Research Article

GIS Applications in Surveying and Mapping of Rice Weeds in Guilan Province, Iran

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Abstract | Present study was carried out in rice farms of Guilan province for mapping and weed distribution using Geographic Information System (GIS) technologies for a period of three years (2014-2016). *Echinochloa crussgalli* was the more important species in 10 regions of Guilan province. The Langarud and Rudsar regions each with 47 species and Anzali and Shaft with 25 species (with 71.2 and 37.9 percent, respectively) had the highest and lowest species diversities, species diversity in 2015 was more than 2014 and 2016 years. The frequency of weed species in Guilan rice farms in 2014-2016 was 3.38, 3.87 and 4.82percent, respectively. *Cyperus esculentus* and *P. distichum* were the most abundant species with 9 and 8 plants/m^2, respectively. *Echinochloa crussgalli* and *C. difformis* with a density of 5 plants/m^2. Weeds were non-uniformly distributed in various families including Cyperaceae, Poaceae, Lythraceae, Polygonaceae, Asteraceae, and Salviniaceae that accounted for 36 species (54.5 percent). Accurate and specific weed maps are the key to achieving all the benefits of weed management. When in an area the distribution and consumption of inputs is based on accurate information from the weed composition of the farms in that area, the efficiency of these inputs is improved and weed damage is reduced.

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Introduction

The culture of man and rice has a historical and profound relationship. Rice has an inevitable role in providing food, economy, religion and civilization in many countries of the world (Jabran and Chauhan, 2015; Dass *et al.*, 2016; Golmohammadi *et al.*, 2018). More than half of the world's rice is produced in Asia (Awan *et al.*, 2015). In Iran also rice is the main staple food in most parts of the country. There are almost 600,000 hectares of rice plantation in Iran with a total production of 2.5 milion tons (FAO, 2016). More than 75percent of the rice crop is grown in the Provinces of Mazandaran and Guilan, north of Iran. Weeds are considered an important challenge to rice production (Tshewang *et al.*, 2016; Yaghoubi *et al.*, 2010). The mean reduction in rice yield caused by weeds competition is 40-60percent, which may reach 94-96percent if weeds are not properly controlled (Chauhan and Johnson, 2011). Rice yield reduction resulting from weed competition may vary depending on rice planting methods, type of weed, degree of importance of the weed, agricultural operations, and weather conditions (Jabran and Chauhan, 2015).

Determining the distribution pattern of weeds and their density at each point is very important. Therefore, before any action, we need to draw up maps of the weed distribution pattern and their density. The preparation of these maps is done using GPS and GIS technology. The ability to use GPS as an effective tool for estimating weed infested areas and the evaluation of different weed control methods has been proven (Nelson *et al*., 1999; Wilson *et al*., 1993). The GIS system is a complex system that provides organized information to a specific location. The GIS is a geographic coordinate system that determines the accuracy of GPS information, dominance map, frequency, distribution, diversity of weed species, or paths that have invasive species (Nkoa *et al*., 2015). GIS maps are digital and effective on each other with information. The GIS system can complete the data collected from a place of information layers, and on the other hand, researchers use the information obtained to further explore them. GIS technology can be used to make maps that theoretically predict the time of weed emergence from weather data (Main *et al*., 2004). The distribution, density and frequency of rice weeds from 8 documentary areas were determined through the GIS system. GIS has been applied in agriculture for ahe spatial analysis of weeds (Nelson *et al*., 1999).

Using the GIS system and collecting accurate information, can be used to compare species distribution and location change from year to year and to summarize infestations by area (Korejo *et al*., 2010). The most popular research techniques used by weed scientists are the use of the GIS system. Most studies of weed science are through the use of GIS with the geographic location of particular weed species and their populations. GIS is used to analyze the issues of what weed species are in the region, and what is the relationship between distribution and dominance with climate, environment and management factors. Tools like ArcGIS can help geographically spread weed science, cluster patterns, and geographic ratio analysis. The use of GIS in analytical ratios, such as the presence and absence of weed, distribution, dominance, abundance, aquatic and non-aquatic conditions, is finally used to better understand (Nkoa *et al*., 2015; Shanwad *et al*., 2002). Using GPS and GIS, we can identify contaminated weed maps and accurately manage farm information accurately. Spatial information is provided by GPS receivers for land border mapping, roads, irrigation systems, and problematic areas such as weed or disease susceptibility. The GPS system helps farmers navigate soil samples or crop conditions year after year to accurately navigate in special farms on farms (Yousefi and Razdari, 2015). Given the presence of weeds in a region, it is possible to decide on their control methods and plan; otherwise, the application of different control methods will not have the desired effects, and on the other hand, inadvertently contaminated in the chemical control of the environment, and even a number of weeds Weeds will also be resistant to herbicides. Therefore, regular weed monitoring will improve the status of the existing GIS technology.

Materials and Methods

In Iran, rice is the main staple in most parts of the country, and more than 75 percent of the rice crop is grown in the Provinces of Mazandaran and Guilan, north of Iran (Ministry of Agricalture Jihad, 2019). During the springs and summers of 2014, 2015 and 2016, when the current study was being done, temperature ranged from 16 to 29.4 °C, monthly average rainfall recorded 213 to 853 mm, average sunshine hours 3320, and relative humidity averaged 45-87percent. The study area is Guilan province of Iran, which situated in the north of Iran (Figure 1). Same is here located 36°34' to 38°27' latitude and 48°53' to 50°34' longitudes (Table 1). Guilan province is divided into 16 counties including Astara, Astaneh-ye Ashrafiyeh, Anzali, Amlash, Talesh, Rasht, Rudsar, Rudbar, Rezvanshahr, Siahkal, Shaft, Foman, Sowme'eh Sara, Lahijan, Langarud and Masal (Figure 1).

Guilan province is the wettest province in Iran and also the wettest region of the southern shores of the Caspian Sea. The average annual rainfall is 1300 mm, the average annual temperature and humidity are 16 °C and 80 percent, respectively (Guilan Meteorological Organization, 1398). Rainfall, rivers, temperature and evaporation of Guilan province are shown in Figure 2. The total cultivated area is about 220,000 hectares of cultivated land, accounting for 33percent of the land area of the country (Ministry of Agriculture Jihad, 2019). Sampling operation was performed by a quadrat of 0.25 m^2 (0.5× 0.5 m). Accordingly, the higher the area under cultivation of the mentioned crop in the regions, the higher the number of samples will be. In order to obtain complete flora from farm weeds, separate quadrates were used, depending on the new species observed. In each city, according to the area under rice cultivation (in farms with an area of up to 2 hectares, 7 quadrats, farms of 2-5 hectares, 9 quadrats and more than 5 hectares, 13 quadrats) from 10 days after transplanting to the end of the rice clustering stage. Farms were randomly selected and sampled. In the evaluated farms, geographical coordinates (latitude and longitude and altitude) were recorded by Garmin GPSMap 62s. These coordinates were used to prepare and produce weed distribution maps in Guilan province by GIS system. A total of 481 farms in Guilan province were visited during the rice growing period. Weeds in each box were identified and counted separately by genus and species. The frequency and density of weeds in each farm and each city were calculated using the following equations (Thomas, 1985).

Table 1: *Latitude and longitude in regions of Gilan province.*

Longitude				Latitude				
Min		Max		Min		Max		
minutes	degrees	minutes	degrees	minutes	degrees	minutes	degrees	
34	48	53	48	15	38	27	38	Astara
46	49	11	50	11	37	28	37	Astaneh-e Ashrafiyeh
0	50	17	50	48	36	8	37	Amlash
11	49	41	49	23	37	34	37	Anzali
32	48	3	49	33	37	16	38	Talesh
27	49	55	49	1	37	27	37	Rasht
40	48	13	49	25	37	40	37	Rezvanshahr
11	49	5	50	33	36	7	37	Rudbar
6	50	37	50	38	36	12	37	Rudsar
43	49	9	50	41	36	11	37	Siahkal
10	49	32	49	57	36	18	37	Shaft
3	49	31	49	15	37	30	37	Sowmee sara
52	48	27	49	1	37	17	37	Fouman
45	49	13	50	5	37	23	37	Lahijan
55	49	16	50	56	36	19	37	Langarud
43	48	11	49	15	37	29	37	Masal

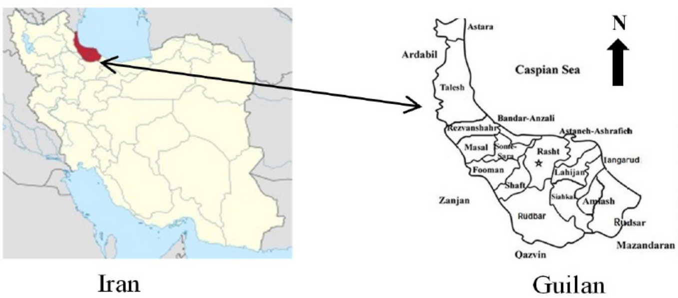

Figure 1: *Geographic map of Guilan province.*

Frequency is concerned with the presence or absence of a species in a quadrat, a farm, or a region, and does not refer to the number or quantity of the species.

$$F_k = \sum (Y_i/n) \times 100 \quad \dots (1)$$

In above equation, Fk represents the frequency of the species, Yi the presence or absence of the species, and "n" the number of visited farms (1).

Density refers to the counted individuals of each species m^2 in the farm of interest:

$$D_{ki} = \left(\frac{\Sigma Z_j}{m_i}\right) \times 4 \quad \dots (2)$$

Dki stands for the density of species k in farm i and Z_j the number of plants in quadrat j (2). The coordinates of each farm, such as latitude, latitude and elevation, were recorded by the Garmin 62CX GPS device. After registering the point with the GPS device, it was converted to KMZ format, then these files became GIS file format for mapping. Then all information was created in the form of a database. The information in ArcMap software was processed from the ArcView GIS 3.1 suite of software, based on latitude and longitude.

Results and Discussion

Sixty- six weed species were found in the area, belonging to 43 genera and 29 families. The families with the highest number of species found were Cyperaceae, Poaceae and Lythraceae. Thirty- four of the identified species were annual grasses and 22 perennial species. Weeds have non-uniformly distributed in various families including Cyperaceae, Poaceae, Lythraceae, Polygonaceae, Asteraceae, and Salviniaceae that accounted for 36 species (54.5 percent). Among the grass weeds, *E. crussgalli* with 89.8 percent was the most common and most frequently species. *P. distichum* and *E. oryzoides* had frequencys of higher than 50 percent.

The most important weeds with high relative frequency value in rice farms were *E. crussgalli* (31.18), *P. distichum* (29.28), *C. esculentus* (25.56), *E. prostrate* (13.7), *E. oryzoides* (13.28), and, *C. difformis* (13.25). The dominant species in terms of frequency and density (m^2) in 10 counties (62.5 percent of the

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Table 2: *Important weed species of field rice showing density and frequency% in Guilan province, Iran. (Astara, Astaneh-e-Ashrafiyeh, Amlash, Anzali, Talesh, Rasht, Rezvanshahr, Rudbar, Rudsar, Siahkal, Shaft, Sowmeesara,Fouman, Lahijan, Langarud and Masal).*

Frequency	Density (m²)	Weeds	Area (ha)	Site	Item
3.326	0.138	Echinochloa crussgalli	3200	Astara	1
3.326	0.285	Paspalum distichum			
2.495	37.000	Azolla filiculoides			
2.287	0.157	Eclipta prostrata			
2.079	0.093	Cyperus difformis			
2.079	0.020	Echinochloa oryziodes			
7.277	1.003	Echinochloa crussgalli	23570	Astaneh-e Ashrafiyeh	2
6.861	0.745	Paspalum distichum			
5.198	0.613	Cyperus difformis			
3.950	0.048	Echinochloa oryziodes			
2.703	0.051	Eclipta prostrata			
2.287	18.500	Algue blue-green			
6.445	0.306	Echinochloa crussgalli	3500	Amlash	3
5.198	0.507	Paspalum distichum			
4.574	0.167	Eclipta prostrata			
4.366	0.054	Echinochloa oryziodes			
3.950	0.936	Cyperus difformis			
3.534	0.712	Monochoria vaginalis			
2.287	0.332	Echinochloa crussgalli	4820	Anzali	4
1.871	0.125	Cyperus difformis			
1.871	0.470	Paspalum distichum			
1.455	0.011	Echinochloa oryziodes			
1.247	0.182	Eclipta prostrata			
1.040	0.021	Cyperus esculentus			
4.990	0.480	Paspalum distichum	15987	Talesh	5
3.742	0.134	Echinochloa crussgalli			
3.326	0.154	Alisma plantago-aquatica			
2.911	24.000	Azolla filiculoides			
2.703	0.141	Cyperus difformis			
2.703	0.071	Cyperus serotinus			
10.395	1.090	Echinochloa crussgalli	62338	Rasht	6
10.395	1.399	Paspalum distichum			
7.900	0.132	Echinochloa oryziodes			
7.484	1.423	Cyperus difformis			
4.990	0.140	Cyperus serotinus			
3.950	0.379	Cyperus esculentus			
2.495	0.085	Alisma plantago-aquatica	10000	Rezvanshahr	7
2.287	0.085	Echinochloa crussgalli			
2.287	0.207	Paspalum distichum			
1.663	0.107	Cyperus difformis			
1.663	0.047	Cyperus serotinus			
1.455	16.600	Azolla filiculoides			
5.198	1.332	Scirpus maritimus	3375	Rudbar	8
4.990	0.281	Echinochloa crussgalli			
3.742	0.265	Paspalum distichum			
3.326	0.352	Potamogeton nodosus			
2.079	26.000	Najas marina			
1.663	0.016	Echinochloa oryziodes			
12.308	0.618	Echinochloa crussgalli	10689	Rudsar	9
9.813	1.101	Paspalum distichum			
9.647	0.148	Echinochloa oryziodes			
6.819	0.226	Eclipta prostrata			
6.653	1.235	Cyperus esculentus			
6.320	1.227	Cyperus difformis			
5.613	0.641	Echinochloa crussgalli	4433	Siahkal	10
4.366	0.496	Paspalum distichum			
3.742	0.645	Cyperus difformis			
3.534	0.036	Eclipta prostrata			
3.326	0.145	Echinochloa oryziodes			
2.911	0.050	Cyperus esculentus			
1.871	0.218	Paspalum distichum	14330	Shaft	11
1.247	0.147	Cyperus esculentus			
1.247	0.046	Echinochloa crussgalli			
1.247	0.179	Cyperus difformis			
1.247	0.067	Eclipta prostrata			
1.247	1.110	Azolla filiculoides			
3.119	0.745	Cyperus difformis	27972	Sowmee Sara	12
3.119	0.164	Echinochloa crussgalli			
2.703	0.137	Paspalum distichum			
2.703	0.379	Eclipta prostrata			
2.287	0.020	Echinochloa oryziodes			
1.663	0.093	Cyperus serotinus			
4.366	0.100	Echinochloa crussgalli	13870	Fouman	13
3.950	0.276	Paspalum distichum			
2.703	0.322	Cyperus esculentus			
2.703	0.111	Eclipta prostrata			
2.287	0.258	Cyperus difformis			
2.287	0.034	Echinochloa oryziodes			
9.771	1.654	Echinochloa crussgalli	23816	Lahijan	14
7.692	0.094	Paspalum distichum			
7.484	0.711	Cyperus difformis			
6.237	0.138	Echinochloa oryziodes			
6.029	1.360	Sagittaria trifolia			
5.613	0.293	Eclipta prostrata			
7.900	0.660	Echinochloa crussgalli	9100	Langarud	15
6.029	0.577	Paspalum distichum			
5.198	0.066	Cyperus difformis			
5.198	0.278	Eclipta prostrata			
4.366	1.244	Echinochloa oryziodes			
3.534	0.917	Monochoria vaginalis			
2.079	0.165	Paspalum distichum	7000	Masal	16
1.663	0.053	Cyperus difformis			
1.663	0.026	Cyperus serotinus			
1.455	0.161	Echinochloa crussgalli			
1.040	0.312	Alisma plantago-aquatica			
1.040	0.021	Eclipta prostrata			

Table 3: *Frequency of weeds Guilan province, Iran (2014-2016).*

2016	2015	2014	Species name	Family	Item
14.7	7.14	9.77	*Sagittaria trifolia*	Alismataceae	1
11.37	9.98	7.34	*Alisma plantago-aquatica*	Alismataceae	2
3.7	3.83	2.66	*Alternanthera sessilis*	Amaranthaceae	3
15.8	20.15	13.53	*Eclipta prostrata*	Asteraceae	4
6.33	4.39	4.65	*Bidens tripartita*	Asteraceae	5
4.45	3.66	2.48	*Xanthium strumarium*	Asteraceae	6
2.58	1.24	2.42	*Butomus umbellatus*	Butomaceae	7
0.26	0.16	0	*Chara vulgaris*	Characeae	8
3.89	2.63	3.88	*Nasturtium officinale*	Cruciferae	9
7.17	4.63	5.46	*Algue blue-green*	Cyanophyceae	10
24.19	17.12	15.23	*Cyperus esculentus*	Cyperaceae	11
22.53	7.01	5.19	*Cyperus serotinus*	Cyperaceae	12
13.44	7.78	10.38	*Cyperus difformis*	Cyperaceae	13
5.43	1.95	2.69	*Scirpus maritimus*	Cyperaceae	14
5.98	3.17	0	*Cyperus fuscus*	Cyperaceae	15
1.84	1.06	0.64	*Cyperus rotundus*	Cyperaceae	16
1.97	1.36	0	*Cyperus longus*	Cyperaceae	17
1.44	0.72	0.96	*Scirpus mucronatus*	Cyperaceae	18
1.49	1	0	*Cyperus strigosus*	Cyperaceae	19
0.95	0.51	0	*Pycreus flavescense*	Cyperaceae	20
0.64	0.4	0	*Cyperus odoratus*	Cyperaceae	21
0	0.33	0.5	*Pycreus lanceolatus*	Cyperaceae	22
0.31	0.31	0	*Fimbristylis miliacea*	Cyperaceae	23
0.21	0.21	0	*Cyperus glomeratus*	Cyperaceae	24
0.34	0.08	0	*Cyperus iria*	Cyperaceae	25
1.16	0.5	0	*Bergia capensis*	Elatinaceae	26
1.04	0.55	0.71	*Equisetum palustre*	Equistmaceae	27
0	0.21	0	*Equisetum arvense*	Equistmaceae	28
26.5	34.99	28.31	*Echinochloa crussgalli*	Gramineae	29
30.17	22.22	27.03	*Paspalum distichum*	Gramineae	30
19.15	23.9	17.24	*Echinochloa oryziodes*	Gramineae	31
2.41	4.23	0	*Echinochloa colona*	Gramineae	32
0	0.21	0	*Eleocharis palustris*	Gramineae	33
0	0.21	0	*Coix lacrima-jobi*	Gramineae	34
0	0.21	0	*Digitaria sanguinalis*	Gramineae	35
6.23	2.56	3.27	*Najas marina*	Hydrocharitaceae	36
1.29	0.52	0.89	*Najas minor*	Hydrocharitaceae	37
4.32	1.56	5.14	*Schoenoplectus juncoides*	Juncaceae	38
0	0.83	0	*Mentha aquatica*	Labiatae	39
10.39	9.68	8.19	*Lemna minor*	Lemnaceae	40
5.89	7.24	3.71	*Ammannia multiflora*	Lythraceae	41
4.25	6.35	0	*Ammannia baccifera*	Lythraceae	42
2.18	0.73	1.25	*Rotala indica*	Lythraceae	43
0	3.95	0	*Ammannia senegalensis*	Lythraceae	44
0	0.83	0	*Ammannia gracilis*	Lythraceae	45
2.94	1.11	2.19	*Marsilea quadrifolia*	Marsileaceae	46
4.29	2.87	1.26	*Ludwigia epilobioides*	Onagraceae	47
2.35	0.37	0.19	*Ludwigia palustris*	Onagraceae	48
3.7	6.49	5.19	*Polygonum persicaria*	Polygonaceae	49
2.45	1.55	2.45	*Polygonum hydropiper*	Polygonaceae	50
0	0.4	0.64	*Polygonum hydropiperoides*	Polygonaceae	51
0	0.21	0.21	*Rumex crispus*	Polygonaceae	52
9.68	3.94	5.71	*Potamogeton nodosus*	Potamogetonaceae	53
0	0.21	0	*Potamogeton crispus*	Potamogetonaceae	54
6.75	4.48	5.4	*Monochoria vaginalis*	Potederiaceae	55
0	0	0.21	*Samolus valerandi*	Primulaceae	56
0	1.2	1.92	*Ranunculus aquatilis*	Rananculaceae	57
1.87	0.62	0	*Riccia glauca*	Ricciaceae	58
0	0.21	0	*Galium aparine*	Rubiaceae	59
15.43	6.65	12.43	*Azolla filiculoides*	Salviniaceae	60
0.87	0.16	0.63	*Azolla pinnatae*	Salviniaceae	61
0.38	0.15	0.3	*Salvinia natans*	Salviniaceae	62
1.12	0.64	0.32	*Veronica anagalis-aquatica*	Scrophulariaceae	63
0	0.83	0.63	*Typha minima*	Typhaceae	64
0	0.83	0	*Berula angustifolia*	Umbelliferae	65
0.77	0.06	0	*Hydrocotyle ranunculoide*	Umbelliferae	66

16 counties of Guilan province) were *E. crussgalli* (Tables 2 and 3). In 2014 growing season, the average species frequency was 3.38percent and 42 species (63.6 percent of all species) were identified. Species diversity in 2015 was higher than in 2013 and 2016. In 2015, the average species frequency was 3.87 percent, 35 percent higher than 2014 years old, and 65 species (98.5 percent) were identified from 66 species. In 2016, the average frequency of species was 4.82 percent, which was 29.8 percent higher than 2014 years and 19.7 percent more than 2015 years old and 53 species (80.3 percent) were identified from 66 species. Species diversity in 2015 was more than 2014 and 2016 years (Table 3). The first and most important step in precision agriculture is the plan for the distribution of weeds.

Maps are often generated by manually drawing polygon around areas where the species is known to occure some automated interpolation procedures. The distribution map of several important and important weed species of Guilan rice farms is shown in Figure 3. In this research, weeds of rice farms in different years

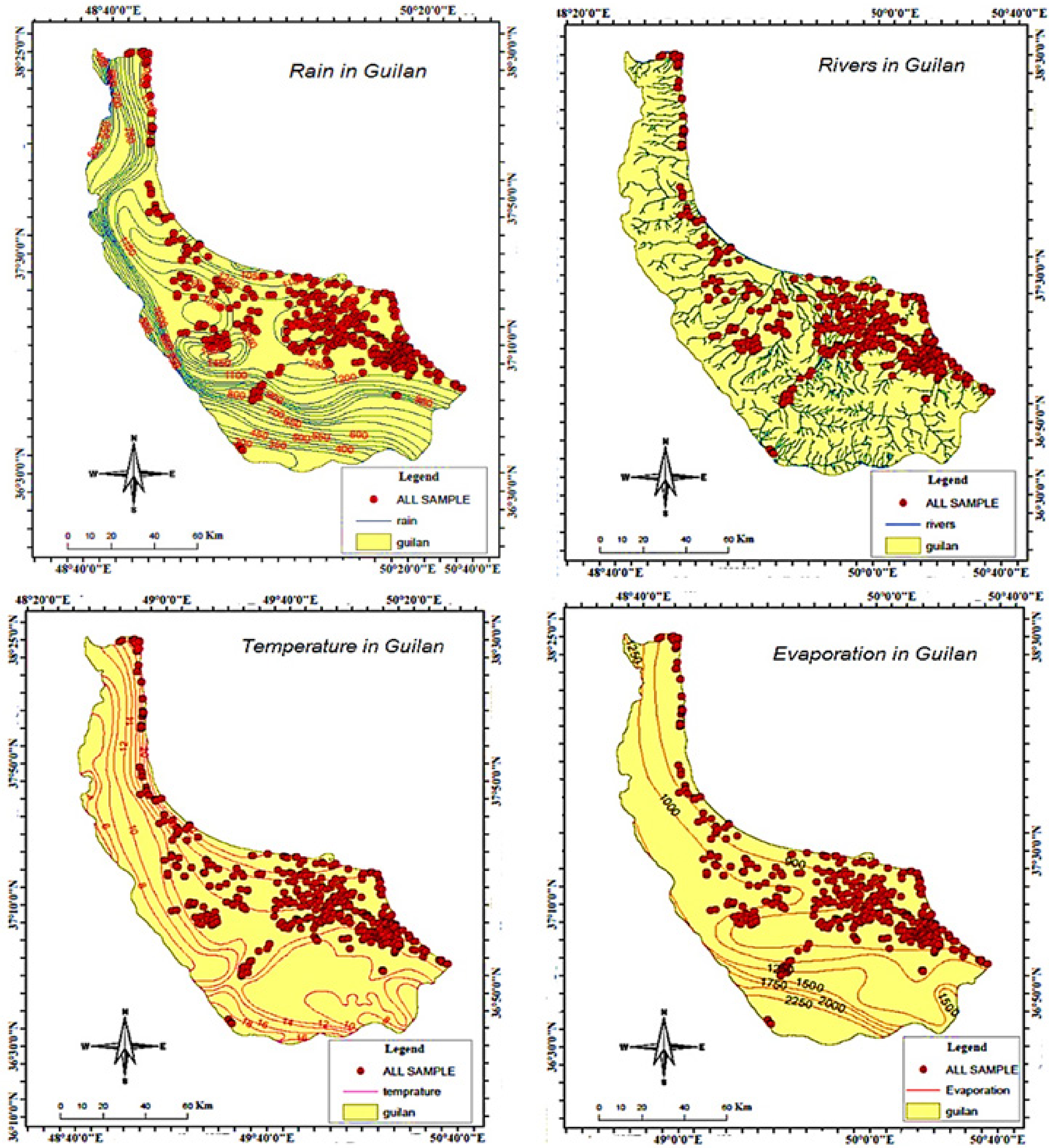

Figure 2: *Geographic map rain, rivers, temperature, evaporation in Guilan province.*

have frequency and species diversity. In 2014, the average frequency of species was 38.3 percent and 42 species (63.6 percent of all species) were identified. The highest frequency of species in the year 2014 consisted of *E. crussgalli*, *P. distichum*, *E. oryzoides*, *C. esculentus*, *E. prostrata, A. filiculoides*, *S. trifolia*, *L. minor* and *A. plantago-aquatica*. In 2015, the average species frequency was 3.87 percent which was 35 percent higher than 2014 years old and 65 species (98.5 percent) were identified from 66 species. The highest amount of weed species in year 2015 was in *E. crussgalli*, *E. oryzoides*, *P. distichum*, *E. prostrata, C. esculentus*, *A. plantago-aquatica, L. minor, C. difformis, A. multiflora and S. trifolia*. In 2016, the average frequency of species was 4.82 percent, which was 29.8 percent higher than 2014 years old and 19.7 percent of the year 2015 and 53 species (80.3 percent) were identified from 66 species. The highest frequency

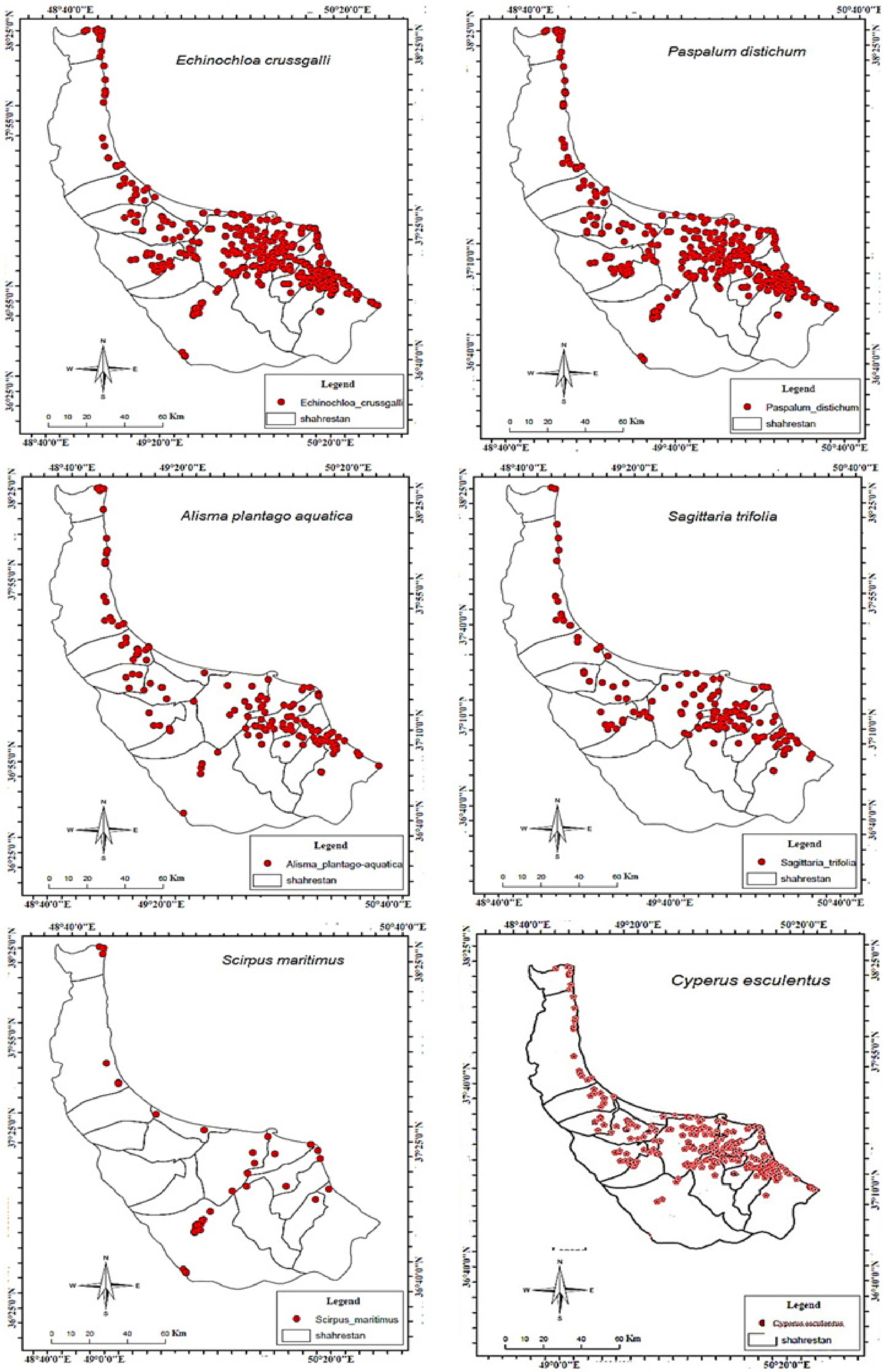

Figure 3: *View of map showing of Echinochloa crussgalli, Paspalum distichum, Alisma plantago-aquatica, Sagittaria trifolia, Scirpus maritimus, Cyperus esculentus in the fields of Guilan province.*

of weed species in the year 2016 was in frequency including *P. distichum*, *E. crussgalli*, *C. esculentus*, *C. serotinus*, *E. oryzoides*, *E. prostrata*, *A. filiculoides*, *S. trifolia*, *C. difformis* and *A. plantago-aquatica* (Table 3). This suggests that the species occurs throughout the area represented by the map polygons. Most of the weeds that had the highest frequencies, uniformity, and mean density in the farm are hard to control (Hakim *et al*., 2013). Weed flora composition in agricultural systems results from seasonal changes, crop rotation, and long-term environmental changes such as soil erosion and climate change. Agricultural operations such as plowing, the crop plant species grown, weed control methods, and fertilizer application change the natural distribution pattern and availability of resources and, hence, change the structure and composition of plant species (Ahmadvand, 2005; Kraemher *et al*., 2016; Lal *et al*., 2014; Noroz zade *et al*., 2008). Accurate determination of weed distribution pattern and density at each location is of great importance. Therefore, before any action is taken, the necessary maps of weed distribution pattern and density must be prepared (Lass *et al*., 1993).

Conclusions and Recommendations

Every year, due to insufficient knowledge in the farm of identification and factors affecting weed control, their population increases and therefore the role of management in changing the structure of communities and diversity of weed species can be useful in developing strategies and weed management. The most important weeds of rice farms in terms of frequency recorded from study area were *E. crussgalli (89.81%), P. distichum (79.42%), E. oryziodes (60.29%), C. esculentus (56.5%), E. prostrate (49.5%), C. serotinus (34.73%), A. filiculoides (34.1%), C. difformis (31.6%), S. trifolia (31.61%), A. plantago-aquatica (28.69%),* and *Lemna minor (28.26%)*. Due to the importance of rice in Guilan and the lack of basic information about the status of weeds in this product, identification of weed flora and distribution map of weed species in the GIS system by each city to important information to improve weed management methods we will achieve this important agriculture.

Novelty Statement

The identification of weeds in Guilan rice fields was done for the first time and according to the up-to-date technology of the GIS, a distribution map for the optimal management of weeds was prepared and made available to users.

Author's Contribution

Mohammad Javad Golmohammadi: Conducted the research.
Hamid Reza Mohammaddoust Chamanabad: Helped in article writing.
Bijan Yaghoubi: Proposal preparation and article writing and visit farms.
Mostafa Oveisi: Helped in data analysis.

Conflict of interest

The authors have declared no conflict of interest.

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