Study of species changes under impact of the change in an ecological factor. Case study: the flood spreading project in Zanjan, Iran

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Abstract

More than 90% of Iran is located in an arid and semi-arid area and water is one of the most important factors that can prevent sustainable development in all agricultural areas. Thus, water plays the important role in ecological condition changes, especially for plants. In this research, it was attempted to survey the water harvesting and its spreading impact on plant composition changes in a flood spreader. The study area is located in the part of the Zanjan plain, in the north-west of Zanjan city and between two rivers; Sorhain and Qarecharian, which includes rain fed and released lands that have been occupied by quaternary deposition. For this purpose, the amount of rainfall and diverted floodwater to the station was monitored and measured during the flooding period. In order to evaluate the plant composition changes in the three sites in spreading area and one in the control site, a total of 11 permanent transects (9 in spreading area and 2 as control) were stabilized using the Line Intercept Method, the canopy cover percentage of all species were noted and all species were distinguished. This study showed that some species under impact of floodwater spreading were omitted, some increased or decreased, and some new species were observed for the first time. The increase of vegetation cover and appearance of palatable plants in the last year showed that floodwater spreading can improve foliage production. Considering the life form of the observed species, although perennial forbs increased, floodwater spreading in the case of establishment of perennial grasses did not operate successfully. Therefore, the shortage of the studying period and changes in the amount of harvested floodwater make the correctness of these obtained results rather less valid.
Keywords: flood water spreading, life form, palatability, vegetation changes, Zanjan plain, Iran.

1 Introduction

Iran is a dry country and faces the problem of water shortages. The limited annual precipitation that falls during short and intense storms is mainly changed into floods. To overcome this problem, floodwater-spreading projects can be useful as one of the most suitable methods in most regions throughout the country. It was probably the first form of irrigation used by man. Its system consists of dams, dikes, ditches, or other means of diverting or collecting runoff from natural channels, and streams for spreading runoff from steep areas over adjacent flood plains (NRCS, 2002). This system allows infiltration of excess water with a minimum of control (Houston, [6]). The water that penetrates is then available for plant growth or deep percolation. The system has been applied effectively in some arid and semi-arid regions and used for improving forage quality and production on much of the dry and poor rangelands. Although range water spreaders are a well-known means of improving forage production, but compositional studies of changes that occur due to the practice are rare.

Kowsar (1987) has reported that barley yield was increased by 700 kg/ha under flood spreading system in Gharebayghan. Also the grazing capacity in this area has increased five times (Ebrahimi, [2]). There are a few reports on effect of flood spreading on plant composition. Perhaps the most detailed study of the effects of water spreading has been reported from Branson [1]. He indicated that herbage yield increased by an average of 160 percent. Total basal ground cover of vegetation increased in all parts of the system. The major compositional changes observed were a decrease in big sagebrush (*Artemisia tridentutu*) and plains prickly pear (*Opuntia pozyacantha*) and an increase in foxtail barley (*Hordeum jubatum*). In an intensive study of water spreading in New Mexico, Hubbell and Gardner [4] concluded that herbage yields were increased 4 to 9 times. The amount of increase was dependent on the duration of flooding. In studies conducted by Hubbard and Smoliak [5] increases in herbage production due to water spreading as high as 34 times were indicated.

This paper reports vegetation cover changes and composition on a water spreading system in a part of Zanjan plain in Iran from October 1998 to June 2003.

2 Materials and methods

The study area consists of a water spreader project within 250 ha with a diverted dam, a 2100 m transfer channel, a 2350 m transfer-spreading channel, and 15 spreading channels, located in north-west of Zanjan city, in the north-western part of Iran. This plain is located between two rivers of Sohrain and Gharecharian (Fig. 1). The most of the plain is under rain fed farming, fallow and abandoned lands. Dominant slope of plain varied between 2 and 5%. The plain has been occupied by quaternary deposition. The climate of the study area is Mediterranean, with hot summers and cold winters that are typical of the semi-arid area in Iran. Mean annual rainfall is about 297 mm and approximately 50 percent of the total precipitation falls during March to May with 15, 18.1 and

15.2% respectively. Mean annual temperature is 10.7°C with the mean maximum and minimum of 17.5 and 3.9°C respectively.

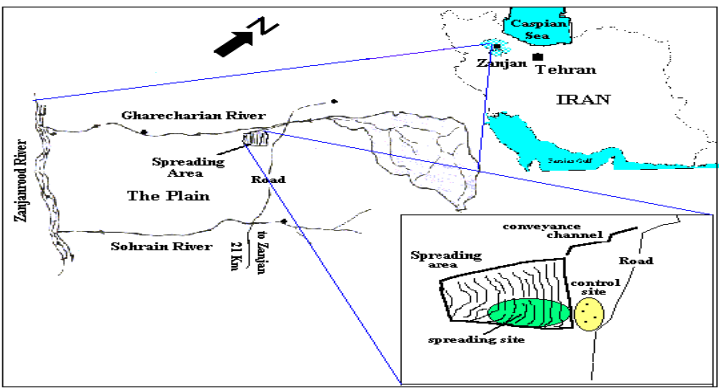

Figure 1: The location of study area.

The elevation of the study area is about 1800 m above sea level. The topsoil is loam with 10-20% gravel that changes with the depth to sandy loam with 40-50% gravel. The dominant species in this area are *Silen sp*., *Ceratocarpus arenarius*, *Reseda lutea*, *Scariola orientalis*, *Carthamus lanatea*, and *Rosa persica* with some types of annual grasses.

The amount of diverted floodwater to the station was measured at all flooding times during five hydrological years from October 1998 to June 2003. Monitoring of vegetation changes was conducted in 11 transects (9 in spreading area and 2 in control area) by Line Intercept Method. The percentage of vegetation cover was measured and all of the species which intercepted the line, were identified and the percentage of canopy cover of each species were noted separately.

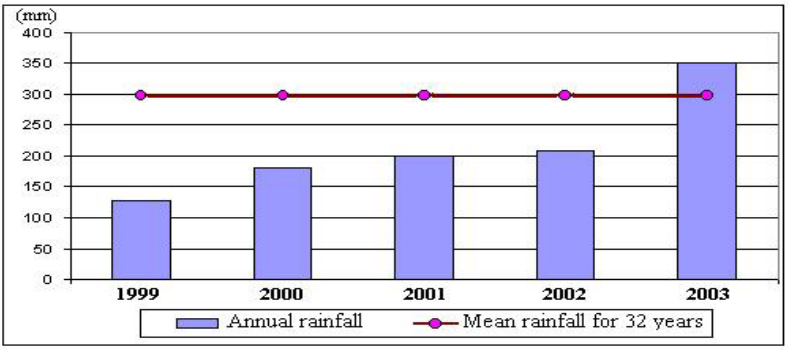

Figure 2: Annual rainfall during study period and mean rainfall of a period of 32 years.

3 Results

3.1 Precipitation

Rainfall was monitored during the study period. In addition, rainfall data was collected for a period of 32 years, which the mean annual rainfall was 297.1 mm (Fig. 2). Based on these data, rainfall in certain years was less than the mean annual rainfall, which, indicates that these years can be considered as a drought period.

3.2 Diverted floodwater

The amount of diverted floodwater and its changes has been shown in Figure 2. During the study period, diversion of flood occurred 5 times. The smallest one has had a volume about 507000 m^3 in April 1999 and the largest one occurred in May 2002 with a volume about 2496300 m^3. In two years 2000 and 2002, water diverting occurred along more than 30 days on April, so in these times the plants generally start to grow.

Table 1: Diverted floodwater data during study period.

Year	1999	2000	2001	2002	2003
Harvested water (1000m^3)	*507.6*	*2498*	*665*	*4500*	*7100*
Harvesting time (day)	*10*	*31*	*6*	*40*	*58*
Duration of Harvesting	*2-12 Apr.*	*25 Mar. – 24 Apr.*	*6-12 Apr.*	*2 Apr. – 12 May.*	*26 Mar. – 24 May*

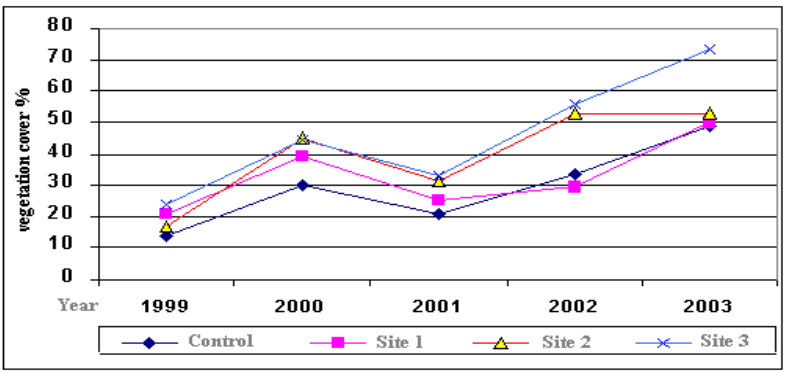

Figure 3: Changes of vegetation cover during 5 years in spreading and control sites.

3.3 Vegetation cover

The changes of vegetation cover during 5 years of study periods in three sites in spreading area and one site as control have been shown in Fig. 3. This figure

shows that the vegetation cover changed with water spreading. On the other hand, more diverted floodwater causes more increase in vegetation cover. The mean vegetation cover in spreading area increased from 22 to 46% for 1999 and 2003, respectively.

3.4 Plant composition

3.4.1 Observed species changes

Total observed species in spreading area were 87 and plant diversity varied from 31 in 1999 to 65, 51, 59 and 60 for 2000 -2003 respectively. Whereas, in control area total observed species are 56 and have varied from 16 to 22, 29, 37 and 39 in these years (table 3). Some species observed only in 2000 and then omitted (e.g. *Poa bolbosa*), some of them gave positive response to water (e.g. *Carthamus lanatea, Henrardia persica,* and *Scariola orientalis*) and some of them gave negative response to water (e.g. *Silen sp., Nonea sp.,* and *Crambe orientalis*). Some species were increased from 1999 to 2003 (e.g. *Achillea sp., Centaurea virgata, and Eremopyrum bonaepartis*) and some of them decrease (e.g. *Reseda lutea, and Ceratocarpus arenarius*). The most striking vegetation changes on the spreader were a decrease in arial cover of *Silen sp.* and *Ceratocarpus arenarius* and an increase in *Eremopyrum bonaepartis.*

Table 2: Plant diversity, precipitation and harvested floodwater in spreading and control areas in 1999 – 2003.

	Location	*1999*	*2000*	*2001*	*2002*	*2003*
*No. of species**	Sprd[1]	31	65	51	59	60
	Cntl[2]	16	22	29	37	39
Precipitation (mm)		128.3	179.3	199.8	208	351
harvested floodwater (*1000 m^3)		507.6	2498	665	4500	7100

*1- spreading area, 2- control sites *: The number of observed species*

3.4.2 Species changes according to palatability

Due to plant palatability, there was not observed important change in site 1 for plant class 2 and only plant class 1 had a small increasing. This increasing was higher for site 2, specially in two last years and also, a small increasing on plant class 1 (Fig. 4). The observation of plants class 1 was the most important cases in site 3 and increasing of them in last year. In control site, the plants class 2 increased and nothing plant class 1 observed.

3.4.3 Species changes according to life form

According to life form of observed plants, only the one perennial shrub observed in spreading area and had small increasing from 0.46 to 1.09%. In the control site nothing of perennial shrub species was observed. Whereas in the spreading sites 35 perennial forbs species observed and total cover percentage of them changed

from 5.9 to 22.6, in the control site observed perennial forbs were 26 and changed from 9.98 to 13.6%. Totally four perennial grasses were observed in the spreading sites and only 0.73 of cover in last year belong to them. But in the control site, this amount was 3.42% (Table 3).

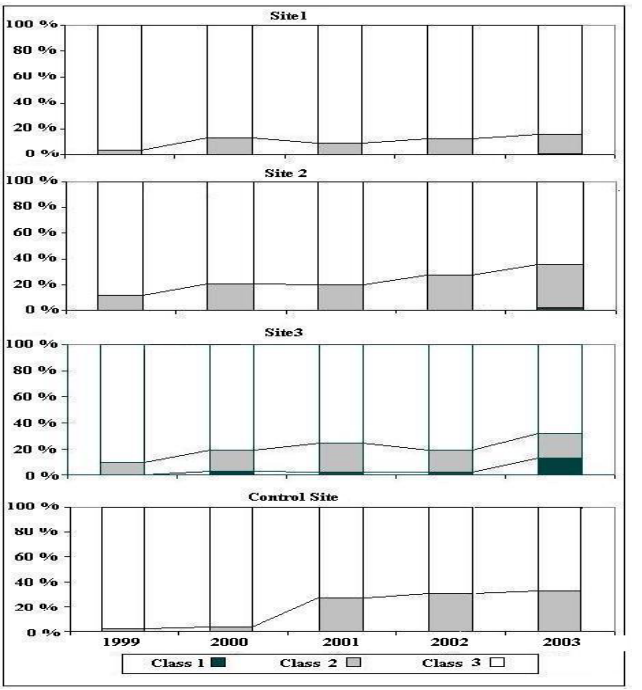

Figure 4: The cover percentage of observed species due to palatability.

4 Discussion

Based on the results obtained in this research, although the annual precipitation during 1999–2002 was about 30% less than the mean annual, but diverted floodwater and its spreading could prevent the effects of drought on vegetation.

This study also showed that floodwater harvesting caused to great changes in number of species and their cover in each year. Then, the species have shown different responses to presence of water as an environmental factor. In the other words, some of the plants response positively to increasing floodwater spreading and some of them showed negative reaction. This result, agrees with some part of Branson [1] finding that *Artemisia tridentata* and *Opuntia polyacantha* decreased and foxtail barley (*Hordeum jabatum*) increased in spreading area. The reason can be explained that remaining of water on the ground surface and saturation of soil and plant root zone for a long time can lead to welting, pale and falling of leaves and finally causes dying of sensitive plants (Kozlowski, 1974).

Table 3: Percentage of observed species cover due to life form.

Life form	Species	Spreading					Control				
		1999	*2000*	*2001*	*2002*	*2003*	*1999*	*2000*	*2001*	*2002*	*2003*
shrubs		0.47	0.86	1.16	1.53	1.10					
Total		**0.46**	**0.85**	**1.15**	**1.50**	**1.09**					
Perennial Forbs	*Achillea sp.*	0.08	0.48	1.04	1.87	1.69					0.2
	adonis			0.01	0.05					0.4	
	Anchusa sp.	0.01	0.10	0.05	0.01						
	Astragalus sp.		0.04	0.07	0.03	1.38				0.2	0.1
	Centaurea depressa	0.03	1.89	2.07	1.75	1.16		2.8	1.0	1.0	2.0
	Centaurea virgata	0.20	1.06	1.13	2.88	6.16	0.3	0.1	0.9	0.3	3.4
	Convolvulus arvensis	0.65	1.28	1.41	0.77	2.63	0.0	0.2	0.4	0.5	0.3
	Coronilla			0.01		1.83					
	Crambe orientalis	0.17	0.24	0.21	0.05	0.34	0.3		0.0	0.2	0.3
	Crepis sp.		0.07	0.00	0.24					0.1	
	Echinops sp.	0.24	0.01	0.63	0.16	2.04				0.0	0.2
	Euphorbia sp.	0.79	0.79	0.33	0.40	0.57	2.5	3.1	0.7	3.2	1.9
	Geranium		0.09	0.10				0.4			
	Gladiolus		0.18	0.22	0.18	0.09				0.1	0.2
	Haplophyllum	0.19	0.01			0.04	0.0	0.3			0.2
	Ixiolirion tataricum		0.01	0.09							
	lactuca					0.44					
	Linaria lineolata	0.05	0.04	0.03	0.03	0.08	0.4	0.3		0.5	1.0
	Linum	0.39	0.10	0.18	0.09	0.18			0.5	0.0	0.3
	Malabaila secacul		0.10	0.04	0.03	0.05					
	Medicago sativa	0.36	0.36		0.03	0.19				0.3	
	Noaea mucronata		0.06		0.02					0.2	
	Nonea sp.	0.28	0.03	0.09					0.2		0.4
	Onosma			0.08							
	Plantago lanceolata					0.06					
	Reseda lutea	1.75	1.20	0.51	0.52	0.27	6.1	4.2	0.5	0.9	1.4
	Sameraria sp.		0.11				0.1	2.4	0.1	0.3	
	Scorzonera sp.	0.10	0.22	0.25					0.1		
	Scrophularia ambros					1.64					
	Turgenia	0.20	4.74	2.53	2.07	1.01	0.3	1.7	0.4	0.1	0.9
	Allium		0.02	0.04	0.03				0.2		
	Hyoscyamus	0.02	0.01	0.10							
	Centaurea aucheri				0.51						0.5
	Cirsium sp.										0.5
	Onopordon sp.	0.38	0.08	0.37	0.06	0.25					
	Tragopogon sp.		0.21		0.30	0.49				0.2	
Total		**5.90**	**13.5**	**11.5**	**12.1**	**22.6**	**9.98**	**15.5**	**4.78**	**8.68**	**13.6**
Perennial Grass	Arrenetherum elatius					0.66					0.1
	Cynodon dactylon					0.04			1.7	3.2	3.3
	Poa bolbosa		0.02			0.03					
	Thevenotia persica		0.06	0.01							
Total			**0.08**	**0.01**		**0.73**			**1.68**	**3.19**	**3.42**
Annual Forb		**14.3**	**24.4**	**12.3**	**20.1**	**22.1**	**2.80**	**7.10**	**6.10**	**11.7**	**20.7**
Annual Grass		**0.21**	**3.79**	**4.06**	**12.2**	**10.2**	**1.16**	**7.60**	**8.74**	**9.82**	**14.2**

The increasing of the vegetation cover and appearance of palatable plants in last year showed that the floodwater spreading could improve the foliage production for livestock and their grazing capacity in such areas. This result, agrees with Hubbell and Gardner [4], Branson [1], Houston [6] findings and some reports from Iran (i.e. Ghaemi [3]; Shafie and Mollaee [11]). Considering to life form of observed species, although perennial forbs increased, but the floodwater spreading in the case of establishment of perennial grasses did not operate successfully.

As a result, it requested a long period for valid evaluating of the trend of vegetation changes under changes on this environmental factor toward improving of range vegetation via increasing of desirable plants (e.g. *Latyrus sp., Vicia sp.* and *Astragalus sp.*) and reduction of the non desirable one. Therefore, shortage of studying period and changes on amount of harvested floodwater make correctitude of these obtained results rather less valid. Nevertheless, floodwater spreading has created a specific ecosystem that causes to improvement of environmental conditions in this region, so, it plays an important role for agricultural sustainable development and wild life.

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