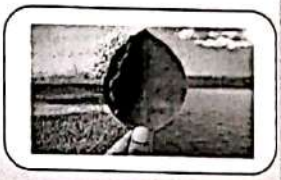
Peer reviewed Journal Impact Factor:5.13 ISSN-2230-9578

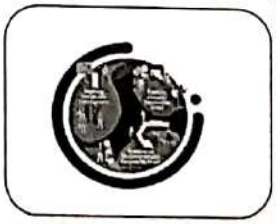
Journal of Research and Development

Multidisciplinary International Level Referred Journal

February-2021. Special Issue-11, Volume-2

Physical and Human Dimensions of Environment, Climate Change, and Sustainable Development





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Journal of Research and Development

Multidisciplinary International Level Referred and Peer Reviewed Journal

February 2021

Special Issue-11, Volume-2

On

Physical and Human Dimensions of Environment, Climate Change, and Sustainable Development

Published by- Principal, Sharadchandra Mahavidyalaya, Shiradhon Tq. Kallam Dist: Osmanabad (Maharashtra)

'Journal of Research & Development'
Multidisciplinary International Level Referred and Peer Reviewed Journal, Impact Factor 5.13, ISSN: 2230-9578, February 2021, Special Issue 11, Volume-2 "Physical and Human Dimensions of Environment, Climate Change, and Sustainable Development"

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Application of Shannon's Entropy Approach For Urban Sprawl Of Solapur City

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Abstract

Urban geography studies various aspects; out of them urban sprawl study focused in recent times. Urban sprawl analysis done by various methods. It includes land use land cover analysis, buffer analysis, multiple buffer analysis, Shannon's entropy approach etc. The GIS and remote sensing are used for quantify sprawl of solapur city. The present paper is deals with Shannon's entropy approach for urban sprawl of solapur city. The Shannon's entropy approach is an only quantitative technique to measure urban sprawl. Its gives clear picture and growth rate of urban sprawl in given area. It is named after Claude Shannon (1948). The term entropy is frequently used to describe the quantity of elements. The entropy is related to the expansion of the spatial variable in a given area, which was given by Shannon's entropy. This approach is useful to measure and distinguish types of sprawl. The entropy method is more appropriate with GIS and Remote Sensing.

Keywords: - Urban sprawl, Shannon's entropy, built up Area, GIS, Remote Sensing

Introduction

Urban geography studies various aspects; out of them urban sprawl study focused in recent times. A term urban sprawl describing the physical pattern of low density expansion of large urban areas under market conditions into the surrounding agricultural areas. Sprawl in lies advance of the principal lines of urban growth and implies little planning control of land subdivision. Urban sprawl analysis done by various methods. It includes land use land cover analysis, buffer analysis, multiple buffer analysis, Shannon's entropy approach etc. The GIS and remote sensing are used for quantify sprawl of solapur city. The Shannon's entropy approach is an only quantitative technique to measure urban sprawl.

Objectives

The present study has certain specific objectives. It includes studying application of Shannon's entropy approach for urban sprawl in solapur city.

Study Area

The city of Solapur is located in between $17^0 43' 30"$ North latitudes and $17^0 46' 15"$ North latitudes to $75^0 52' 10"$ East to $75^0 58' 20"$ East longitude. The city lies about 550 meters above the mean sea level. The area under the jurisdiction of the Solapur, in Municipal Corporation has an area of 178.5 square kilometer.

Database and methodology

The present study covering an entire solapur city as the study area. The database for present work is satellite images collected form NRSA. The images processed by ArcGIS software. The built up area measurement tabulated with zone wise. The Shannon's entropy method applied for zone wise decadal tables.

Shannon's Entropy Approach for urban sprawl of solapur city

It is named after Claude Shannon (1948). The term entropy is frequently used to describe the quantity of elements. The entropy is related to the expansion of the spatial variable in a given area, which was given by Shannon's entropy. This approach is useful to measure and distinguish types of sprawl. The entropy method is more appropriate with GIS. Shannon's entropy values from 0 to 1. If the distribution of built up is more concentrated at one area; the lowest entropy value is 0. If the entropy value 1, it means distribution of built up across the area.

The Shannon's entropy method calculated using the following formula.

$$E_1 = \frac{\sum_{j=1}^{m} PDj\left(\log\left(\frac{1}{PDj}\right)\right)}{log(m)}$$

$$\text{Where= } PDj = \frac{Dj}{\sum_{j=1}^{m} Dj}$$

E_1 - Entropy,

P is Probability,

Dj is the density of land growth it equals to the quantity of built up land divided by the total quantity of land in the j^{th} zone in the total of m zone.

The difference in entropy values among two different periods of time used to find out the change in the amount of urban sprawl.

Relative entropy

$$\Delta Et = E_t (y+1) - E_t (y)$$

Where ΔE_t is the difference of the relative entropy values between two periods E_t (y + 1) is the relative entropy value at time period y+1, E_t (y) is the relative entropy value at time period y.

Table 1.1

Entropy Calculation for the Time Period of 1992

Zones	TGA	1992	Density(Dj)	PDj	1/PDj	Log(1/PDj)	PDj*log (1/PDj)
I	25.45	2.77	0.1088	0.0391	25.5754	1.4078	0.0550
II	32.30	3.20	0.0990	0.0356	28.0898	1.4485	0.0515
III	7.73	4.29	0.5549	0.1995	5.0125	0.7000	0.1396
IV	19.41	2.24	0.1154	0.0415	24.0963	1.3819	0.0573
V	45.71	4.25	0.0929	0.0334	29.9401	1.4762	0.0493
VI	41.06	3.31	0.0806	0.0289	34.6020	1.5391	0.0444
VII	3.52	2.94	0.8352	0.3003	3.3300	0.5224	0.1568
VIII	3.39	3.03	0.8938	0.3214	3.1113	0.4929	0.1584
Total	178.57	26.03	2.7806				0.7123

Source: Computed by Researcher

TGA = Total Geographical Area

Log (m) = log 8 $E_t = 0.7123/0.9030$

Log 8= 0.9030 $\mathbf{E_t = 0.7888}$

Table 1.2

Entropy Calculation for the Time Period of 2002

Zones	TGA	2002	Density(Dj)	PDj	1/PDj	Log(1/PDj)	PDj*log (1/PDj)
I	25.45	3.15	0.1237	0.0400	25	1.3979	0.0559
II	32.30	4.25	0.1315	0.0425	23.5294	1.3716	0.0582
III	7.73	5.13	0.6636	0.2145	4.6620	0.6685	0.1433
IV	19.41	3.22	0.1658	0.0536	18.6567	1.2708	0.0681
V	45.71	5.66	0.1238	0.0400	25	1.3979	0.0559
VI	41.06	3.75	0.0913	0.0295	33.8983	1.5301	0.0451
VII	3.52	3.06	0.8693	0.2811	3.5574	0.5511	0.1549
VIII	3.39	3.13	0.9233	0.2985	3.3500	0.5250	0.1567
Total	178.57	31.34	3.0923				0.7381

Source: Computed by Researcher.

TGA = Total Geographical Area

Log (m) = log 8 $E_t = 0.7381/0.9030$

Log 8= 0.9030 $\mathbf{E_t = 0.8173}$

Table 1.3

Entropy Calculation for the Time Period of 2012

Zones	TGA	2012	Density (Dj)	PDj	1/PDj	Log(1/PDj)	PDj*log(1/PDj)
I	25.45	4.60	0.1807	0.0500	20	1.3010	0.0650
II	32.30	5.95	0.1842	0.0510	19.5694	1.2915	0.0658
III	7.73	5.81	0.7516	0.2083	4.8007	0.6813	0.1419
IV	19.41	4.65	0.2395	0.0663	15.0829	1.1784	0.0781
V	45.71	9.40	0.2056	0.0569	17.5746	1.2448	0.0708

VI	41.06	4.59	0.1117	0.0309	32.3624	1.5086	0.0466
VII	3.52	3.35	0.9517	0.2638	3.7907	0.5787	0.1518
VIII	3.39	3.33	0.9823	0.2723	3.6724	0.5649	0.1538
Total	**178.57**	**41.69**	**3.6073**				**0.7738**

Source: Computed by Researcher.
TGA = Total Geographical Area

Log (m) = log 8 E_t = 0.7738/0.9030
Log 8= 0.9030 E_t = **0.8569**

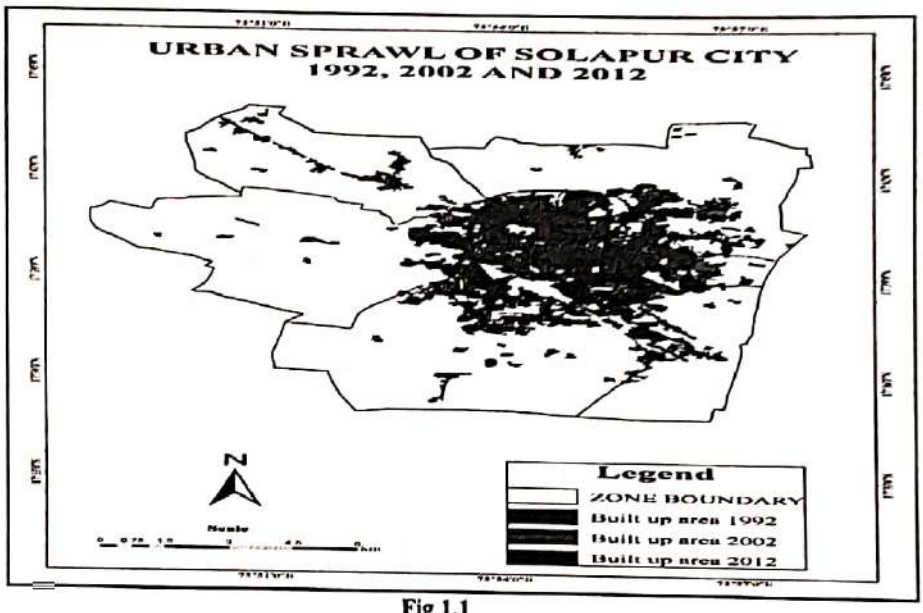

Fig 1.1

Table 1.1, 1.2 and 1.3 shows the entropy calculation for the time period of three decade. The entropy value of period 1992, 2002 and 2012 shows that, 0.7888, 0.8173 and 0.8569 respectively. The entropy values of this three decade shows above 0.5, indicating a higher rate of urban sprawl.

The On-Going Rise of Urban Sprawl

The calculation of Shannon's entropy measure indicated that Solapur city continue to sprawl from 1992 to 2012. The entropy value for 1992 is lower than that of 2012. Table 1.4 shows relative entropy. The analysis of entropy value shows that, urban sprawl in Solapur city is far serious. The Shannon's entropy values shows above 0.5, it means a higher rate of urban sprawl. The force behind the urban sprawl is rapid population growth. The city development plan should prepare according to sprawl.

Table 1.4
Shannon's Entropy values of Solapur city

Sr.No	Year	Entropy (E_t)	ΔE_t
1	2002-1992	0.7888	0.0285
2	2012-2002	0.8173	0.0396
3	2012	0.8569	-

Source: Computed by Researcher

Conclusion

1. The Shannon's entropy value is applied for analysis of urban sprawl. The entropy values continuously increasing, i e. 0.7888 in 1992, 0.8173 in 2002 and 0.8569 in 2012. It means sprawl is increased continuously.

2. The rapid growing population and increasing built up area will produce urban sprawl in future much faster than present.

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