Biodiversity threat through exotic species monitoring and management using Remotely Sensed data and GIS techniques

- *A Case Study of Banni (Kachchh) Gujarat, India.*

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Abstract

*The Rio-summit 1992 (United States Conference on Environment and Development) reflected Global Consensus of biodiversity, the environment and the bio-sphere area in perilous state and that the current state of these natural system has being caused by human activity (Ref. Weaver RD & Ke.Chun.Kim) Global warming a side effect of air pollution may play havoc with the worlds eco-systems in the coming decades, but present threat to bio-diversity is most alarming one and needs immediate attention. Bio-diversity encompasses the totality of Life on Earth, in all its variety of molecular, cellular, species wise, ecological & landscape patterns includes millions of plants, animals and micro-organisms, the genes they contain and the intricate ecosystems of which they are a part. India has tremendous biodiversity, genetic as well as of species and ecosystems. It contains over 5 percent of the world's biodiversity on 2 percent of the Earth's surface. This diversity can be attributed to the vast variety of landforms and climates resulting in habitats ranging from tropical to temperate, and from alpine to desert. The number of plant species in India is estimated to be over 45,000, representing about 7 percent of the world's flora. These include over 15,000 flowering plants of which 4,900 species are endemic to the countty (MoE&F 1994). It is extremely difficult to measure loss of biodiversity. One way to estimate biodiversity loss is to measure loss of specific habitats. But if biodiversity is being lost, so what? Why should we worry? It is a cause for concern because biodiversity, in all its forms, is important for the health of our planet and of human society in terms of various facts. Biodiversity is essential for sustainable development, but finding sustainable ways of living is essential through conservation of biodiversity. However this study relates to one of the major causes of biodiversity loss, i.e. introduction of non-native species (also known as "alien" or "exotic" species), deliberately or accidentally, has been a major threat to biological diversity worldwide as the introduced species have often flourished at the cost of the local species. Based on the analysis carried out it was found that by the **year 2020** more than **56%** of the total geographical area of Banni would be under prosopis which destroys entire bio-diversity and grassland eco-system of the area, if proper controlling measures were not taken immediately.*

Introduction

Natural grassland is a plant community in which the dominant species are perennial grasses, there are few or no shrubs and trees are absent or less in numbers. Usually associated with the dominant grasses are less abundant grass species and variety of other herbaceous plants, both annual and perennial types, which at certain times of the year give a characteristic aspect to the plant community.

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Grassland is one of the numbers of seral phases of vegetation. The vegetation structure is dynamic rather than static. One ecological association follows upon, and grows in consequence of, its predecessor in a well-marked and orderly sequence. One association therefore acts as a nursery to its immediate successor. This series of successional phases, from the first to the last, is referred to as the "sere", grassland forming one characteristic phase of that sere. The development of the sere may be arrested at any given point if environmental conditions are such that further development is retarded. The sere may thus end at a sub-climax rather than at its climax stage, e.g. in semi-arid areas the natural vegetation may be steppe or open grassland with no trees of any kind. In areas of higher rainfall forest is the climax.

In regions of high rainfall, the tendency to revert toward forest is particularly marked and confronts the pioneer with difficult problems of stock and pasture management. Continued under-stocking will allow a normal reversion, first to weeds, and then to shrubs and scrubs, habitual overgrazing will tend to weaken the sward so that the establishment of weeds is made easier.

Many of the large grassland areas, such as the prairies and plains of North America, the pampas of South America, the steppes of Asia and the Veld of Africa are believed to be of great antiquity and are climax formations determined by soil and climate. Other grasslands are of more recent origin and have replaced forests that have been destroyed mainly by cutting and fire; these have been maintained largely through grazing animals.

True grasslands exist in most part of the world where the rainfall is not sufficient to produce thick forest, and yet sufficiently high to prevent the creation of a desert. The great grasslands once covered nearly half of the earth's land surface, from the rolling Prairies of North America to the great Savannahs of Africa and the vast Steppes of Eurasia. Generally speaking, grassland have few, scattered, small sized **trees to break the drying winds.** Most of these areas go through periodic drought conditions. As a result, majority of plants of these regions lives more " in " the soil than above it. Just under the surface there is a tangled map of roots and rhizomes. Some grassroots grow down to the depths of a meter into the soil, while the tap roots of other soft stemmed plants may penetrate to five meter in their search for water and nourishment.

Importance of Grassland.

When we talk about grassland, we have to first consider the main component, that goes to form the bulk of the grassland, that is grass. Of all, the grasses are the most important to man. All our food stuff like corn, wheat, oats, rye, barley, and rice, sugarcane are grasses. Bamboo's are also grasses. Although, the great importance of grasslands lies in providing sustenance, grasses also serve humanity in other ways. Grass may be used for building homes and furniture (walls, thatch, matting, brooms) lawns, sports fields and as components of some cosmetics and medicines.

Grassland provides crucial grazing land and pastures for the domestic and migrated livestock, which forms important livelihood for majority of the population **of Banni and surrounding districts**. The milching capacity and overall health of the cattle, is an indicator of grassland quality. From these grasslands large quantity of forage grass is collected annually by cutting, and storing it in grass godowns for the droughts. However, free grazing can deteriorate these grasslands, for which only controlled " rotational grazing " is useful.

Introduced Species :

Introduction of non-native species (also known as "alien" or "exotic" species), deliberately or accidentally, has been a major threat to biological diversity worldwide as the introduced species have often flourished at the cost of the local species. India's Biodiversity, too, has been affected by introduction of alien species. Several exotic animals and plants introduced in the Andaman and Nicobar Islands are posing a threat to the local species of fauna and flora. Animal husbandry, an occupation of majority of Indian farmers, is directly dependent upon grassland for sustenance and it contributes a significant 5 to 6% towards India's national income (The State of India's Environment 1984-85).

Study Area

The Banni area, as the name signifies, is a ‘Banni hui’ (in Hindi) meaning made up land formed by the detritus brought down and deposited predominantly by the Indus river, which was reported to flow through the Great Rann in the past. The great and the little ranns of Kachchh were the old arms of the sea in the old geological period. Due to the eruption and formation of the Allah Bund near the Kori Creek, the lands in the Great and Little ranns got blocked up and were filled up by the deposits brought down by the Indus river (Source: Notes from Animal Husbandry of Agriculture, Gujarat). Once upon a time Banni was considered the largest grassland of its kind in Asia, but has fallen upon sad times in the last decade. The Banni area under the present investigation extends over Bhuj and Nakhtrana Talukas of Kachchh Districts. It is situated on the northern border of Kachchh mainland, consisting of 45 villages. The actual area

lies between North latitudes of 23°19' and 23°52' N and East longitudes of 68°56' to 70°32' E. Vegetation comprises of grassland, shrubs and legumes found naturally in the Banni area. Normally the area is covered with coarse and low perennial grasses and other non-grass species present in Banni area are as follows (Source : Banni Development Office, Bhuj, Kachchh).

1. *Dichanthium-annulatum, (Forsk) Stapf*
2. *Sporobolus helvolus (Trin) Thw.*
3. *Chloris barbate, SW.*
4. *Cenchrus biflorus, Roxb.*
5. *Eleusine bianata*
6. *Elysecarpus rugosus (legume), Wall*
7. *Heylandis latebrosa (legume), DC*
8. *Digitarea sanguinalis, Scop. Var Ciliaris Prain*
9. *Crotolaria medicaginea, Lam.*
10. *Indigofera sps. (Legume), Linn.*
11. *Sida sps. (Malvaceaa) L.*
12. *Malanocenchrus jacquemontii, J&S*
13. *Sporobolus diander (Retz) P. Beauv*
14. *Cenchrus setigerus, vahl*
15. *Aristida adscensionis, L*
16. *Aristida funiculata, Trin & Rupr*
17. *Setaria rhachitricho, Cook*
18. *Eragrostis minor and major, Host.*
19. *Eragrostis trimula, Hochst.*
20. *Cyprus rotundus, Linn(dupareate form)*
21. *Desmostachya bipinnata (L.) Stapf*
22. *Cyperus rotundus, Linn*
23. *Cressa cretica (Convovulaceae), Linn*
24. *Eragrostis bulbosa*
25. *Kochia sps. (Polygonaceae), Roth*
26. *Suaeda fruticosa*

Out of the above 26 grass species first 12 species are palatable and rest of them are salt-tolerant grasses.

Banni area deterioration is linked to the **increasing salinity ingress**, impoverishment and illiteracy of its inhabitants, a **growing human and livestock population**, and **invasion of prosopis juliflora**, which offers quick fuelwood, but its proliferation is dangerous for the grassland, **over grazing** and improper management of the land.

Data used

The following data was used during the course of this study

1. IRS 1C/1D LISS-III data(transparencies) of two seasons at 1:50,000

2. Banni area map prepared by Banni Development Authority and WRD/CDO joint report.

3. Ground truth data collection.

GIS Database Design and Organisation for Banni

The data base for the Banni development plan has basically two components, Spatial and Non- Spatial. The Geographic Information system (GIS) package is the core of the database for handling the two sets of data. In the present study ARC/INFO GIS package has been employed as the main tool to design, Organization, storage, retrieval, analysis and generation of cartographic outputs. Non-Spatial Data basically consisting of numeric/attributes in respect of Grassland type-code, Salinity range-code, composition and prosopis density class-code.

Since it was required that a typical analysis had to be carried out for Banni Development Plan, as it was discussed with other participating agencies like Gujarat Institute of Desert Ecology (GUIDE), Animal Husbandry, Banni Development office at Bhuj. The database contents are given in ***TABLE – 1*** .

Table – 1 : Primary and derived Themes used for Banni development plan

Sr. No.	Theme	Type	Primary/ Derived	Source	Criteria	Remarks
1	Grassland/ Landcover map	Polygon	Primary	IRS 1C/1D 1998-99	-	-
2	Banni Boundary	Polygon	Primary	Banni Devp. Office	-	-
3	Roads	Line	Primary	SOI toposheets and IRS 1C/1D L3 DATA	-	-
4	Elevation	Points	Primary	SOI toposheets & limited GPS points	-	-
5	Drainage	Lines	Primary	SOI toposheets	-	-
6	Contours	Polygons and lines	Derived	Elevation points	-	Tin and Lattice Model of ARC/INFO
7	Slope	Polygons	Derived	Elevation Points		Tin and Lattice Model of ARC/INFO
8	**Action Plans For:**					
8.1	Palatable Grass	Polygons	Derived	Landcover Map	Multi-parametric criterion based Analysis	Identification & Extraction using GIS
8.2	Mass Weeding of Prosopis	Polygons	Derived	Landcover Map	Multi-parametric criterion based Analysis	Identification and Extraction using GIS
8.3	Pure Prosopis	Polygons	Derived	Landcover Map	Multi-parametric criterion based Analysis	Recursive Elimination Analysis using GIS
8.4	Salinity range	Polygons	Derived	Landcover Map	Criterion based Analysis	Identification of fertility island of Vegetation types
8.5	Water Harvesting	Polygons	Derived	Slope Map & Drainage	Criterion based Analysis	Possible sites identified as per the discussion with experts

Each of the above mentioned action plans was generated using multi – parametric criterion based analysis by GIS techniques.

Methodology

Looking in to the typical problems of Banni grasslands and subsequent discussions held with experts, participating agencies and also with the agencies working in Banni development activity at Bhuj, it is felt that the problems of Banni can be addressed by four major action plans which are required for implementing for Banni development.

They are:

i. Palatable good Grasslands protection and conservation

ii. Arresting Prosopis juliflora invasion into grasslands (both Palatable and Salt tolerant)

iii. Phase – wise removal of Prosopis in non – saline areas and

iv. Rain water harvesting for salinity leaching and increasing grass production

The methodology flow chart is given below:

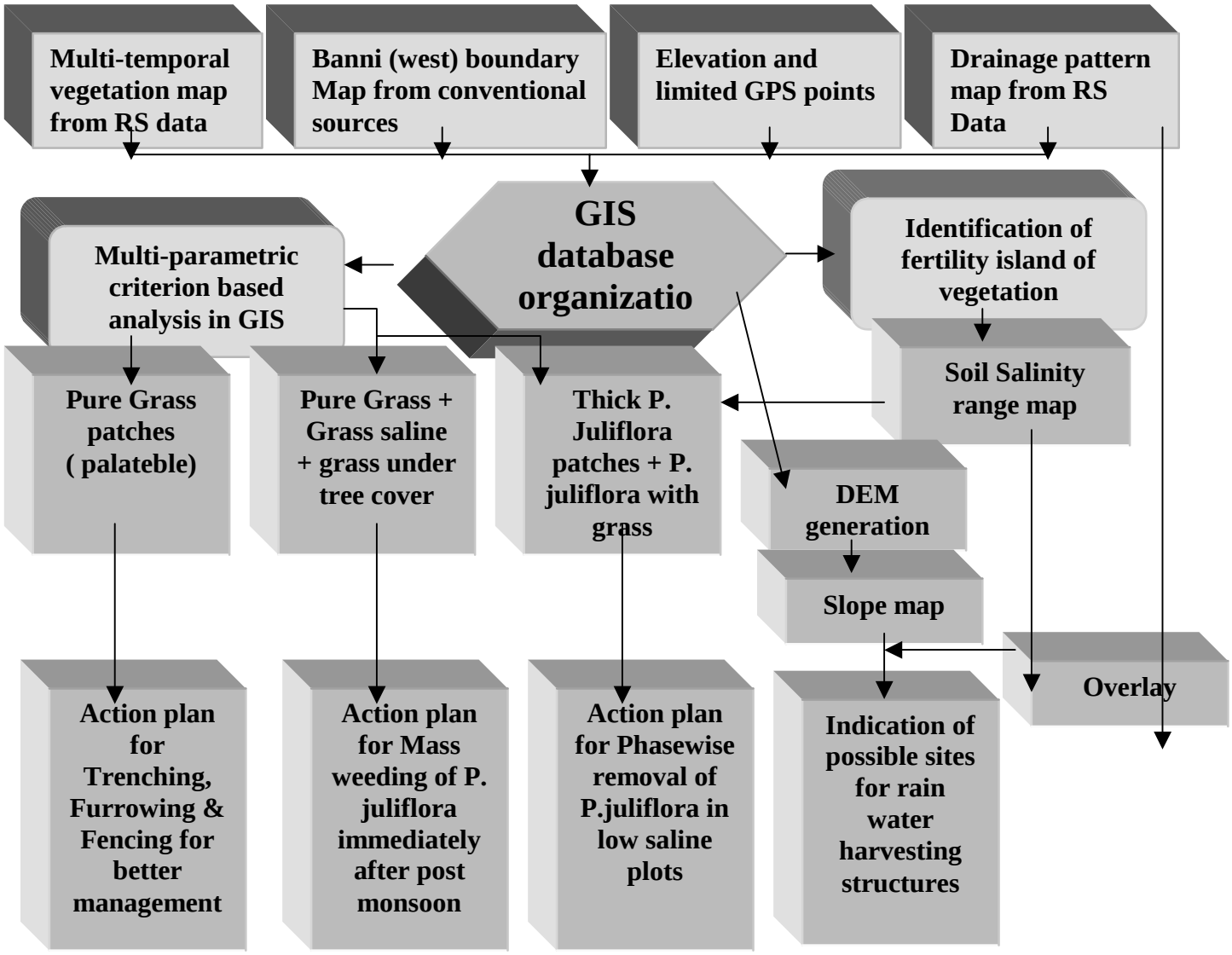

Fig - 01: Schematic Representation of Methodology for Banni Development Plan

Results, Discussions and Suggestions

Based on the analysis carried out the following results were found.

❖ **Prosopis invasion**

Invasion of Prosopis can be attributed to various allogenic and autogenic factors operating at spatial scales ranging from the small patch to entire landscape. Allogenic factors include climatic changes, over grazing etc. Allogenic factors operating to favor Prosopis invasion over good grasslands is an increase in the spatial and temporal heterogeneity of soil salinity, cattle droppings etc.. which promotes the invasion of Prosopis.

Prosopis invasion in Banni using multi-temporal Satellite data of 1980,1985 1988 and 1998 (Normal, Drought, Normal) have been calculated. The percent of area under P.juliflora are as follows:

Year	Area (Ha.)	%
1980	37893	9.85
1985	35046	9.11
1988	76786	19.96
1998	118675	31.23

Looking at the present scenario and comparing with our own previous studies, it is very interesting to calculate the future trend of invasion in the Banni (W) area. To do the trend analysis of Prosopis invasion in Banni, Kachchh, we have considered an imperial equation, which had been validated by using 1988,1998 & 1999 Satellite data. Based on that equation we have predicted P-invasion in Banni upto 2020.The results are as follows:

Year	**Area (ha.)**	**%area**
1998	118799.40	31.2630
2005	149275.78	39.2831
2010	171017.48	45.0046
2015	192736.38	50.7201
2020	214432.71	56.4297

This shows very alarming situation for Banni Grasslands. By the year 2020 more than 56% of the total geographical area of Banni would be under prosopis and destroys entire bio-diversity, and grassland eco-system of the area, if proper controlling measures were not taken immediately. One of the measures suggested was **Mass weeding of Prosopis** immediately after post – monsoon so as to control its invasion in new areas where good and palatable grass is growing at present. **Fig-02** shows spatial distribution of areas for mass weeding of P.juliflora immediately after the post-monsoon.

❖ **Phase – wise removal of prosopis**

Looking at the stock of Prosopis in Banni, it is very essential to remove (uprooting or cut and burn with kerosene) from non – saline areas. But, removing entire Prosopis at once may cause ecological problems. So, it is suggested to remove Prosopis phase – wise (may be 1kmX1km plots) starting from matured patches to complete with in Four or Five years. **Fig-03** shows priority areas for phase-wise removal of P.juliflora from pure patches of prosopis and prosopis invading in good grasslands.

❖ **Protecting and Controlling open Grasslands**

It is observed from the analysis that, if the rainfall is normal, there is a good grass growth in non–saline patches of land in Banni. Because of over grazing by domestic and migrated cattle from surrounding districts and also from Rajasthan, the grass is getting exhausted before it fully grows to a particular stage. To overcome this problem it is essential to protect open (uncontrolled) grasslands to arrest the entry of cattle freely from all sides of the

patches. So, it is suggested to fence these patches. Moreover, it is required to do furrowing in these lands for moisture retaining and thereby better production in the subsequent years.

❖ **Salinity ingress**

➢ **Trenching**

This is another major problem in Banni. Salinity ingress is approximately about 4% per year in the region. To control this ingress to some extent it is suggested to dig a trench around good grasslands, which helps in leaching out salinity and arrest cattle entry to some extent. **Fig - 04** depicts the length of trenching and fencing required and the cost may be calculated based on local labor and material charges.

➢ **Ghaduli – Santalpur**

It is also suggested that the road which is planned to construct between Ghaduli – Santalpur (via. Khavda – Katwndh – Dolaveera – Amrapur – Bela and Madhutra) must be completed having sluice gate opening only one side to arrest salinity ingress into Banni and other areas.

❖ **Rain water harvesting**

Leaching out salinity atleast Five to Eight inches from the surface will help grass to grow in low – saline areas of Banni. This is possible by allowing fresh water (rain water) to flow over saline areas. For this purpose rain water harvesting is necessary. So, the possible locations were suggested. However, it is very much required to study "What type of structure ?, How much capacity etc.. " for implementation. **Fig - 05** shows the topography of the area and **Fig - 06** shows the status of drainage pattern in the area and suggested rainwater-harvesting structures.

References

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