Transactions
Institute of Indian Geographers

Department of Geography, University of Pune
Ganeshkhind, Pune 411 007

Vol. 37
No. 1
January 2015

Trans.Inst.Indian Geographers
ISSN 0970-9851

Water Balance and Cropping Pattern of the Garladinne Mandal, Anatapuramu District, Andhra Pradesh, India.

M. Sambasiva Rao and N. Madhana Bhaskara, Anantpuram, Andhra Pradesh

Abstract

The Garladinne mandal covering an area of about 304.97 km2 of Anantapuramu district of Andhra Pradesh has been studied with a view Study the water balance elements on monthly, seasonal and annual basis adopting Thornthwaite and Mather (1955) method. The crop concentration, intensity of cropping pattern, crop diversification and crop combination are studied at village level. The index of Agriculture development of Garladinne mandal is worked out taking 15 variables at village level. Correlation technique has been adopted between water balance elements and intensity of cropping pattern and water balance elements and index of agriculture development. From the correlation analysis it is found that there is a good positive correlation among them.

Introduction

Water balance is the comparative of rainfall and potential evapotranspiration. It plays an important role Earth science especially for development of agriculture and water resources. It is a well established fact that water supply through a region is primarily through precipitation and water loss is entirely due to evaporation and evapotranspiration. The wetness and dryness is therefore determined by the relative magnitudes of precipitation and potential evapotranspiration. In the present study the water balance elements of the Garladinne mandal has been worked out taking mean monthly rainfall and mean temperature adopting Thornthwaite and Mather (1955) method. Cropping pattern represents the spatial crop sequence in a given area at particular point of time. It indicates the relative proportion of area under different crops at given point of time. According to Ramanaiah (1984) cropping pattern may be defined as the spatial and hierarchical arrangement and association of different crops at point of a time in a particular areal unit. Cropping pattern reflects the interplay of the diversified, physical, socio-economic, technical and organizational factors. It is not static. It changes with changes in technology and socio-economic conditions. Mavy Harpal Singh (1963) has studied the cropping diversification of Malwa tract of Punjab. Hussain (1970) has studied the patterns of crop concentration in Uttar Pradesh; Jasbeer Singh (1976) has studied the agriculture climatology of Haryana state. Saravanan (1979) describing cropping pattern and crop combination of Madurai. Sambasiva Rao and Kalavathy (1983) have studied the water balance and cropping pattern of Madurai district of Tamila Nadu. Kalavathi (1985) has mapped the cropping pattern of Chengal Pattu district of Tamila

Nadu. Vasthala (1987) has studied the land suitability, water balance and cropping pattern of Tirunalevai basin, Krishna Reddy (1990) has described the land use, cropping pattern of Kadapa district, Madhuramma (1991) has brought out relation between water balance and cropping pattern of the Nellore district. Suresh Babu (1993) studied the drought climatology and cropping pattern of Anantapuram district, the study on water balance, cropping pattern of Rayalaseema region carried out by Somanna (2013).

Study Area

Garladinne mandal covers an area of about 304.97 sq km and lies in the Anantapuramu district of Andhra Pradesh in between 14^0 49" 14' to 14^0 57"20' North latitudes and 77^0 35" 48' to 77^0 43" 43' East longitudes (Fig.1). There are 18 revenue villages in Garladinne mandal. The total population of Garladinne mandal is 53,882 (2011 census). Geologically, it is mainly comprised of Archean rocks consisting of granitic gneisses with dolerite and quartzite intrusions. The annual rainfall is about 568 mm.The annual minimum temperature of 140 c is noticed in January and the annual maximum temperature of 42^0 C is noticed in the month of April. Climatologically the mandal is located in dry sub-humid type of climate.

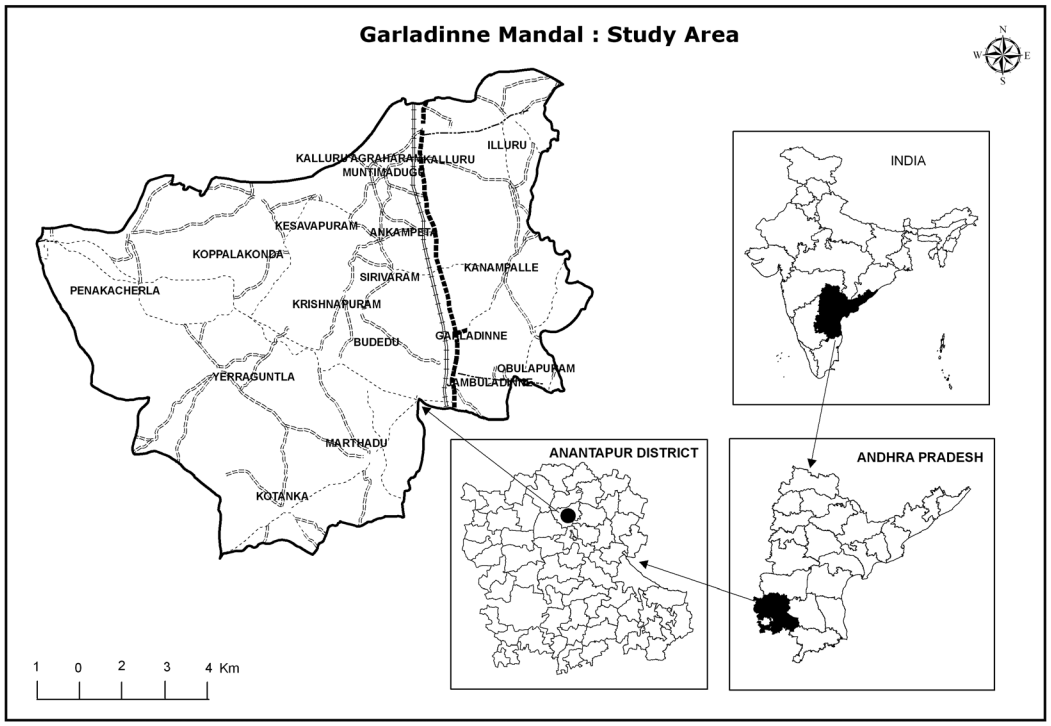

Fig.1 : Location Map

Objectives

The main objectives of the study are

1. to study the monthly, seasonal and annual water balance elements of the Garladinne mandal,
2. to bring out the water balance of the Garladinne mandal,
3. to study the crop concentration and spatial distribution of crops in the Garladinne mandal,
4. to describe the intensity of cropping pattern and crop combination and
5. to analyze the index of agriculture development of the Garladinne mandal.

Methodology

The water balance elements of the Garladinne mandal are studied basing on monthly precipitation and temperature data of Garladinne station collected over period of fifty years adopting Thornthwaite and Mather (1955) book keeping procedure. The water balance of the Garladinne mandal has been brought out by evaluating surface water resources, ground water resources, run-off and water lost in the form of evaporation and evapotranspiration. The concentration of various crops has been studied adopting Bhatia (1965) crop concentration index. The intensity of cropping pattern is worked out talking total cropped area at village level and total net are sown at village level multiplied by 100. The crop diversification index is worked out Bhatia (1965) method and crop combination is worked out using Doi's method (1959). The index of agriculture development is worked out talking fifteen variables at village level adopting one standard deviation method.

Results and discussions

Monthly water balance elements of the Garladinne mandal

The mean rainfall is less than 10 mm in January, February, March and December months. It varies from 10 mm to 50 mm in April, May, and November months. In June, July and August months the mean rainfall ranges from 50 mm to 100 mm. The mean rainfall exceeds 100 mm in September and October months. The mean PE varies from 100 mm to 150 mm in February, July, August, September, October and November months. The mean PE is above 150 mm in March, April, May and June months. The mean AE is less than 50 mm in January, February, March, April and December months. The mean AE varies from 50 mm to 100 mm in May, June, July and November months. The AE exceeds 100 mm in August, September and October months. The water deficit is less than 50 mm in August, September, October, November and December months. The water deficit varies from 50 mm to 100 mm in January, June and July months. It exceeds 100 mm in February, March and May months. In the Garladinne mandal there is no water surplus in all the months from January to December. The Ima values are less than 50% in January, February, March, April, May and June months. The Ima values exceed 50% in July, August, September, October, November and December months. The Aridity Index values are less than 50% in July, August, September, October, November and December months. It exceeds 50% in January, February, March, April, May, and June months. According to the values of the Moisture Index in January, February, March, April and May the arid type of climate prevails in Garladinne

mandal. In June, July and December months the semi-arid type of climate is noticed. In August, October and November months the dry sub- humid climate prevails. In September month the moist sub-humid type of climate is noticed.

Seasonal and annual water balance elements of the Garladinne mandal

The rainfall is less than 100 mm in winter and summer periods. It is 145 mm in northeast monsoon period and 370 mm in summer period. The average annual precipitation is 568 mm. The PE is less than 500 mm in winter and northeast monsoon period. It is 500 mm and above 500 mm in summer and in southwest monsoon period respectively. The mean annual PE is 1653 mm.The AE is less than 200 mm in winter and summer periods and is more than 200 mm in southwest and northeast monsoon periods. The mean annual AE is 850 mm. The WD is less than 100 mm in northeast monsoon period. It ranges from 100 mm to 200 mm in winter and southwest monsoon period and exceeds 300 mm in summer period. The mean annual water deficit is 803 mm.There is no water surplus in any season in Garladinne mandal. The annual water surplus is nil. The moisture adequacy is less than 30% winter and summer periods and it is more than 60% in southwest monsoon and northeast monsoon periods. The mean annual moisture adequacy value is 51%. The values are less than 40% in southwest monsoon and northeast monsoon periods and it is more than 70% in winter and summer periods. The mean annual Ia value is 49%.The climatic classification shows semi-arid type of climate in winter and summer periods and dry sub-humid type of climate in southwest and northeast monsoon periods. The annual Moisture Index value shows dry sub-humid type of climate in Garladinne mandal (Table.1).

Table.1 : Seasonal water balance elements of the Garladinne mandal

S.No	Water balance elements	Winter	Summer	Southwest monsoon	Northeast monsoon	Annual
1	P (mm)	2	51	370	145	568
2	PE (mm)	222	500	602	329	1653
3	AE (mm)	58	108	418	266	850
4	WD (mm)	164	392	184	63	803
5	WS (mm)	0	0	0	0	0
6	Ima (%)	26	22	69	81	51
7	Ia (%)	74	78	31	19	49
8	Im (%)	-44.4	-46.8	-18.6	-11.4	-29.4
9	CC	D	D	C1	C1	C1

Water balance of the Garladinne mandal

- Total surface water resources: 173,222,960 m3.
- The water stored in tanks, ponds and reservoirs: 17,322,296 m3 (10%).
- The total ground water resources: 26,132,361 m3 (15.08%).
- The water resources lost in the form of surface run off: 34,644,592 m3 (20%).
- The total water resources lost in the form of evaporation, evapotranspiration: 95, 123,711 m3 (54.92%).

From the analysis of the water balance of Garladinne mandal that out of 173,222,960 m3 surface water resources about 10% is stored in the tanks and ponds. About 15.08% is recharged to ground water. About 20% of water resources is lost in the form of surface run off and about 54.92% water resources is lost in the form evaporation and evapotranspiration.

Crop concentration of the Garladinne mandal (Table.2)

Paddy: The total cropped area of paddy both in kharif and rabi season is 4454

Table.2 : Village wise index of concentration of different crops of Garladinne mandal (2010-11)

S.No	Village name	Paddy	Ground-nut	Fruits	Maize	Jowar	Sun-flower	Wheat	Bengal gram	Red gram	Castor
1	Penakacherla	0.54	1.03	1.54	0	0	0	0	0	1.62	0.84
2	Koppalakonda	1.59	0.97	0.36	0	1.36	0	0	0	1.26	0.68
3	Kesavapuram	3.26	0.13	0.64	0		0	0	6.51	0.10	0
4	Muntimadugu	1.15	1.12	0.49	0	0	0	0	2.90	1.16	0
5	Kallru (R.S)	1.32	0.89	0.58	0	0	0	3.62	10.87	0.79	1.81
6	Kalluru	3.41	0.25	0.19	0	5.43	0	0	1.10	0.18	0
7	Illuru	3.36	0.18	0.47	0	0	7.53	0	0	0.10	1.12
8	Kannampalli	0.02	1.66	0.32	0	0	0	0	0	1.97	3.28
9	Ankampeta	2.40	0.58	0.61	0	0	0	0	0	0.36	0
10	Sirivaram	0.60	1.46	0.26	0	0	0	0	0	1.39	1.87
11	Krisnapuram	1.51	0.75	0.99	0	0	11.06	5.54	2.07	1.44	0
12	Yerraguntla	0.61	0.74	2.27	0	1.76	0	2.82	2.86	1.20	0.44
13	Kotanka	0.11	1.47	0.67	0	5.72	0	0	0	2.12	4.63
14	Marthadu	0.67	1.21	0.88	0.91	0	1.46	1.46	0	1.43	0.73
15	Budedu	0.38	0.80	2.38	0	5.61	0	6.74	0.42	1.27	0
16	Garladinne	0.40	1.20	1.24	11.65	1.74	0	2.33	0.17	1.34	0.58
17	Obulapuram	0.29	1.72	0.21	0	0	0	0	0	1.66	2.68
18	Jambuladinnee	1.38	1.03	0.45	0	0	0	0	0	1.54	0

hectares which accounts to 23.90% of the total cropped area. The total cropped area of paddy crop varies from 1 hectare in Kalluru village to a maximum of 867 hectares in Illuru village. The concentration of paddy crop is high in Koppalakonda, Kesavapuram, Muntimadugu, Kalluru (RS), Kalluru, Illuru, Ankampeta, Krisnapuram and Jambuladinne villages. The concentration of paddy crop is moderate in Penakacherla, Sirivaram, Yerraguntla and Marthadu villages. It is low in Kanampalli, Kotanka, Budedu, Garladinne and Jambuladinne villages.

Groundnut: The total groundnut crop area in kharif and rabi season is 9650 hectares, which amounts to 51.79% of the total cropped area. The total cropped area of groundnut varies from 22 hectares in Ankampeta village to a maximum of 1391 hectares in Marthadu village. The concentration of groundnut is high in Penakacherla, Muntimadugu, Kanampalli, Sirivaram, Kotanka, Marthadu, Garladinne, Obulapuram and Jambuladinne villages. The concentration of groundnut is moderate in Koppalakonda, Kalluru (RS), Ankampeta, Krisnapuram, Yerraguntla and Budedu villages.

Fruits & vegetables: The total cropped area under fruits and vegetables is about 3571 hectares which accounts to 19.61% of the total cropped area. The total cropped area of fruits and vegetables vary from 8 hectares in Ankampeta village to a maximum of 955 hectares in Yerranguntla village. The concentration of fruits and vegetables is high in Penakacherla, Yerraguntla, Garladinne and Obulapuram villages. It is moderate in Kesavapuram, Kalluru (RS), Ankampeta, Krisnapuram, Kotanka and Marthadu villages. The concentration of fruits and vegetables is low in Koppalakonda, Muntimadugu, Kalluru, Illuru, Kanampalli, Sirivaram, Obulapuram and Jambuladinne villages.

Maize: The total cropped area of maize crop is only 5 hectares, which amounts to 0.02%. The maize crop is not noticed in Penakacherla, Muntimadugu, Kanampalli, Muntimadugu, Kalluru (RS), Kalluru, Illuru, Kanampalli, Ankampeta, Sirivaram, Krisnapuram, Yerraguntla, Kotanka, Budedu, Yerraguntla and Jambuladinne villages. In Marthadu it is cultivated in only one hectare and in Garladinne village the maize crop is cultivated in four hectares. The concentration is high in Garladinne and moderate in Marthadu village.

Jowar: the total cropped area of jowar is 46 hectares. It amounts to 0.25% of the total cropped area. The jowar crop is not found in Penakacherla, Kesavapuram, Muntimadugu, Kalluru, Illuru, Kanampalli, Ankampeta, Sirivaram, Krisnapuram, Marthadu, Obulapuram and Jambuladinne villages. The jowar cropped area varies from 3 hectares in Koppalakonda village to a maximum of 15 hectares in Kotanka village. The crop concentration is high in Koppalakonda, Kalluru, Yerraguntla, Kotanka, Budedu and villages. In other villages there is no jowar crop.

Sunflower: The total cropped area of sunflower is 17 hectares and accounts 0.09% of the total cropped area. The sunflower is not found in Penakacherla, Kesavapuram, Muntimadugu, Kalluru (RS), Kalluru, Illuru, Kanampalli, Ankampeta, Sirivaram, Kotanka, Budedu, Garladinne, Obulapuram and Jambuladinne villages. The total cropped area of sunflower varies

from 2 hectares in Marthadu village to a maximum of 6 hectares in Yerraguntla village. The concentration of sunflower is high in Illuru, Krisnapuram, Yerraguntla and Marthadu villages. In other villages there is no sunflower cultivation.

Wheat: The total cropped area of wheat is 25 hectares, which amounts to 0.13% of the total cropped area. The wheat crop is not cultivated in 2010-11 in Penakacherla, Kesavapuram, Muntimadugu, Kalluru, Illuru, Kanampalli, Ankampeta, Sirivaram, Kotanka, Obulapuram and Jambuladinne villages. The total cropped area of wheat varies from 2 hectares in Kalluru (RS) to a maximum of 7 hectares in Yerraguntla village. The concentration of wheat crop is high in Krisnapuram, Yerraguntla, Marthadu, Budedu and Garladinne villages. In other villages there is no wheat crop.

Bengal gram: The total Bengal gram cropped area of the Garladinne mandal is 112 hectares, which accounts to 0.60% of the total cropped area. The Bengal gram is not found in Penakacherla, Koppalakonda, Illuru, Kanampalli, Ankampeta, Sirivaram, Kotanka, Marthadu, Obulapuram and Jambuladinne villages. The total cropped area of bengalgram varies from 1 hectare in Budedu village to a maximum of 32 hectares in Kalluru village. The Bengal gram concentration is high in Kesavapuram, Muntimadugu, Kalluru, (RS) Kalluru, Krisnapuram and Yerraguntla villages. It is low in Budedu and Garladinne villages. In other villages there is no Bengal gram crop.

Red gram: The total cropped area of red gram is 711 hectares, which accounts to 3.82% of the total cropped area. The total cropped area red gram varies from 1 hectare in Ankampeta to a maximum of 94 hectares in Marthadu village. The concentration of red gram is high in Penakacherla, Koppalakonda, Muntimadugu, Kanampalli, Sirivaram, Krisnapuram, Yerraguntla, Marthadu, Budedu, Garladinne, Obulapuram and Jambuladinne villages. It is moderate in Kalluru (RS) village. The concentration red gram is low in Kesavapuram, Kalluru, Illuru, Kanampalli and Ankampeta villages. The red gram is cultivated as a inter crop in groundnut.

Castor: The total area of castor is 41 hectares, which amounts to 0.22% of the total cropped area. The castor crop is not found 2010-11 in Kesavapuram, Muntimadugu, Kalluru, Ankampeta, Krisnapuram, Budedu and Jambuladinne villages. The total cropped area of castor varies from 1 hectare in Obulapuram village to a maximum of 12 hectares in Kotanka village. The concentration of castor is high in Kalluru (RS), Illuru, Kanampalli, Sirivaram and Kotanka villages. It is moderate in Penakacherla, Koppalakonda, Marthadu, Garladinne and Obulapuram villages.

Spatial distribution of crops in the Garladinne mandal:

The total cropped area of the Garladinne mandal is 18,632 hectares, which accounts to 61.09% of the total area of the Garladinne mandal. The hierarchy of cultivation of crops in 2010-11 in Garladinne mandal are groundnut (9650 ha), paddy (4454 ha), fruits & vegetables (3571 ha) red gram (711 ha), Bengal gram (112 ha), jowar (46 ha), castor (41 ha), wheat (25 ha), sunflower (17 ha) and maize (5 ha). The total cropped area varies from a minimum of 74 hectares in Ankampeta village to a maximum of 2244 hectares in

Marthadu village. The total cropped area is less than 500 hectares in Kesavapuram, Ankampeta, Obulapuram and Jambuladinne villages. It varies from 500 hectares to 1000 hectares in Muntimadugu, Kalluru (RS), Kalluru, Sirivaram, Krisnapuram and Budedu villages. It exceeds 1000 hectares in Penakacherla, Koppalakonda, Illuru, Kanampalli, Kotanka, Marthadu and Garladinne Villages. Bhatia (1965) method of crop concentration is adopted to study the spatial distribution and concentration of crops in Garladinne mandal.

Intensity of cropping pattern

The intensity of cropping pattern is the ratio in percentage of total cropped area and net area sown. The intensity of cropping pattern during 2010-11 varies from 87.55% in Budedu village to a maximum of 114.03% in Kesavapuram village. The intensity of cropping pattern is less than 90% in Budedu and Jambuladinne villages. It varies from 90% to 100% in Sirivaram, Krisnapuram, Yerraguntla, Kotanka, Marthadu, Budedu, Garladinne and Obulapuram villages. In southern side of the Garladinne mandal the intensity is moderate. It is more than 100% and high in Penakacherla, Koppalakonda, Kesavapuram, Muntimadugu, Kalluru (RS), Kalluru, Illuru, Kanampalli and Ankampeta villages. In the northern part of the Garladinne mandal the intensity of cropping pattern is high. (Table.3) The correlation has been carried out between water balance elements and intensity of cropping pattern. The results showed positive correlation between rainfall and intensity of cropping pattern (+ 0.67), actual evapotranspiration and intensity of cropping pattern (+0.58) and water deficit and intensity of cropping pattern (+0.54).

Table 3 : Village wise intensity of cropping pattern & Crop diversification index of Garladinne mandal (2010-11)

S. No	VILLAGE NAME	Intensity of cropping in percentage	Crop diversification index in %
1	Penakacherla	104	20
2	Koppalakonda	108	107
3	Kesavapuram	114	53
4	Muntimadugu	106	79
5	Kallru (R.S)	107	38
6	Kalluru	113	82
7	Illuru	102	96
8	Kannampalli	100	133
9	Ankampeta	100	10
10	Sirivaram	97	94
11	Krisnapuram	92	56

12	Yerraguntla	99	138
13	Kotanka	95	117
14	Marthadu	99	150
15	Budedu	87	57
16	Garladinne	97	106
17	Obulapuram	92	24
18	Jambuladinnee	89	46

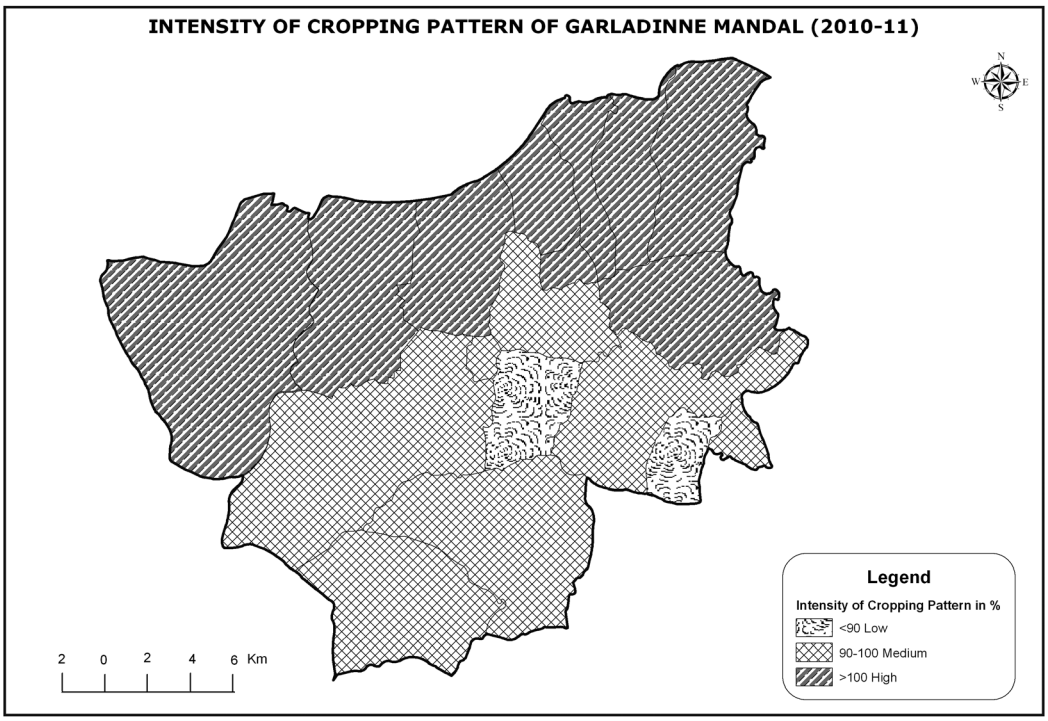

Fig:2

Crop diversification index

S.S Bhatia (1965) crop diversification index has been used to study crop diversification index. It varies from 10% in Ankampeta village to a maximum of 150% in Marthadu village. The diversification is less than 50% in Penakacherla, Kalluru (RS), Ankampeta, Obulapuram and Jambuladinne villages. The diversification index varies from 50% to 100% in Kesavapuram, Muntimadugu, Kalluru, Illuru, Budedu, Sirivaram and Krisnapuram villages. The diversification index is more than 100% in Koppalakonda, Kanampalli, Yerraguntla, Kotanka, Marthadu and Garladinne villages. (Table.3)

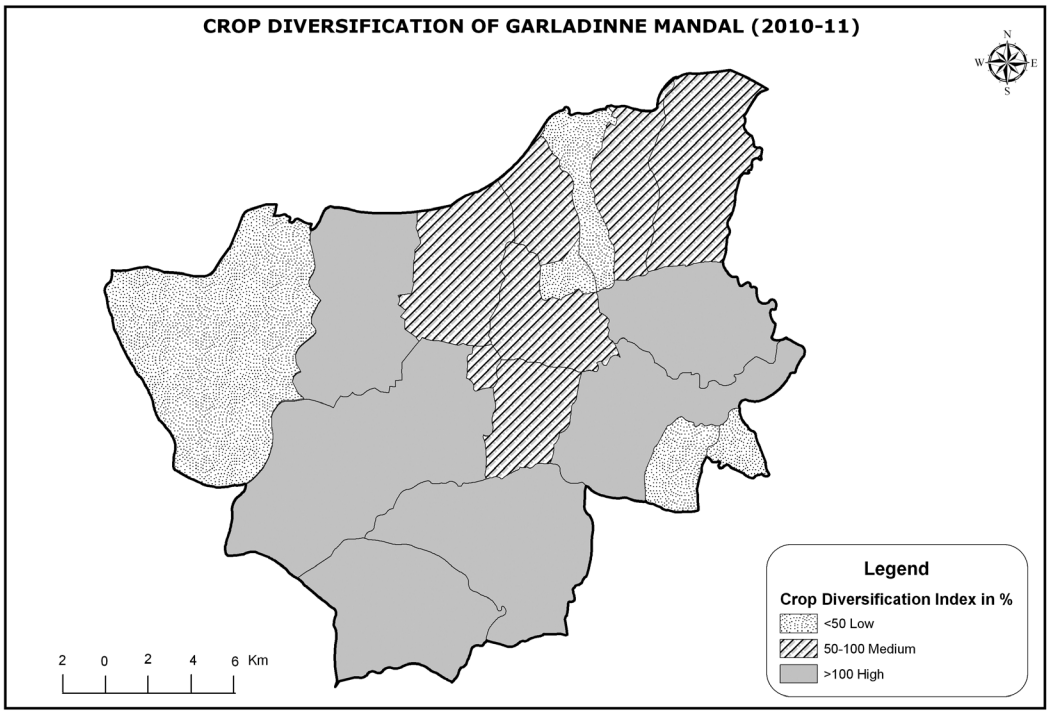

Fig: 3

Crop combination of the Garladinne mandal

The crop combination of the Garladinne mandal has been worked out adopting Doi's (1959) method. According to this method in Garladinne mandal the mono cropped villages are Kesavapuram, Kalluru, Illuru, Kanampalli, Sirivaram, Kotanka and Obulapuram villages. The mono crop is paddy in Kesavapuram, Kalluru and Illuru villages. The mono crop is groundnut in Kanampalli, Sirivaram, Kotanka and Obulapuram villages. The two crop combinations are noticed in Penakacherla, Koppalakonda, Muntimadugu, Kalluru (RS), Ankampeta, Krisnapuram, Yerraguntla, Marthadu, Budedu, Garladinne and Jambuladinne villages. The two crop combination is paddy and groundnut in Ankampeta village. The groundnut and fruits and vegetables are two crop combinations in Penakacherla, Marthadu and Garladinne villages. The two crop comination is fruits and vegetables and groundnut in Yerraguntla and Budedu villages. (Table.4)

Index of agricultural development

The index of agricultural development has been worked out for the Garladinne mandal at village level taking 15 variables like net sown area, area sown more than once, total cropped area, total irrigated area, intensity of irrigation, intensity of cropping pattern, irrigated area more than once, number of ploughs, number of bullock carts, livestock, cultivators, agriculture workers, pump sets, fertilizers and pesticides used, tractors and dusters. One standard

Table 4 : Village wise crop combination of Garladinne mandal (2010-11)

S. No	VILLAGE NAME	Crop combination
1	Penakacherla	Two crop
2	Koppalakonda	Two crop
3	Kesavapuram	Mono crop
4	Muntimadugu	Two crop
5	Kallru (R.S)	Two crop
6	Kalluru	Mono crop
7	Illuru	Mono crop
8	Kannampalli	Mono crop
9	Ankampeta	Two crop
10	Sirivaram	Mono crop
11	Krisnapuram	Two crop
12	Yerraguntla	Two crop
13	Kotanka	Mono crop
14	Marthadu	Two crop
15	Budedu	Two crop
16	Garladinne	Two crop
17	Obulapuram	Mono crop
18	Jambuladinnee	Two crop

deviation method is adapted to bring out the index of agricultural development. In the Garladinne mandal the index of agricultural development varies from 16% in Obulapuram village to a maximum of 79% in Yerraguntla village. The index of agricultural development is less than 35% in Kalluru (RS), Kanampalli, Ankampeta, Sirivaram, Budedu, Obulapuram and Jambuladinne villages. The index of agricultural development varies from 35% to 50% in Koppalakonda, Kesavapuram, Muntimadugu, Kalluru, Krisnapuram and Kotanka villages. The index of agricultural development is more than 50% in Penakacherla, Illuru,Kalluru Yerraguntla, Marthadu, and Garladinne villages. (Table.6) Correlation technique has been worked out to bring out relationship between rainfall and index of agriculture development (+0.85), actual evapotranspiration and index of agriculture development (+0.76) and water deficit and index of agriculture development (+0.44). The correlation values showed positive relationship (Table.5).

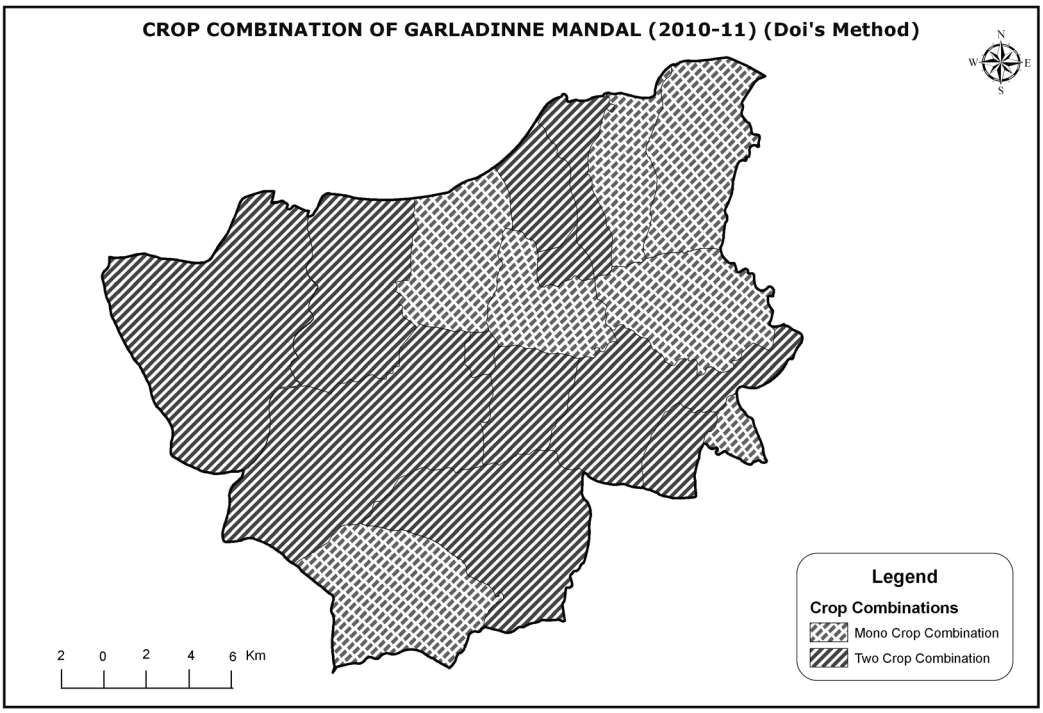

Fig: 4

Table 5 : Village wise index of agriculture development in Garladinne mandal (2010-11)

S.No	Village name	Index of agriculture development in %
1	Penakacherla	**63**
2	Koppalakonda	**48**
3	Kesavapuram	**39**
4	Muntimadugu	**38**
5	Kallru (R.S)	**33**
6	Kalluru	**37**
7	Illuru	**60**
8	Kannampalli	**29**
9	Ankampeta	**26**
10	Sirivaram	**29**
11	Krisnapuram	**48**
12	Yerraguntla	**79**
13	Kotanka	**36**
14	Marthadu	**68**
15	Budedu	**24**
16	Garladinne	**63**
17	Obulapuram	**16**
18	Jambuladinnee	**28**

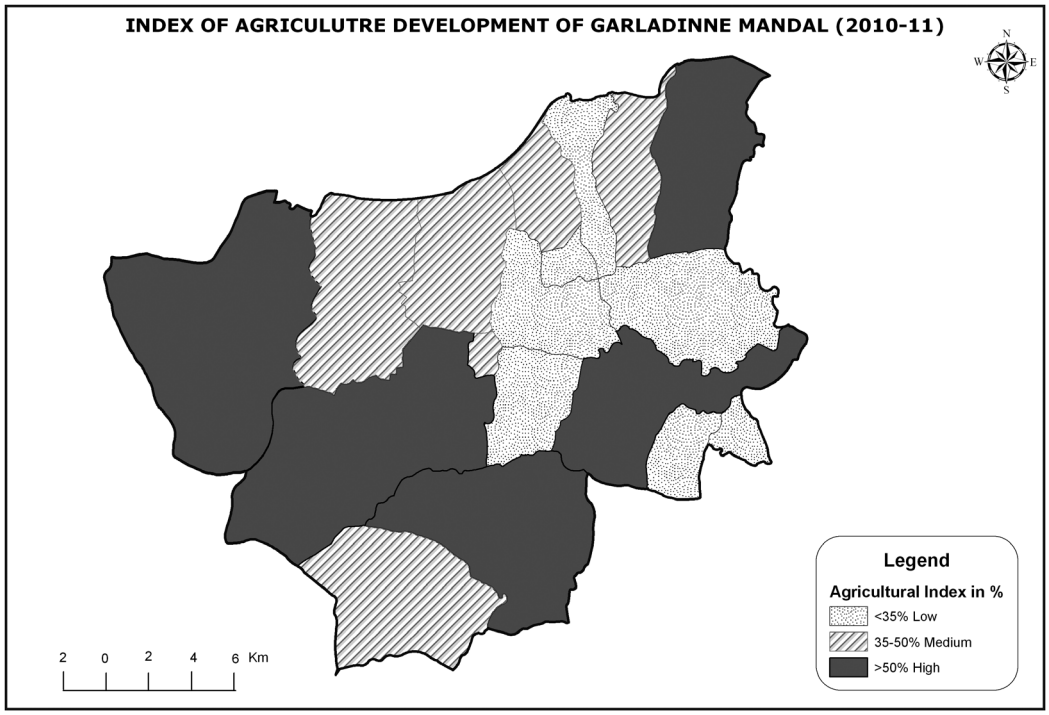

Fig: 5

Conclusions

From the analysis of water balance elements it is found that the water input in the form of precipitation is less than 10mm in January, February, March and December months. The mean rainfall exceeds 100mm per month in September and October months. The mean monthly PE varies 100mm to 150 mm in January, February, Jul y, August, September, October, November and December months. The other months the PE is above 150mm. the AE is less than 501 mm in January, February, March, April and December months. The AE exceeds 100 mm in august, September and October months. The WD is less than 50 mm in august, September, October, November and December months. It exceeds 100 mm in February, March and may months. There is no ware surplus. The analysis of cropping shows that groundnut, paddy and fruits and vegetables are predominant crops and account for 941.86% of the total cropped area. The intensity of cropping pattern is high in eight villages. The crop diversification index very high in six villages. Mono and two crop combinations are found. The index of agriculture development is high in Penakacherla, Illuru, Kalluru, Yerraguntla, Marthadu and Garladinne villages.

References

Thornthwaite C.W. and J.R Mather (1955): The water balance. Publications in climatology. Laboratory of climatology. Centorton (NJ) Vol 8 (1) pp 104.

Mavi Harpal Singh, (1963): Crop Diversification in Malwa tract of Punjab. Indian Geographical Journal, Madras, Vol.38. Pp. 75-78.

Hussain, M., (1970): Patterns of Crop concentration in U.P. Geographical review of India, Vol.32, No .3. pp. 169-185.

Jasbir Singh, (1976): An Agriculture geography of Haryana, Kurukshetra, Vishal Publications, University Campus.

Sarvanan, E., (1979): Cropping pattern and crop combination in Madurai district. Unpublished M.Phil. Dissertation submitted to Madurai Kamaraj University, Madurai.

Samasiva Rao.M., and Kalavathy, N.V., (1983): Water balance and cropping pattern of Madurai District, Tamilnadu. Indian Geographical journal.vol.58, No.2, pp.172-182.

Kalavathi, N.V. (1985): Land, Water, Irrigation, and Agricultural Resources of Chengalpattu District, Tamil Nadu-Unpublished M.Phil., dissertation submitted to Madurai Kamaraj University Madurai, pp.25.

Vatshala, I., (1987): Land suitability, water balance and cropping pattern of Tirunelvalli district, Tamilnadu. Unpublished PhD Thesis submitted to the Madurai Kamaraj University, Madurai.pp.308.

Krishna Reddy, P.R., (1990): Some aspects of Agro climatology, Land use and cropping pattern of the Kadapa district, A.P. Unpublished. Theses submit. To SKU, Anantapur.

Maduramma, C.H., (1991): Water balance and cropping pattern of Nellore district. Unpublished M.Phil, thesis submitted to S.K.University, Anantapur.

Suresh Babu (1993): Water balance, Drought Climatology, Cropping pattern, Land and Water resources development of Anantapur district. A.P, India. PhD thesis S.K.University, Anantapur.

K.Somanna (2013): Water balance and cropping pattern of the Rayalaseema region, Andhra Pradesh, India. PhD thesis S.K.University, Anantapur.

Prof. M. Sambasiva Rao

Dr. N. Madhana Bhaskara,
Dept. of Geography,
S. K.University,
Anantapuramu, Andhra Pradesh.