AN APPRAISAL OF LAND MAN RATIO IN KADALUNDI RIVER BASIN - A DEMOGRAPHIC CASE STUDY USING GEOINFORMATICS

Bindu K.B.*, Jayapal G.**

***** Research Scholar, Dept. of Geography, Kannur University, Swami Anandatheertha Campus, Payyanur.
**Asst. Professor, Dept. of Geography, Kannur University, Swami Anandatheertha Campus, Payyanur.

Abstract

The present paper attempts to study the land man ratio in Kadalundi river basin using geoinformatics. Kadalundi river basin is a medium river basin in Kerala, flowing at a length of 130 km draining an area of 1122 sq. km. The study area owes its natural and demographic significance to its geographical location which gives it a unique identity. There exists a significant man and land relationship which is reflected in the extent of land cover / land use pattern and demographic status of population in the study area. There are several statistical and geospatial methods of analysis which can evaluate the man land relationship among which the most popular method is man land ratio which describes the concentration of people per unit area. However it cannot be used to calculate unit of land available per person as it requires a slight deviation from the normal calculation of man land ratio. This particular research paper focus on the significance of land man ratio to understand the availability of land as a resource for per person and how over population and urbanization lead to stress on the geographical land of Kadalundi river basin. The whole study was carried out based on secondary data and ArcGIS 10.1 software was used to map and analyze the land man ratio in Kadalundi river basin.

Keywords: *Kadalundi river basin, GIS, Land man ratio, Remote Sensing, Geoinformatics*

Introduction

In any geographical, demographic and environmental studies, the man and land relationship is a major concern to assess the available natural and human resource, the level of land utilized by man, the per capita availability of arable land and type of land use pattern in a geographical area under study. In the present study the man and land relationship in Kadalundi river basin was studied based on the calculated land man ratio. The land and man are the most important resources which are mutually interrelated and inter dependent on each other. It is always a difficult task to define the spatial relationship between land and man, as due to development in technology and spread of urbanization the level of spatial interrelationship varies from land to land and from time to time. Even it gives only a wage idea about the land and man relationship in an area, as neither the whole population of an area is dependent on land for their livelihood nor all land available in an area is cultivated. Therefore the ratio is misleading, but this land man ratio can be derived more accurately for small unit of area using specific statistical data. The land man ratio is otherwise defined as the unit of land per person in particular context. Three types of densities namely arithmetic density, physiological density and agricultural density were calculated to derive the land man ratio in the study area based on which the area of demographic stress of population in Kadalundi river basin was assessed.

Study area – Kadalundi river basin

The Kadalundi river basin drains through 49 panchayats, and 3 municipalities (Figure 1). Out of 49 panchayats, 46 panchayats comes under Malappuram district, 2 panchayats from

Palakkad district and 1 from Kozhikode district. The 3 municipalities come under Malappuram district. According to the 2011 census, The Kadalundi river basin inhabits 1.83million population in area of 1122 sq. km with the population density of 1688 persons per sq. km. The decadal growth of population from 1991 to 2011 in Kadalundi river basin (79.4 %) indicates a fast rate of growth than that of the whole Malappuram district (27.7 %), during 1991 – 2011 (Table 1). The Kadalundi river basin being located in the central part of Malappuram also has a geographical advantage of accessibility. The advancement of infrastructure and technology, along with the development in the economic activities and increased urbanization also had led to this fast growth of population from 1991 to 2011. Being a part of the most populous district in Kerala, the 79.4 % of the decadal growth says all about the trend of development in Kadalundi river basin. This fact highlights the fact that there is faster rate of population growth, spread of urbanization, development of infrastructural facilities and conversion of rural urban fringes into urban areas. The present study hence focuses on the present status of land man ratio based on selected parameters under assessment.

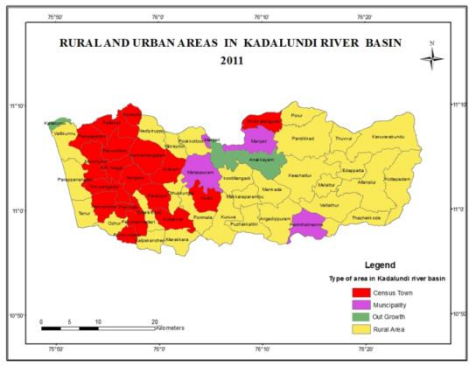

Figure 1. Map of study area

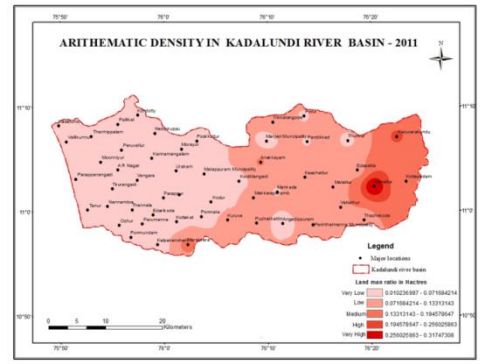

Figure 2. Arithematic density in Kadalundi river basin.

Objectives

To study the land man ratio generated based on arithmetic, physiological and agricultural density in the Kadalundi river basin. To assess the land man ratio based demographic stress in the Kadalundi river basin.

Methodology

The present study mainly used secondary data collected from different government and non-governmental sources. The census data of 2011, agricultural statistics for the year 2015 - 2016 and land use details for the year 2016, of the Kadalundi river basin were used for analysis. Spatial extension of ArcGIS 10.1 software was used for mapping and analysis. The derived Inverse Distance Weighted (IDW) surface for arithmetic density, physiographic density and agricultural density was used to derive the spatial stress on land and availability of land per person in different scenario (Table 2). Each type of density has some kind of relationship with any one or more type of demographic characteristics and land use pattern in Kadalundi river basin which was analyzed and interpreted in this present research work.

Result and discussion

Arithmetic density in Kadalundi river basin

As per the Figure 2, very high arithmetic density (above 0.25 hectare) was found in Alanallur panchayat and in some parts of neighboring panchayats. High concentration of arithmetic density (0.19 to 0.25 hectare) was recorded in some areas in Karuvarakundu and Alanallur panchayat. Medium concentration of arithmetic density (0.13 to 0.19 hectare) was recorded in some areas in Alanallur and part of Kottapadam, Marukara and Karuvarakundu panchayat. Low concentration of arithmetic density (0.07 to 0.13 hectare) was recorded in Thrikkalangode, Melattur, Keezhattur, Vettathur, Pandikkad, Thuvvur, Edapetta, Porur, Anakayam, Puzhakatteri, Mankada, Angadippuram, Kuruva, Makarapparamb panchayat and Manjeri and Perinthalmana municipality. Very low concentration of arithematic density (below 0.07 hectare) is recorded in Parapanangadi, Kadalundi, Vallikunnu, Tanur, Thenjipalam, Munniyoor, Nannambra, Thirurangadi, Pallikal, Kondotty, Nediyiruppu, Peruvalloor, Kannamangalam, Othukkungal, A R Nagar, Vengara, Parappur, Thennala, Ponmundam, Perumancaleri, Kottakal, Ponmala, Morayoor Ozhur, Kalpakancheri, Edarikode, Urakam, Pookkottoor, Kodur, Koottilangadi, and in Malappuram municipality. It is also found in small parts of Angadippuram, Thuvvur, Mankada, Pandikkad, and Manjeri municipality. The arithmetic density values was found very high in the eastern part of the Kadalundi river basin, from which it reduces towards the western part indicating that the availability of area in hectare per head which is high in the eastern part, medium in the central part and low in the western part of the study area. Eventhough this map gives general information about the availabity of land per head; it has some definite relationship with the population density in Kadalundi river basin. For example, where there is high population density, the arithmetic density is low and where there is low density, the arithmetic density is high (Figure 3). This indicates that there is inverse relationship between population density and arithmetic density, which means when the population density is high the availability of land per head is less where as in places where the population density is low the availabity of land per head will be more. But in the real scenario, all land available in Kadalundi river basin is not utilized by man, and there is inequality in the ownership of land which vary depending on the economic status of people and more than that the ownership changes time to time so to get an accurate information in this regard is not possible. But this method of calculating land man ratio is useful to understand that in general, due to high concentration of population in western part of Kadalundi river basin, the availability of land per head is comparatively less than in the eastern part of Kadalundi river basin, where there is less concentration of population. Interpreting this result based on the Figure 1 showing the rural and urban areas makes this fact more clear. In the urban areas the arithmetic density is low compared to the rural areas where the arithmetic value is found high.

Physiographical density in Kadalundi river basin

The physiographical or nutritional density is a method to calculate land man ratio in which cultivated land per person is calculated. The physiological density helps to understand the level of dependency of population on the productive cultivated land. In this regard, the total population and total net sown area in hectare of each panchayat and municipalities are used to calculate the physiological density in Kadalundi river basin. In this method of calculating land man ratio, unproductive area is omitted, based on the aim to identify to what level the cultivable area alone is able to cater the need of total population in Kadalundi river basin. It is a refined method of calculating land man ratio when compared with arithmetic density. But it has a drawback that it considers all uncultivated area as unproductive. Whereas non arable areas at times may be put to diverse uses yielding high economic returns. As per the Figure 4, very high physiographic density (above 0.20 hectare) was found in Alanallur and

Keezhattur panchayat. High concentration of arithmetic density (0.15 to 0.20 hectare) was recorded in parts of Keezhattur, Vettathur and Alanallur panchayat. Medium concentration of physiographic density (0.11 to 0.15 hectare) was recorded in Kottapadam, Alanallur, Keezhattur and Vettathur panchayat and in some parts of Angadippuram, Karuvarakundu and Anakayam panchayat. Low concentration of arithmetic density (0.06 to 0.11 hectare) was recorded in Mankada, Puzhakatteri, Angadippuram, Kuruva, Makarapparamb, Koottilangadi, Thrikkalangode, Anakayam, Pandikkad, Thuvvur, Porur, Karuvarakundu, Melattur, Edapetta and Thazhekkode panchayat and Manjeri and Perinthalmana municipality.

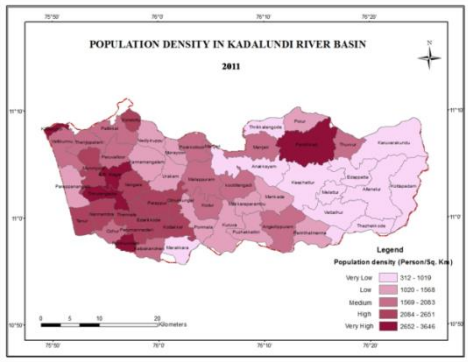

Figure 3. Population density in Kadalundi river basin

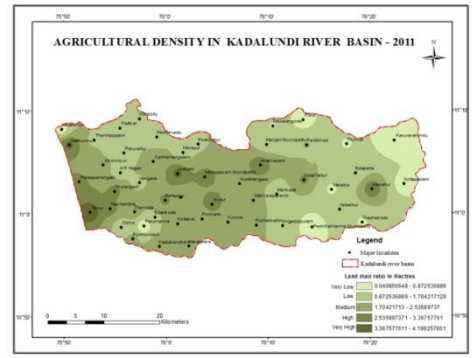

Figure 4. Physiological density in Kadalundi river basin

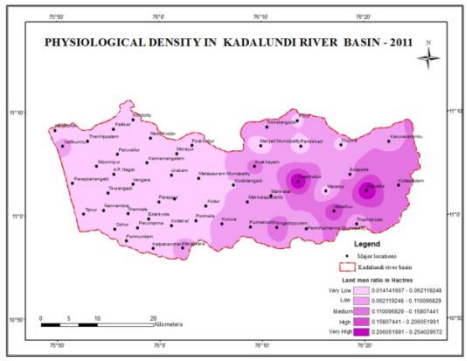

Figure 5. Arthematic density in Kadalundi river basin

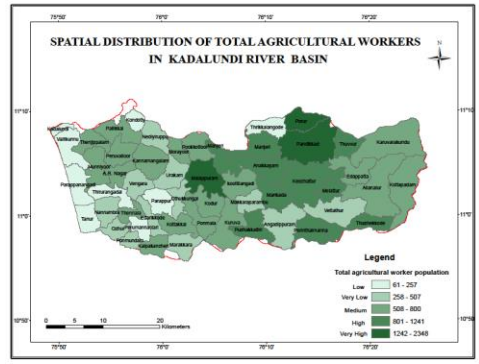

Figure 6. Spatial distribution of agricultural workers in Kadalundi river basin

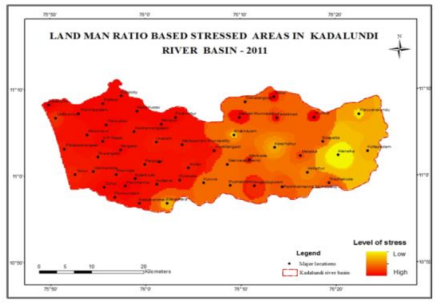

Figure 7. Map of land man ratio based stress in Kadalundi river basin

It is also found in some parts of Vallikunnu and Marukara panchayat. Very low concentration of physiographic density (below 0.01 hectare) was recorded in Parapanangadi, Kadalundi, Tanur, A R Nagar, Vengara, Parappur, Thennala, Ponmundam, Perumancaleri, Kottakal, Ponmala, Morayoor Ozhur, Kalpakancheri, Edarikode, Urakam, Pookkottoor, Kodur, Thenjipalam, Munniyoor, Nannambra, Thirurangadi, Pallikal, Kondotty, Nediyiruppu, Peruvalloor, Kannamangalam, Othukkungal and in Malappuram municipality. It was also found in small parts of Thuvvur, Mankada, Pandikkad panchayat and Manjeri municipality. The physiological density values are found very high in the eastern part from where it reduces towards the western part of Kadalundi river basin.

Table 1. Decadal statistics of Kadalundi river basin in reference with Malappuram and Kerala

Name of the District	Area (sq. km)	% Area	Population in million			% Decadal growth (1991 – 2011)
			1991	2001	2011	
Kerala	38854.97		29.1	31.8	33.3	14.4
Malappuram	3550	9.50 % of Kerala	3.21	3.63	4.1	27.7
Kadalundi river basin	1122	2.9 % of Kerala 31.6 % of Malappuram	1.02	1.14	1.8	79.4

Source : District Census Handbook 2011.

Table 2. Land man ratio in Kadalundi river basin

Panchayat	Arithmetic density	Physiological density	Agricultural density	Panchayat	Arithmetic density	Physiological density	Agricultural density
Kadalundi	0.03	0.00	0.51	Karuvarakundu	0.20	0.10	3.49
Tirurangadi	0.03	0.03	2.82	Trikkalangode	0.10	0.10	0.84
Parappanangadi	0.06	0.06	2.69	Porur	0.07	0.06	0.48
Nannambra	0.05	0.04	2.91	Thuvvur	0.06	0.05	0.83
Moonniyur	0.04	0.03	1.72	Pandikkad	0.03	0.10	1.73
Peruvallur	0.05	0.03	1.24	Perinthalmanna Muncipality	0.07	0.04	1.73
Vallikunnu	0.05	0.08	3.59	Vettathur	0.13	0.19	1.59
Thenhippalam	0.05	0.04	1.61	Edapatta	0.11	0.10	1.13
Pallikal	0.05	0.03	1.26	Melattur	0.10	0.05	0.73
Kondotty	0.04	0.03	0.99	Thazhekode	0.10	0.08	0.81
Nediyiruppu	0.01	0.05	1.30	Keezhattur	0.10	0.25	2.68
A R Nagar	0.04	0.02	1.24	Mankada	0.07	0.06	0.84
Thennala	0.04	0.01	2.14	Koottilangadi	0.06	0.06	2.19
Edarikode	0.05	0.03	1.62	Angadippuram	0.06	0.13	1.57
Othukungal	0.04	0.03	1.77	Puzhakkattiri	0.08	0.07	1.72
Vengara	0.04	0.03	1.47	Makkaraparamb	0.08	0.07	2.16
Kannamangalam	0.07	0.04	2.33	Kuruva	0.08	0.08	2.07
Parappur	0.04	0.04	2.75	Kodur	0.05	0.04	2.87
Morayur	0.07	0.03	1.01	Marakkara	0.16	0.08	1.80
Ponmala	0.06	0.06	1.93	Kottapadam	0.14	0.12	0.52
Pookkottur	0.05	0.05	1.51	Alanallur	0.32	0.25	8.02
Urakam	0.07	0.06	3.62	Anakkayam	0.14	0.13	3.20
Tanur	0.05	0.03	4.20	Malappuram Muncipality	0.06	0.03	2.73
Ozhur	0.05	0.03	1.09	Manjeri Muncipality	0.05	0.03	1.21
Ponmundam	0.04	0.03	2.03	Kottakal	0.05	0.03	2.32
Perumanna	0.04	0.03	1.87	Total river basin	0.06	0.05	1.61
Kalpakancheri	0.05	0.04	2.39				

This implies that the ability of cultivated area to cater the need of total population is high in the panchayat and municipalities located in the eastern part whereas it is comparatively less in the western part of the Kadalundi river basin. This result is based on the availability of net sown area in a panchayat or municipality which is not uniformly distributed and the total population dwelling in that area. Hence it is clear that where there is high availability of net sown area and low population concentration the physiographic density indicating the availability of cultivable land per person will be high whereas in area where there is low availability of net sown area and high population concentration the physiographic density indicating the availability of cultivable land will be comparatively low. But as not all population depends on the available net sown area for their nutrition and livelihood and as in some places non cultivable land yields high income and provide livelihood for population, this physiographic density results gives a general idea of the actual scenario in the Kadalundi river basin. Even though this map gives general information about the ability to cater the nutrient requirement per head, it has some definite relationship with the population density in Kadalundi river basin. As per Figure 3 where there is high population density, the physiographic density is low and where there is low density, the physiographic density is high. This indicates that there is inverse relationship between population density and physiographic density, which means when the population density is high the ability of cultivable land to cater the nutrient requirement of the population is low whereas in areas of low population density the ability of cultivable land to cater the nutrient requirement of the population is comparatively high. But in the real scenario, all land available in Kadalundi river basin is not utilized by man, and there is inequality in the availability of cultivable land which vary depending on the physical, climatic and economical factors of an area and more than due to the increase in population and spread of urbanization, the amount of net sown areas is reducing time to time so to get an accurate information in this regard is not possible. But this method of calculating land man ratio is useful to understand that that to what extent the available cultivable area is able to cater the need of nutrient of the inhabiting total population. Based on the assumption that the nutrient required for the dwelling population should be served by the land area in Kadalundi river basin and the major stress of this task lies on the total available cultivable land, the derived physiological density is acceptable. Interpreting the derived result based on the Figure 1 showing the rural and urban areas makes this fact more clear. In the urban areas the physiological value is low compared to the rural areas where the physiological value is found high.

Agricultural density in Kadalundi river basin

The agricultural density is a method of calculating land man ratio in which the area of cultivable land per head of agricultural population can be derived. In this calculation the agricultural population which depend on the cultivable area for their livelihood and the cultivable area in an area. It has proved a useful index of land man relationship primarily in agrarian context. In this regard the total agricultural working population and net sown area in hectare in each panchayat and municipality in Kadalundi river basin was used for calculating the agricultural density in Kadalundi river basin. In this method of calculating the non workers, cultivators, household workers, and other workers in Kadalundi river basin are omitted and hence this calculation is proved more accurate than the former two method of calculating land man ratio. But it has its own drawback that more than agricultural workers the working population in other categories are more in number similarly the uncultivated area in hectare are comparatively found more than the area under net sown area in Kadalundi river basin. But with an aim to get a filtered and more accurate land man ratio, the net sown

area in hectare was taken as the basic unit and the depended agricultural worker population was used to calculate agricultural density. Figure 5 represents the spatially interpolated surface generated based on the agricultural density calculated for each panchayat and municipalities in Kadalundi river basin. As per the map, very high agricultural density (above 3.36 hectare) was found in Vallikunnu, Tanur and Urakam panchayat. High concentration of agricultural density (2.53 to 3.36 hectare) was recorded in Parapanangadi and Nannambra panchayat and in some parts of Tanur, Vallikunnu, Parappur, Anakayam, Kannamangalam, Kodur, Keezhattur, Alanallur and Malappuram municipality. Medium concentration of agricultural density (1.70 to 2.53 hectare) was recorded in Kuruva, Makarapparamb, Thennala, Kalpakancheri, Edarikode, Munniyoor, Puzhakatteri, Keezhattur, Anakayam, Koottilangadi, Kannamangalam, Parappur, Othukkungal, Kottakal, Ponmala, Marukara, Ponmundam, Perumancaleri, Thirurangadi, Parapanangadi, and Vallikunnu panchayat and Malappuram municipality. It is also found in some parts of Alanallur, Pandikkad, Pookkottoor, Morayoor, Vengara, A R Nagar and Thenjipalam panchayat and Manjeri municipality. Low concentration of agricultural density (0.87 to 1.70 hectare) was recorded in Vettathur, Angadippuram, Kondotty, Mankada, Pandikkad, Thrikkalangode, Thuvvur, Edapetta, Melattur, Pookkottoor, Morayoor, Nediyiruppu, Peruvalloor, Pallikal, Thenjipalam, Vengara, A R Nagar, Ozhur and Ponmundam panchayat. It was also found in some parts of Kottapadam, Karuvarakundu, Porur, Keezhattur, Puzhakatteri and Kadalundi panchayat and in some areas of Manjeri and Perinthalmana municipality. Very low concentration of agricultural density (below 0.87 hectare) was recorded in Perinthalmana municipality and in some parts of Kottapadam, Karuvarakundu, Porur, Thuvvur, Thazhekkode, Perumancaleri and Kadalundi panchayat. The agricultural density value was found high in the western part of the Kadalundi river basin from where it reduces towards the eastern part of Kadalundi river basin. This indicate that the cultivable land available for per agricultural workers is high in the panchayat and municipalities located in the western part where as it is comparatively low in the eastern part of Kadalundi river basin. This result is truly based on the available data of total agricultural workers population and total net sown area in the panchayat and municipalities which are not uniformly distributed in Kadalundi river basin. Hence the result should be interpreted in context of agricultural scenario. In terms of agricultural population, it is a logical fact that where there is high availability of net sown area there will be more concentration of agricultural workers and where there is low availability of net sown area there will be less concentration of agricultural workers. Hence the area with high value of agricultural density shows the high availability of cultivable land for every agricultural worker as the concentration of agricultural workers is less in these areas. On the other hand in areas with low value of agricultural density shows the low availability of cultivable land for every agricultural worker as the concentration of agricultural population is high in these areas. Eventhough this map gives general information about the availability of cultivable land for every agricultural worker; it has some definite relationship with the spatial distribution of agricultural workers in Kadalundi river basin. Figure 6 represents the spatial distribution of agricultural workers in Kadalundi river basin based on 2011 census. High concentration of agricultural workers was found in the eastern part of the Kadalundi river basin which reduces towards the central and western part of Kadalundi river basin. Hence in area of high concentration of agricultural workers there will be high density and where there is low concentration of population there will be low density. Thus the high density areas have low available cultivable land per agricultural worker and the low density areas have high available cultivable land per agricultural worker. This indicates that the agricultural population density is inversely related with agricultural density as former represents the

availability of agricultural population in an area where as the later represents the available cultivable land for an agricultural worker to cultivate and earn his livelihood. But in the real scenario, all land available in Kadalundi river basin is not utilized by agricultural workers, and there is inequality in the availability of cultivable land which vary depending on the physical, climatic and economical factors of an area and not all the available cultivable land is utilized in same pace every year. Not only that due to the increase in population and spread of urbanization, the amount of net sown areas is reducing time to time so to get accurate information in this regard is not possible. But this method of calculating land man ratio is useful to understand that that to what extent the available cultivable area is able to provide employment to agricultural labour and to what extent an area is utilized for agricultural production. Interpreting the derived result based on the Figure 1 showing the rural and urban areas makes this fact more clear. In the urban areas the agricultural density value is low compared to the rural areas where the agricultural value is found high.

Land Man Ratio Based Stressed Areas in Kadalundi River Basin

The derived Inverse Distance Weighted (IDW) surface for arithmetic density, physiographic density and agricultural density gives the information about the spatial stress on land and availability of land per person in different scenario. Each type of density has some kind of relationship with any one or more type of demographic characteristics and land use pattern in Kadalundi river basin. Eventhough they have some drawbacks, still they depict some of the general characteristics of the land and man relationship in Kadalundi river basin. Moving one step further, using all these arithmetic, physiographic and agricultural density based rasters, an attempt was made to delineate the stressed areas in Kadalundi river basin. For this purpose, the Spatial Analyst extension in ArcGIS 10.1 Software is used, In the Spatial Analyst extension, reclassify and weighted sum tools are used to interact with the values of raster, performing reclassification by assigning ranks based on preference and finding the stressed areas using weighted sum tool. The IDW surface generated for arithmetic density gives 5 classes of values showing areas of very low, low, medium, high and very high arithmetic density in Kadalundi river basin. The areas of high arithmetic density value have low population density and more availability of land per head hence there will be less stress on the land where as in the areas of low arithmetic density value have high population density and comparatively less availability of land per head hence there will be high stress on the land. Based on this interpretation, the 5 classes of raster values in arithmetic density based interpolated surface are reclassified and ranked according to the risk of stress. For example the very high class is given 5^{th} rank, high class given 4^{th} rank, medium class given 3^{rd} rank, low class given 2^{nd} rank and very low class given 1^{st} rank. Similarly, in case of physiological density the area of high physiological density value have low population density and high ability of the land to cater the nutrient requirement per head hence there will be less stress on land where as in area of low physiological density value have high population density and low ability of the land to cater the nutrient requirement per head hence there will be high stress on land. Based on this interpretation, the 5 classes of raster values in physiological density based interpolated surface are reclassified and ranked according to the risk of stress. For example the very high class is given 5^{th} rank, high class given 4^{th} rank, medium class given 3^{rd} rank, low class given 2^{nd} rank and very low class given 1^{st} rank. In case of agricultural density the area of high agricultural density value have low concentration of agricultural workers and more availability of cultivable land per head hence less stress on land where as in area of low agricultural density value have high concentration of agricultural workers and less availability of cultivable land per head hence more stress on land. Based on this interpretation, the 5 classes of raster values in

agricultural density based interpolated surface are reclassified and ranked according to the risk of stress. For example the very high class is given 5th rank, high class given 4th rank, medium class given 3rd rank, low class given 2nd rank and very low class given 1st rank. After reclassifying the raster layers of arithmetic density, physiological density and agricultural density, they are overlayed, multiplying each by their given weightage and is summed together using Weighted Sum tool in Spatial Extension of ArcGIS 10.1 Software. Among these 3 reclassified layers agricultural density layer is comparatively more accurate as filtered and interrelated data of agricultural population and cultivable land is used for understanding the agricultural density in Kadalundi river basin. Hence based on the accuracy the reclassified layer of agricultural density is given more weightage followed by reclassified layers of physiological density and arithmetic density with less weightage. The criteria of weightage allocation vary based on the accuracy, importance of layers and the purpose of the study. If 100 % is the total weightage, reclassified layer of agricultural density is given 70 % weightage, followed by the reclassified layer of arithmetic density with 20 % and reclassified layer of physiological density with 10 % weightage. Each reclassified layer of agricultural density, physiographic density and arithmetic density is multiplied with its respective weightage and summed together using Weighted Sum tool in Spatial Analyst extension in Arc GIS 10.1 Software. The derived raster layer shows the stressed areas in Kadalundi as calculated based on the land man ratio in the form of agricultural density, physiographic density and arithmetic density. Figure 7 shows the land man ratio based stressed areas in Kadalundi river basin. As per the map the colour ramp in the raster layer shows 5 classes of very highly stressed, highly stressed, medium stressed, low stressed and very low stressed areas in Kadalundi river basin. The very low stressed area was found in some parts of Alanallur and Karuvarakundu panchayat. Low stressed area is found in Kottapadam, Karuvarakundu Thrikkalangode and Alanallur panchayat and in some parts of Marukara, Anakayam, Keezhattur, Thazhekkode and Vettathur panchayat. Medium stressed area was found in Anakayam, Makarapparamb, Keezhattur, Puzhakatteri, Kuruva and Vettathur panchayat. It was also found in some parts of Marukara, Koottilangadi, Mankada and Edapetta panchayat and Manjeri municipality. High stressed area was recorded in Pandikkad, Thuvvur, Porur, Melattur, Edapetta, Angadippuram and Manjeri and Perinthalmana municipality. It was also found in some parts of Karuvarakundu, Thazhekkode and Vallikunnu panchayat. Very highly stressed areas was found in Parapanangadi, Kadalundi, Thenjipalam, Munniyoor, Nannambra, Tanur, Thirurangadi, Pallikal, Kondotty, Nediyiruppu, Peruvalloor, Kannamangalam, Othukkungal, A R Nagar, Vengara, Parappur, Thennala, Ponmundam, Perumancaleri, Kottakal, Ponmala, Morayoor Ozhur, Kalpakancheri, Edarikode, Urakam, Pookkottoor, Kodur and Malappuram municipality. It was also found in some parts of Angadippuram, Mankada, Pandikkad, Thuvvur, Porur and Manjeri municipality.

As per the result the high stresses area was found in the western part of the Kadalundi river basin which reduces towards central and eastern part of the Kadalundi river basin. While interpreting the result with the information regarding the distribution of population density as shown in Figure 3 it shows a direct relationship between the level of stress and level of population density. In areas where there is high concentration of population the result shows areas with high stress and in areas of low concentration the result shows areas with low stress. This implies that there is a link between the population density and the level of stress forced on land. If this implication is true then there may be some definite links between the other demographic characteristics of population and its related stress on land in Kadalundi river basin. Not only that when the derived result was interpreted based on type of areas in

Kadalundi river basin as shown in Figure 1, majority of the urban areas are found in the high stressed areas including few rural areas adjoining them in coastal areas where as all the rest of the rural areas and few urban areas are found in medium and low stressed areas. This indicates the fact that there is also a direct link with urbanization and level of stress forced on land. In urbanized areas the stress on land will be more compared to non urbanized areas. Hence with the help of land man ratio general information about the land man relationship is derived. Eventhough this method has several drawbacks, it was able to depict the true characteristics of land man relationship in Kadalundi river basin which was found true in this analysis.

Conclusion

The land man ratio highlights the fact that there is a direct relationship between demographic characteristics of population and level of stress on land in Kadalundi river basin. Eventhough it was analyzed based on the selected parameters, it gives generalized information regarding the land man relationship and highlights the stressed areas in Kadalundi river basin. Considering this fact the present study can be used as a reference for land use planning and integrated river management plan for sustainable development of Kadalundi river basin.

References

Acharya, A. K. and Praveen Nangia., 2004., "Population growth and changing land use pattern in Mumbai metropolitan regions of India," Caminhoes De Geographia, 11(11) pp. 168 – 185.

Bhende, Asha A and Kanithkar, Tara., 2010., Principles of Population Studies, Himalaya Publishing House, Mumbai.

Bindu K. B. and Jayapal G., 2015., "An Analysis of Land Use / Land Cover Change Detection in Kadalundi River Basin in Kerala – A Geoinformatics Approach," National Conference on Application of Remote Sensing, GIS and GPS Technologies .

Bogue D., 1969., Principles of Demography, New York, John Willey and Sons,

Ehrlich Paul R. and Anne H. Ehrlich., 1972., "Population, Resources, Environment: Issues in Human Ecology," Freeman, Second Edition, p 509.

Meyer W.B and Turner B L., 1992., Human Population Growth and Global Land Use/Cover change, Annual Review of ecology and Systematic.

Perz Stephen G., 2001., Household Demographic factors as life cycle determinants of land use in the Amazone, Population Research and Policy Review, Vol. 20, pp 159-186.