vegetation and salinization.

.The quantitative level of desertification ,defined according FAO classification (1984) is shown in table 1.

Table 1:Different levels of desertification due to field survey

Desertification Degree	Geomorphology Map Units	Human Pressur	Saliniz-.	Water Erosion	Animal	Wind Erosion	Desertification Area
None	Floodplain	10,98	30,22	2,24	0	20,4	**0**
Slight	Alluvial plane (playa)	49,04	10,15	10,28	51.5	18	**20,88**
Slight/mod	High terraces	0	0	10,98	8.35	8,09	**0**
Moderate	Low terraces	3,5	21,91	38,99	23.66	8,9	**26,55**
Mod./ Sev.	Alluvial fan;low terraces	6,65	16,84	0,89	0	12,99	**20,34**
Severe	Alluvial fan	29,83	20,88	25,76	16.49	2,2	**23,88**
Very Severe	High terraces;alluvial planes	0	0	10,89	0	29,4	**8,35**

The areal representation of the different levels of desertification obtained in the field (figure 1) shows that moderate is the most enlargement degree follows by severe degree.

To analyse the different products of integration of radar and optical images we overlapped the boundaries of field map with each of the four enhanced images.
We assigned the following values to characterize each map unit *1: No identifiable ; 2: Fairly   identifiable and   3: Clearly identifiable* as   result for the visual comparison.These were shown in table 2.

Table 2:*Efficiency Of The Different Algorithm In Differentiation Desertification Degrees*

Desertification degree	Radar-NI-MI(figure 2)	IHS)	Principal Components-Radar-Inverse(fig.3)
None	--	--	--
Slight	2	1	3
Slight/mod	--	--	--
Moderate	1	2	3
Mod./ Sev.	1	1	2
Severe	3	2	3
Very Severe	2	1	3

Figure 3 lets us see the product obtained by the Principal Component (PC) transform.

We can see in table 3 the areal cover of the   desertification map units in enhanced image with PC transform ;field survey and IHS.

The correlation value between principal components/radar/inverse fourier and ground truth and IHS/radar indicates the efficiency of the different algorithm in differentiation desertification degrees.

Table 3:Levels of deserfication map units according to the enhanced images and to the field

Desertification levels	Princ.Comp-Radar-Inverse	Desertif.(Field)	Radar-Optical
None	0%	0 %	0%
Slight	12,23%	20,88%	6,6%
Slight/mod	0%	0%	0%
Moderate	30,67%	26,55%	57,1%
Mod./ Sev.	27%	20,34%	5,78%
Severe	17,04%	23,88%	27,7%
Very Severe	12,05%	8,35%	2,75%
	R:0,88		R:0,692
	R2:0,82180203		R2:0,483078

Conclusions:

The whole valley of the Santa Maria river has been subjected to some degree of dessertification.In fact, 70% the valley falls evenly either into moderate to severe or the severe category.

The useful image obtained to identificate different desertification map units was principal component transform with radar and reverse transform (figure 3). This product highlight moderate to severe degree. The merge of optical and radar data convey both chemical and physical information and could prove more useful than either image alone.

It is expected that on the basis of desertification indicators obtained from this survey, together with the methodology developed, the early, quick and efficient detection of different desertification levels and the monitoring thereof, will be possible. It will also be possible to reinforce the gathering of data and of concrete experiences, with the positive and negative aspects of the different actions carried out in the region in connection with desertification.

Figure 7:Desertification degree (Field survey)
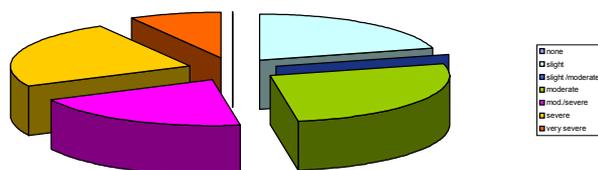
UBACyT program (Buenos Aires University).

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