APPLICATION OF RS, GPS & GIS IN A NATIONAL MONITORING SYSTEM FOR ACCURATE RANGE ASSESSMENT

H. Arzani

Professor, Faculty of Natural Resources
University of Tehran, Iran

M. Farahpour, M. Azimi and H. Kaboli

Research Institute of Forests and Rangelands
Tehran, Iran

H. Mirdavodi

Scientific member, Agricultural and Natural Resource Research Center
Markazi Province, Iran

M. Borhani

Scientific member of Agricultural and Natural Research
Center of Isfahan Province, Iran

J. Abdollahi

Scientific member, Agricultural and Natural Research Center
Yazd Province, Iran

Abstract

Sustainable use of rangelands requires information on vegetation cover and its changes through time, condition trend and the effect of climate as well as management practices. The main objective of this research was showing variation of vegetation parameters, i.e. vegetation cover, soil surface cover, production and density, in the long term in three provinces of Iran, Markazi, Isfahan and Yazd. Efficiency of satellite data for estimation of vegetation parameters and suggestion of a system for vegetation cover monitoring were other goals of the study. All selected provinces were equipped with one site locating in the key area of the main vegetation communities. Data in arid and semi arid areas were collected along four 400 or six 200 meter transects using 60 two or one square meter quadrates. Correlations between satellite data and ground truth data were investigated. Primary results shows that range ecosystems in arid regions of all three provinces have fragile conditions. Rangelands in these provinces generally are characterized with low vegetation cover, small production and poor range conditions. Desirable species were absent in vegetation composition in its place

moderate or low desirable species are abundance. Biological balance has been lost because of sever grazing. Integration of five years field and satellite data, the time course of the study, indicates that range assessment in wide areas, with assistant of digital data is possible. Also application of GPS and GIS can facilate using satellite data in a national monitoring system.

Keywords: *rangeland, site, satellite data, GPS and GIS.*

INTRODUCTION

Vegetation is a dynamic entity due to climatic variation and management activities. The role of rangeland ecosystems in economy, soil and water conservation and other services giving to society is important. Their sustainable use therefore, needs correct, accurate and permanent information. Such a data can be provided by a National Monitoring System (NMS). This information is important for the stakeholders in on hand and application of new technologies e.g. RS and GIS in another Arzani *et al* [5]. Changes in vegetation parameters are influenced by different biotic and abiotic factors. So determination of factors affecting vegetation changes is important for better management Anderson & Holte [2].

Buffington and Herbel [9] reported that drought has been the main factor affecting vegetation cover changes in the South west of the United States during 1858 to1963. Hensi *et al* [12] and Arzani [4] reported the same findings for Semi desert of New Mexico and Western Division of New South Wales in Australia. While York *et al* [19] found that reducing grazing pressure was most important factors for recovery of vegetation cover in south west shrub lands of Utah.

Curry and Payne [10] believe that for better management of rangelands collecting information about production potential and problems of range management is essential. For permanent monitoring they established monitoring sites in the main vegetation types to show long term changes and to recognize causes of vegetation and soil degradation. Based on such comments the monitoring system of Western Australia has been formed Hacker *et al* [11]. On a yearly base, important factors are measured in a network of sites to show and separate effects of climatic factors and management on rangelands.

Connor and Roux [14] reported that changes in shrub lands of Caro in South Africa during 1949- 1971 has occurred in response to rainfall variation and animal grazing. Sever grazing has been recognized as the most important reason of reduction of vegetation density in the Kobotarkhan region during the last 40 years by Rostami [16]. Mohammadi Golrang [13] also believed that sever grazing has changed vegetation compositions in Amir Kabir watershed of Karaj dam from 1973- 1993. Range condition of inside and outside of an exclosure in Posht Kouh of Yazd was compared by Arzani *et al* [7] and concluded that changes of vegetation communities in arid zones is very gradual and a monitoring system for

permanent evaluation of vegetation and soil characteristics of rangelands is essential.

This study focuses on the long term variation of vegetation parameters such as vegetation cover, soil surface cover, production and density in three provinces of Iran, Markazi, Isfahan and Yazd. It also attempts to test the efficiency of satellite data for vegetation parameters estimation.

Material and Methods

The research was conducted in three provinces described as:

1. Markazi province with the area of 29400 square kilometer located between 33°23' to 35°34' N and 48°58' to 51°4' E. Average rainfall is 250 mm. Almost 1940000 hectares equal to 64% of the province area is known as rangelands embracing 46.6% of highlands, 36.8% of midlands and 16.6% of lowlands. Vegetation of the rangelands could be put into eleven vegetation type boundary table 1. In each vegetation type one site with four 400 meters parallel transects was established. Four sites were located in the *Artemisia* community, 3 sites in the *Astragalus* community and four sites in other vegetation communities. Elevation ranged from 980 to 2200 meter. Soil characteristics differed between sites.

Table 1. Selected vegetation types in Markazi province.

Site name	Vegetation type	Rainfall (mm)
Nemati	*Artemisia sieberi- Salsola rigida*	213.0
Anjilavand	*Artemisia sieberi- Noaea mucronata*	144.3
Azablo	*Artemisia sieberi - Stipa barbata*	267.6
Akbarabad	*Pteropyrum olivieri – Artemisia sieberi*	296.9
Khoshkrod	*Hulthemia persica - Noaea mucronata*	296.2
Sian	*Astragalus gossypinus - Scariola orientalis*	183.0
Gol-zard	*Astragalus gossypinus - Cousinia cylindrical*	323.4
Farnagh	*Astragalus prrawianus - Phlomis persica*	199.4
Aznojan	*Noaea mucronata- Artemisia sieberi*	173.2
Shanagh	*Artemisia sieberi- Stipa barbata*	231.8
Chazan	*Camphorosma monspeliacum- Halimione verrucifera*	227.0

2. Isfahan province with an area of 105937 square kilometers located between 30° 43' to 34° 27' N and 49° 36' to 34° 27' E. Rangelands area is 6.3 million hectares sectioned as 49% semi desert, 37% arid and 14% semi arid. Selected vegetation types are illustrated in table 2.

3. Yazd province is located between 29° 48' to 33° 30' N and 52° 45' to 56° 30' E. Area of province is 72156 square kilometers. Winter is cold and relatively humid with hot and dry summer. Average annual rainfall is 127.5 (mm). Fifteen major vegetation communities were selected in Yazd province (Table 3).

In each site for all provinces cover and yield were measured within 60 two square meter quadrates along four 400 meters transects. Measurements were repeated for a period of 5 years. Yield was measured using a double sampling procedure suggested by Arzani and King [8]. Based on this method cover and yield in 15 excluded quadrates was measured and the correlation equation between these two was calculated. The result was applied to the other 45 quadrates having the information of the vegetation cover in hand.

Minitab 13.3 was used for data analysis. Ground data on cover and yield of five sites during the time course of the study and their corresponding digital data (ETM+) were used. Correlation between cover and yield of ground data, found by GPS, and image digital numbers (DN) of pixels, as an out come of application of vegetation indices, was calculated.

Range condition for each year of measurement was determined using the four factorial method suggested by Parker [15]. One photo point was established in the beginning of transect 1 in order to make repetitive photos at each time of measurement. Summary of information obtained from monitoring program of each year was sent to range holders and government agencies.

Table 2. Vegetation types in the stepic regions of Isfahan province.

Site name	Vegetation Type	Rainfall(mm)
Alavije	*Artemisia sieberi- Anabasis aphylla*	167
Khoandab	*Artemisia sieberi*	277
Golpayegan	*Scariola orientalis- Cousinia cylindrica*	270
Mote	*Artemisia sieberi*	260
Klahrod	*Artemisia sieberi- Scariola orientalis*	152
Kamsheche	*Noaea mucronata- Cousinia cylindrical*	108
Shor abad	*Convolvulus fruticosus- Astragalus spp.*	114
Charmshahr	*Artemisia sieberi- Noaea mucronata*	111
South of Shahrreza	*Euphorbia spp– Scariola orientalis*	117
East North of Shahrreza	*Convolvulus fruticosus - Scariola orientalis*	94
Gardane Shayan	*Artemisia sieberi- Acantholimon sp.*	107

Plant species were classified into three palatability classes, I (desirable), II (moderately desirable) and III (low or non desirable). Climatic data in each region was collected from synoptic stations.

Table 3. Vegetation types in the steppe regions of Yazd province.

Site	Vegetation Type	Rainfall (mm)
Gariz-Sofla	*Artemisia sieberi- Salsola tomentosa*	-
Mazrae-Amin	*Artemisia aucheri- Astragalus gossypinus*	211
Sadrabad(1)	*Artemisia sieberi -Zygophyllum eurypterum*	145
Sadrabad(2)	*Artemisia sieberi-Zygophyllum eurypterum*	140
Sadrabad(3)	*Artemisia sieberi- Eurotia ceratoides*	140
Eshniz	*Fortuynia bungei- Artemisia sieberi*	70
Mazre-Amin	*Artemisia sieberi- Pteropyrum aucheri*	123
Chah-Afzal	*Seidlitzia rosmarinus-Artemisia sieberi*	55
Fahraj	*Hammada salicornia-Artemisia sieberi*	60
Ebrahim-Abad	*Cornulaca monacantha- Artemisia sieberi*	116
Dasht –Kalmand	*Artemisia sieberi –Lactuca orientalis*	-
Dehshir	*Artemisia sieberi -Aellenia subaphylla*	140
Ali-Abad	*Ephedra strobilacea- Zygophyllum eurypterum*	126
Marvast(1)	*Haloxylon persicum- Salsola arbuscula*	80
Marvast(2)	*Calligonum polygonoides- Salsola tomentosa*	70

Results

The results obtained in Markazi province are illustrated by table as an example and the results of other provinces are briefly described in the text. Rangelands in Arak (Shanagh and Chazan sites) showed higher canopy cover and yield, i.e.31% and 385 kg/ha, table 4. This has occurred where *Halimiom verrucifera* and *Camphorosma monspeliacum* were dominant on salty soil with high moisture content. In such community range production was less affected by rainfall variation. Saveh (Nemati, Anjilavand, Azablo, Akbarabad and Khoshkrod) had lowest canopy cover and yield in this province, 19% and 47.41 kg/ha. Most of its species belong to class III of palatability. Forage yield come mostly from *Artemisia sieberi*, *Noaea mucronata*, *Stipa barbata* and *Salsola rigida* in Markazi province. Range condition in different sites varied from poor to fair with constant or upward trends.

Average annual rainfall during the five years of monitoring in this province has been shown by figure 1. According to the results most vegetation indices had significant correlations with cover; however their performance differs depending on vegetation characteristics in different sites (table 5).

Table 4. Mean of canopy cover and production of Markazi province.

City	Year	Mean of cover % (palatability classes)			Mean of production kg/ha (palatability classes)			Total cover %	Total production kg/ha
		I	II	III	I	II	III		
Saveh	1998		8.5	11.9		52.04		20.4	52.04
	1999		8.26	10.45		52.53		18.71	52.53
	2000		5.59	10.11		32.08		15.7	32.08
	2001		8.92	9		40.18		17.93	40.18
	2002		10.08	11.58		60.25		21.67	60.25
Mean			8.27	10.6		47.41		18.88	47.41
Khomein	1998	0.1	6.54	8.78		113.89	0	15.42	113.89
	1999	0.1	4.13	10.76		47.79	1.55	15.01	49.34
	2000	0.03	7.32	13.58		56.38	1.41	20.9	57.79
	2001	0.08	11.24	14.52		67.5	1.55	25.84	69.05
	2002	0.06	12.21	16.36		121.85	1.75	28.63	123.57
Mean		0.07	8.28	12.8		82.08	1.25	22.26	82.08
Arak	1998		15.5	8.08		348.15	25.35	23.6	373.5
	1999		15.98	4.7		262.35	19.1	20.68	281.45
	2000		18.18	5.39		364.82	19.9	23.57	384.72
	2001		17.4	11.14		310.7	16.25	28.54	326.9
	2002		18.66	12.27		324.8	19.02	30.94	343.82
Mean			17.14	8.31		322.11	19.92	26.46	346.09

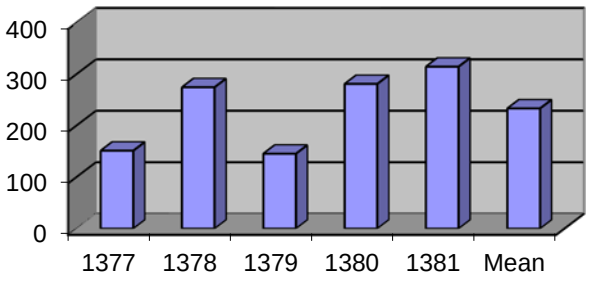

Figure 1. Mean of rainfall during five years in Markazi province (mm).

In Isfahan province, Golpayegan (Khoandab and Golpayegan sites) with 11.5 percent canopy cover and 158 kg/ha yield has the best condition. Najaf Abad (Alavije) with 5% canopy cover and 40 kg/ha however, is the poorest one. Range production mostly comes from class II of palatability.

In Yazd province Sadough area (Sadrabad1, Sadrabad2 and Sadrabad3) with 22% of canopy cover and Taft (Gariz Sofla and Mazrae Amin) with 227 kg/ha yield had highest cover and yield compared to Maybod (Eshniz) with 4% canopy cover and 38 kg/ha yield.

Communications was part of this study for that the results of each site with comments were sent to owners, information of sites located in each region were sent to local government offices and information of the sites located in each of the provinces was sent to the central government office.

Discussions

Generally the main reason for changes in vegetation cover and yield during the five years of study for all provinces was found precipitation variation and then management practices. Boufington and Herbel [9], Hensy *et al*. [12], Arzani and king [8] and Connor and Roxs [14] also had similar findings in different areas. We found that changes in arid areas are very gradual. The same finding was also reported by Arzani *et al.* [7] after 10 years grazing abandon in Poshtkouh of Yazd. So a monitoring system should be designed to determine the trend of qualitative and quantitative changes of cover and yield in arid zones. In such a system it is possible also to estimate cover and yield using ETM+ data. This was previously supported by findings of [8 & 1]. They stated that remote sensing can be used as a tool for collecting frequent information from vegetation parameters over a large area in conjunction with ground truth data.

Table 5. Regression equations of vegetation cover with selected vegetation indices in Markazi province.

Site	Veg. Form	Regression	R	SE
Aznojan	Annuals	6.09 + 77.7 VNIR1-a	82.89	4
	Grasses	- 11.2 + 67.2 Pd322-a	81.55	1.1
	Forbs	- 11.8 + 14.7 MIR-a	71.41	2.1
	Shrubs	- 22.1 + 13.8 MSI-a	89.16	2.6
	Total	- 4.95 + 15.2 Ferr-a	81.85	5.6
Chazan	Annuals	24.8 - 82.9 Pd312	94.66	2.2
	Grasses	9.44 - 4.03 Iron_oxide	70.36	2.9
	Forbs	8.67 + 323 Savi	83.96	4.1

	Shrubs	9.09 - 3.48 Iron oxid-a	61.16	1.7
	Total	53.6 - 245 Pd311	87.58	4.1
Shanagh	Annuals	- 0.882 - 6.43 IR1-a	60.50	0.47
	Grasses	0.851 + 0.435 Ra	60.00	0.17
	Forbs	11.4 - 18.5 MIRV2	77.14	1.5
	Shrubs	22.5 - 15.6 Tv1-a	69.86	2.9
	Total	- 16.2 + 652 Ref7	76.49	7.3
Nemati	Annuals	11.3 - 41.4 Ref3	55.6	1.7
	Grasses	-	-	-
	Forbs	- 0.568 - 0.0595 VI-a	45.3	1
	Shrubs	22.0 + 0.230 VIL	54.0	3.4
	Total	33.4 + 0.262 VIL	54.1	3.9
Khoshkrud	Annuals	1.12 + 39.2 Mini	82.22	1.6
	Grasses	7.96 - 0.0787 B2L	83.07	1.1
	Forbs	7.40 + 22.9 PVI	73.76	0.3
	Shrubs	- 198 + 187 Clay Minerals	55.23	4.3
	Total	33.5 - 27.8 Pd322-a	58.82	4.5

Rainfall variation during the five years has not been regular so it is difficult to relate vegetation changes only to rainfall variation. This is similar to the findings of West *et al.* [18], Anderson & Holt [2] and Souna *et al*. [17] in sagebrush community in USA. West *et al*. [18] did not report significant changes for perennial grasses in five, 13 years old exclosures in spite of desirable variation of rainfall during the five years of their study. They believed that improvement of range production as a consequence of increasing grass density requires more. Anderson and Holt [2] reported slow changes after 25 years of exclusion from

grazing. However Souna *et al.* [17] reported an increase in grass production compared to sagebrush production after 30 years.

Generally rangelands in arid zones were characterized by low vegetation cover and yield, and poor condition. Class I species were not presented in vegetation composition and classes of II and III formed the main part of vegetation cover. Desirable species had degraded and ecosystems were in fragile conditions. A national monitoring system is suggested for permanent measurement to distinguish reasons of the changes (climate or management). Such a monitoring system will provide sufficient information for decision makers at national level, and lets proper management to be set though which utilization levels of rangelands could be justified.

References:

[1] Abdollahi, J., Arzani, H., Baghestani N. & Rahimian, M.H. Developing a method for mapping forage production in arid and semi desert areas using RS-GIS, Iranian J. of Range and Desert Research, 2007.

[2] Anderson J.E. & Holte, R.E. Vegetation development over 25 years without grazing on sagebrush dominated rangeland in southeastern Idaho. J. Range management. 34: 25-29, 1981.

[3] Arzani, H. Investigation on relationship between cover and yield, MSc Thesis, University of Tehran, 1989.

[4] Arzani, H. Some aspects of estimating short and long term rangeland carrying capacity in the Western Division of New South Wales, PhD Thesis, UNSW, Australia, 1994.

[5] Arzani, H. Manual for range monitoring in different climatic zones, Research Institute of Forests and Rangelands, 50p, 1997.

[6] Arzani, H. & King, G.W. A double sampling method for estimating forage production from cover measurement, 8th Biennial Australian Rangeland Conference, pp. 201-202, 1994.

[7] Arzani, H., Fatahi, M. & Ekhtesasi, M. Investigation on changes in rangeland vegetation of Poshtkouh of Yazd during (1986 to 1998), J. Pejuhesh and Sazandegi, 12: 31-35, 1999.

[8] Arzani, H., King, G.W. & Forster, B. Application of the Landsat TM data for vegetation cover and yield measurement, Iranian J. Natural Resources, 50: 21-28, 1997.

[9] Buffington L.C. & Herbel, C.H. Vegetation changes on a semi desert range (1963-1985). Ecol. Mong. 35: 139-164, 1965.

[10] Curry P. & Payne, A. Rangeland surveys, in “Rangeland Management in Western Australia”, Dept. Agriculture, Western Australia, Miscellaneous publication 8/92, pp. 9-14, 1992.

[11] Hacker R., Beurle D. & Gardiner, G. Monitoring Western Australia’s Rangelands, in “Rangeland Management in Western Australia”, Dept. Agriculture, Western Australia, Miscellaneous publication 8/92, pp. 15-20, 1992.

[12] Hensy J.T., Gibbens, R.P. Tromble J.M. & Cardenas, M. Vegetation changes from 1935 to 1980 in mesquite duneiands and former grasslands of Southern New Mexico. J. Range Manage. 36: 370-374, 1983.
[13] Mohammadi Golrang, B., Vegetation changes in Amir Kabir Watershed (1973-1993), MSc Thesis, Gorgan University, 1994.
[14] O, Connor T.G. & Roux, P.W. Vegetation changes (1949-71) in a semi-arid, grassy dwarf shrub lands in the Karoo, South Africa, J. Applied Ecology. 32: 612-626, 1995.
[15] Parker, K.W.and Robert W. Harris.1952. The 3- steps method for measuring condition, USA.V.S. for serv. South and Southeast, for expert, Sta. Proc.PP.55-96.
[16] Rostami, S., Investigation on factors affecting vegetation changes, MSc Thesis, University of Tehran, 1995.
[17] Sneva F.A., Rittenhouse L.R. & Tueller, P.T. Forty years – inside and out. PP: 10-12 In: oregoin Agr. Exp. Sta. Spe. Rep. 586, 1980.
[18] West N.E., Provenza, F.D., Johnson, P.S. & Owens, K. Vegetation change after 13 years of livestock grazing exclusion in west central Utha. J. Range Manage. 37(3): 262-264, 1984.
[19] Yorks T.P., N.E. west and K.M. Capels. Vegetation differences in desert shrub lands of western Utah, J. Range Manage. 45(6): 569-577, 1992.