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Land Degradation/Desertification Vulnerability Index:UsingModified Weighted Index:A study on West Khasi Hills District, Meghalaya India

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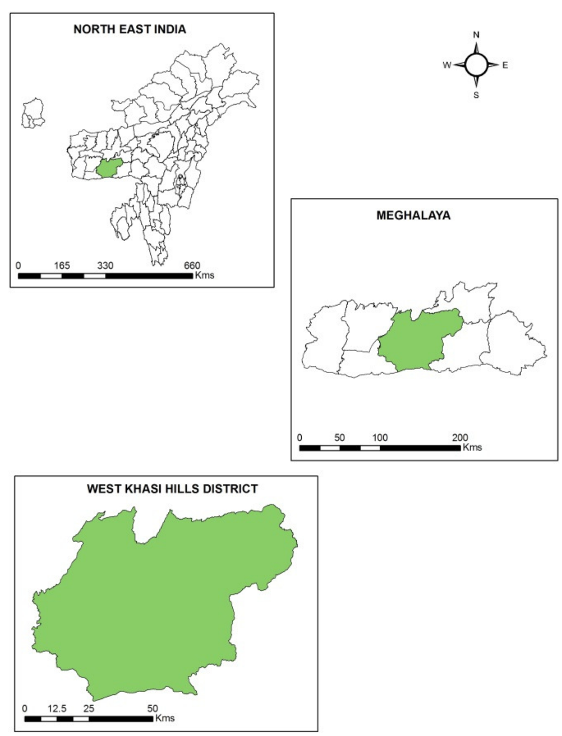
Abstract: Conceptuallydesertification falls under arid, semi-arid and dry sub humid regions of the world but the process of desertification due to continuous land degradation process can occur or symptomized in any climatic region. The study area West Khasi Hills comes under North Eastern part of India and falls under *tropical monsoonal climatic region*. According to 2011 census the district has population density 73 persons per sq.km. The total geographical area of district is 5241 sq.kms. Based on 2011-2013 LISS III data and ground verification; about 2781.59 sq.kms of geographical area of the district is identified as area under desertification/land degradation process, which represents 53.01 percent of the total geographical area of the district. The present study is a part of ongoing national project titled "Desertification and land degradation: Monitoring, Vulnerability Assessment and Combating Plans" funded by Department of Space (ISRO), Government of India. The project team is continuously monitoring and assessing country's land.Thiscurrent study primarily deals with evaluationof desertification/land degradation vulnerability index of the district using MWI(Modified Weighted Index) examining the ability of the method to identify the vulnerable areas.

Key words: land degradation desertification vulnerability index, biophysical index, socio economic index,

Introduction: The U.N convention to combat desertification (UJCCD) defines the concept of desertification as "Land degradation in arid, semiarid and dry sub humid areas, resulting from various factors, including climatic variations, human activities". Land degradation is in turn defined as the reduction or loss of the biological economic productivity of land (Adeel. et. al., 2005). Desertification is the extreme condition of land degradation, primarily triggered due to long term imbalance between ecosystem carrying capacity and human population and their demands. The continuously increasing pressure on land for food and fuel is over exploiting the natural capability of land and also it is converting once productive land to dry land. In present day scenario these unsustainable human activities conjoint with climate changesisaccelerating the desertification process faster than expected.

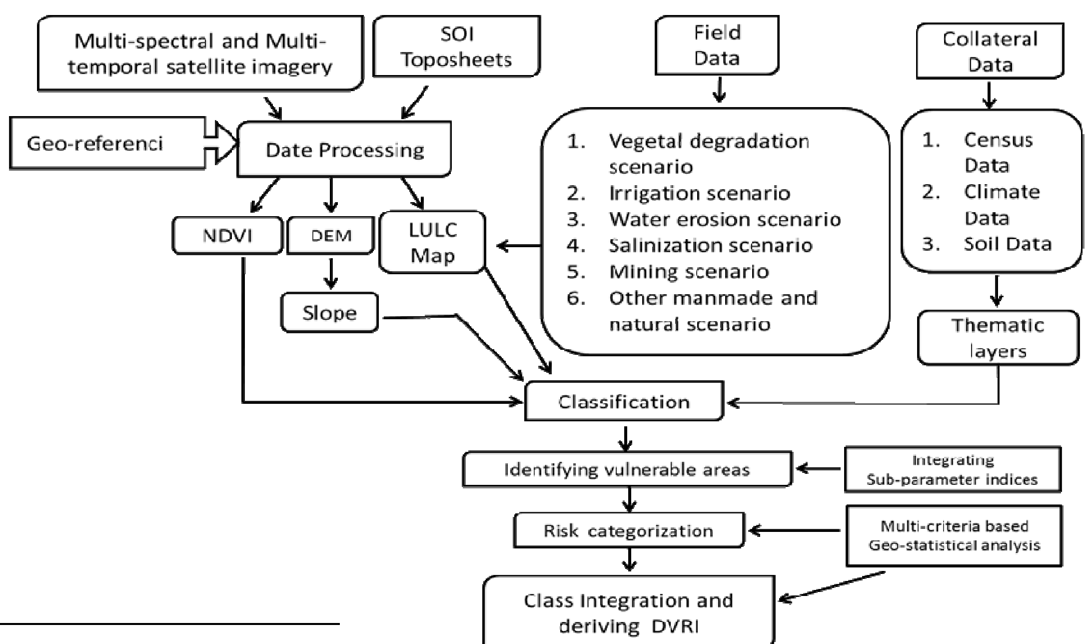


In West Khasi Hills it is noted that despite of low population density the current study area records more than 50 percent of land under desertification/land degradation processes. Which is also a hypothetically indication that the present population of the district is mostly depends upon primary economic activates (agriculture & allied sectors) rather than secondary and tertiary. The present study emphasises to evaluate the desertification/land degradation vulnerability indexes of West Khasi Hills of Meghalaya. The keyfocus of the study is to examine the potency of MWI method regardingassessmentof land degradation/desertification vulnerability and established it applicability in West Khasi Hills.

Database: It is taken according to previous work on "Potency of Modified Weighted Index Analysis for Land degradation /desertification vulnerability Index: A case study on Golaghat District, Assam, India"(Bora et.al, 2021)

1. IRS LISS III, time frame 2011 -2013(NRSC)[1]. LISS III (Linear Imaging Self Scanning Sensor) is an optical sensor with 7 bits data with 141 km wide ground swath. Spatial resolution is 23.5 meters in all spectral bands. Repetitive cycle 24 days. The satellite data has considered based on 3 agro climatic seasons asKharif (September – November), Rabi (December – March) and Summer (April – June)
2. Ancillary Data ; Water body, Rivers (Natural Resources Data Base), Forest Boundary (FSI)[2], demography& Infrastructure (Census of India, 2011), Climate (IMD)[3] and soil data (NBSS & LUP)[4]
3. DEM (Source SRTM). The spatial resolution is 90 meters. Further it is resample it to 30 meters using nearest neighbour.
4. Ground through verification (GPS points and field photograph)

Methodology: Modified Weighted Index (MWI) Analysis (Vedas.SAC.gov.in): It is a multi-variate Geo-statistical method, which uses for deriving the composite indices for all the spatial units separately. There are three important steps involved in the derivation of the indices i.e. Normalization of all the variables and weightages assignment, Calculation of indices at each sub-variables of Natural, Social and Economic parameters separately for deriving rate of severity and Generation Composite Index and integration with spatial polygons (KLN Sastry,2014) (Bora. et.al., 2021)



[1]National Remote Sensing Centre, Hyderabad
[2]Forest survey of India
[3]Indian Meteorological Department
[4]National Bureau of soil Survey and Land Use Planning

Amenity index: It is calculated based on Modified Cumulative Weighted index Model for each class of amenity i.e. education, medical, transport and communication. The availability of the amenities is extracted from 2001 and 2011 national census by examining 1088 settlements.

$$Ic = \frac{\sum Ai \times Wi}{\sum Wi} \quad (1)$$

i = 1 to …n numbers

Where, Ic is index for a particular settlement vis-à-vis class of amenity

n = Number of amenities in a category (e.g. 8 or10 nos. in Edu.)
Ai = 0 or 1 (0 = Not available, 1 = Available)

Wi = Weight of the amenity with in category/class of facility, and it is defined as

$$Wi = \frac{(N-fi)}{N} \times 100 \quad (2)$$

N = Total no. of Settlements & fi = No. of Settlements having amenity i

Cumulative Amenities index:

Cumulative index for a particular settlement is calculated as:

$$AI = \sum Ic. \quad (3)$$

c = 1 to N numbers n = Number of amenity categories (e.g. Med. Edu. Trans. etc.)

AI = Cumulative index for a particular settlement vis-à-vis all amenities
Ic = Index for a category of amenity derived earlier

Economic Development Index:

Economic development of a settlement is derived based on:

$$E = \sqrt{[D.W\,(W - A)]} \quad (4)$$

Where E = Economic development status
D = Population density
W= Total proportion of employed population
A = Total proportion of unskilled workers
(I.e. unemployed + agricultural labours + marginal workers/total population)

Result & Discussion: The land degradation/desertification vulnerability index is primary based on two basic parameters as: biophysical index and socio economic index. Within biophysical index another five sub parameters have been considered such as: climatic index, terrain index, vegetation index, soil index and land utilization index. Further these sub parameters are compiled in GIS environment and the final biophysical index or natural resource (NR) classes have been developed.

Climatic Index isevaluated based on annual average temperature, annual average rainfall and annual average relative humidity of the study area. The monthly rainfall ranges between 3 mm (lowest)in the month of March to 739 mm (highest) in the month of July. The calculated mean (µ) is 242.85 mm and standard deviation is (σ)[1] 320.94 m. The temperature varies from 17.66º C (lowest)in the month of January to 28.17º C (highest) in the month of July. The calculated mean (µ) is 24.43º C and standard deviation (σ) is 3.73º C. On the other hand relative humidity varies from 61.72%in the month of March to 83.11% in the month August with mean (µ) of 74.53% and Standard Deviation (σ) is 7.19%.

The Relative Humidity is evaluated with help of the following equation:

RH = (E/Es)*100 Where,
RH is relative humidity in percentage
E is actual vapor pressure[2] in mill bar (mbar)
Es is saturation vapor pressure[3] in mill bar (mbar)

The evaluation shows that around 21.06% of the total geographical area comes under level-I (very low), 24.67% is in level-II (low), 18.60% of area is in level-III and 27.67% of total geographical area comes under level-IV (high)

Terrain Index is based on slope, aspects and elevation of the study area. The slope is categorised as 0 to 5 degree as first level slope, 5 – 10 degrees gentle slope, 10 – 15 degree moderate slope, and 15 – 20 degreesteep slope and above 20 degree as very steep slope. As the district has hilly undulations7.32% of the total geographical area falls under very steep slope, subsequently 19.06% of area falls under 15 to 20 degree steep slopes, 16.12% area falls under 10 to 15 degree moderate slopes, 30.79% of area falls under 5 to 10 degree gentle slope and of 26.71% of area falls under 0 – 5 degree first level slope.

Vegetation Index is evaluated with help ofNDVI(Normalized Difference Vegetation Index technique).It is a simple graphical indicator that quantifies vegetation by measuring the difference between near infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). NDVI ranges between values -1 to +1.

The vegetation index is classified into five classes based on NDVI values as: very dense vegetation that covers 23.18% of total geographical area of the district followed by dense vegetation covers 28.01% of area, open vegetation that covers 18.70% of area, sparse vegetation covers 15.35% of area and very sparse vegetation covers 14.76% of total geographical area of the district.

Soil Index: The soil index is based on physical and chemical properties of soil. For the study the properties of soil depth, texture, soil erosivity, drainage density, soil water holding capacity and pH values are taken in to consideration. The soil index is primarily represents the land capability index of a particular area, which also represents the productive capacity of the soil. The generated land capability index shows that 7.32% of total geographical area comes under class 2 land capability class, 23.02% comes under class 3 land capability class, 22.39% comes under class 4 land capability class, 23.24% under class 5, 19.54% under class 7 and 4.49% of total geographical area comes under class 8 land capability class.

[1] High standard deviation indicates that the data points spread out over a wider range of values.

[2] Actual vapour pressure is a measurement of the amount of moisture in a volume of air.

[3] The saturation vapour pressure is the pressure of a vapour when it is in equilibrium with the liquid phase. It depends upon temperature; as the temperature rises the saturation vapour pressure rises as well.

Table: 1 Soil properties: West Khasi Hills

Soil index code	Description					
	Depth	Texture	Drainage intensity	Erosion intensity	pH	Soil Quality
1	>50	Fine, Fine Loamy	Very Low	Very Low	< 4.70	V. good
2	40 – 50	Sandy Clay Loamy, Coarse Loamy	Very Low to Low	Very Low to Low	4.70 – 4.90	Good
3	30 - 40	Loamy Skeletal	Low to Moderate	Low to Moderate	4.90 – 5.10	Moderate
4	15 - 30	Coarse Loamy, Loamy Skeletal	Moderate to High	Moderate to High	5.10 – 5.30	Poor
5	0 - 15	Sandy Skeletal	High to Very High	High to Very High	> 5.30	V. poor

Table: 2 Land capability: West Khasi Hills

Class	Description
I	Arable use, slight or nil limitation
II	Arable use, moderate limitation
III	Arable use, severe limitation
IV	Arable use, very severe limitation
V	Non arable use, slight or nil limitation
VI	Non arable use, moderate limitation
VII	Non arable use, sever limitation
VIII	Non arable use, very sever limitation

Subclass	Description
e	Soil erosion/loss of top soil, slope gradient
s	Soil depth/root penetration/drainage/salinity/sodicity
t	Topography/landform/landscape

Land Utilization Index: The land utilization index is the compilation of land use/land cover, NDVI (vegetation index), terrain index and land capability index. The extracted result is divided in three basic categories, underutilized, optimum utilized and over utilized. However settlement and water body are categorized separately and are not considered under land utilization index. Around 22.85% of total geographical lands are underutilized category, 73.78% of lands are optimally utilized and 3.73% of lands are over utilized by the locals for agriculture and other productive activities.

Biophysical Index/Natural Resource Index: The Biophysical Index/Natural Resource Index (NR) is the compilation of all physical parameters. The NR index of the present study is based on terrain index, land utilization index and climatic index. The NR index primarily represents the biophysical condition of that particular land area. It also represents the vulnerability priority zone in terms of available natural resources. The evaluated result shows that level 4 is the most vulnerable in terms of desertification vulnerability index as well is considered as very high priority zone, covers an area of 1291.28 sq.km (25.72%) of total geographical area. Followed by level 3, is considered as high priority zone covers 964.13 sq.km (19.20%), level 2 is considered as moderate priority zone covers 1181.48 sq.km (23.53%) and level 1 is considered as low priority zone, covers1583.90 sq.km (31.55%) of total geographical area.

Fig: 1 Natural resource classes; West Khasi Hills

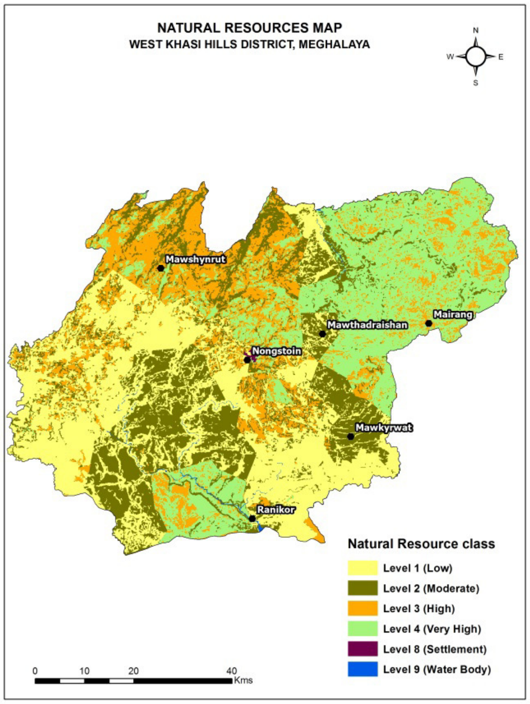
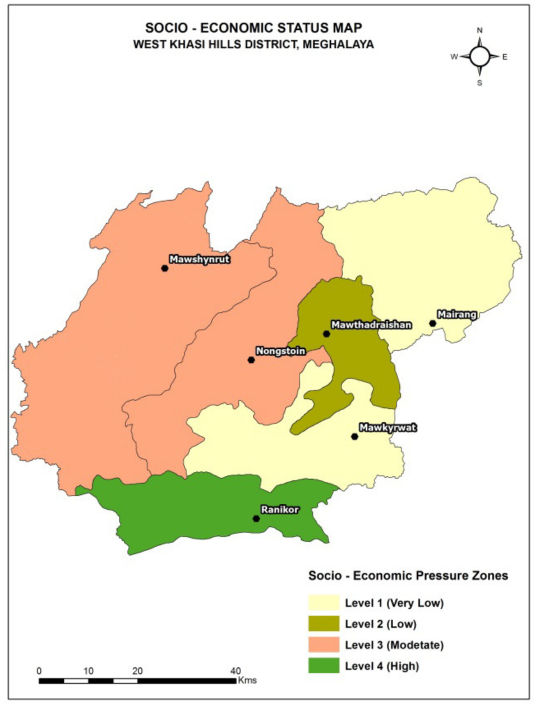


Fig: 2 Socioeconomic status: West Khasi Hills



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Socio-economic Index: The socio-economic index is based on broadly social index and economic development index. The social index emphasises on facility available, broadly categorised as; education, medical, transport and communication facility and calculated based on equation no 1, 2 and 3. It is evaluated separately for 5 different administrative blocks namely Ranikor, Mawshynrut, Nongstoin, Mawkyrwat, Mawtharaishan and Mairang. Education facility includes total 6 different types of amenities (primary, middle, secondary, senior secondary schools, colleges and adult literacy centres). The amenities index (Ic) for education varies from 0 (Nongstoin) to .10 (Mawshynrut). The medical facility includes total 13 different types of amenities (allopathic dispensary, maternity and child welfare, health centre, primary health centre, family welfare centre, registered private medical centre, subsidies medical practitioner, maternity home, community health works and other medical facilities). The amenities index for medical facility varies from 0 (Nongstoin) to .01 (Mawkyrwat and Mairang). The transport facility includes total 3 different types of amenities (bus service, railway service and navigable water ways). The amenities index for transport facility varies from 0 (Nongstoin) to .09 (Mairang). The communication facility includes 4 different types of amenities (post office, telegraph office, telephone connection and post and telegraph office). The amenities index for communication facility varies from 0 (Nongstoin) to .04 (Mairang).

The economic development index is emphasising on population density, proportion of employed population and unskilled workers. The economic development index of that calculated differently for all 5 different administrative blocks applying equation No. 4. The economic development index varies from 1.3 (Ranikor) to 2.2 (Mairang). Further compiling social index and economic development index the final output of socio-economic index is evaluated. *Here it is important to mention that, the assessment takes* *socio economic index as; high in socio economic development is low in population pressure and low in socio economic index high in population pressure .Which is fairly contradictory in itself.*

The extracted result shows that Mawkyrwat and Mairang blocks are most developed in terms of socio-economic conditions. Both blocks are having very low socio-economic pressure. It is followed by Mawthadraishanblock with low socio- economic pressure. Mawshynrut and Nongstoin blocks are categorised moderate socio-economic pressure zone. Whereas Ranikor is the least developed block in terms of socio-economic condition and categorised as high socio-economic pressure zone.

Desertification Vulnerability Index: It isbasically the compilation of biophysical index and socio-economic index. The estimated values of desertification vulnerability are showing that 13.78% of land area falls under very low vulnerability, 39.80% of land is low vulnerability and 34.93% of land falls under moderate vulnerability. On the other hand only 4.34% of land falls under high vulnerability and 7. 15% of land area falls under very high vulnerability.

Table: 4 Desertification vulnerability Index: West Khasi Hills

Index Code	Desertification Vulnerability	Area in sq. km	Area in %
1	Very Low	691.97	13.78
2	Low	1998.04	39.80
3	Moderate	1753.77	34.93
4	High	217.88	4.34
5	Very High	359.12	7.15

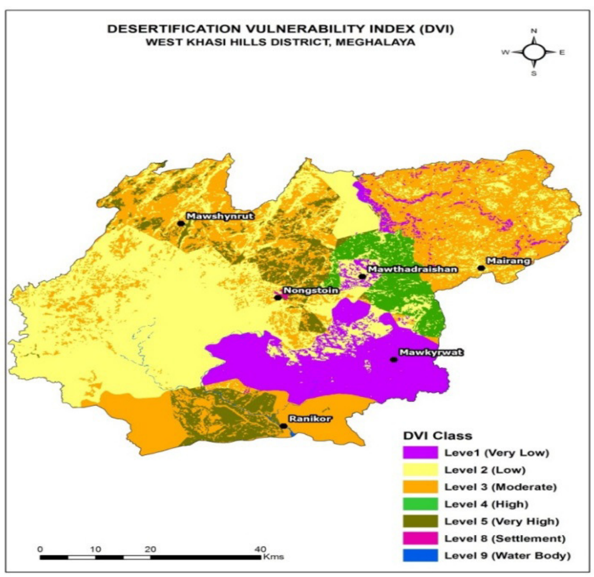

Fig: 3. Desertification Vulnerability Index of West Khasi Hills

Conclusion: The present study shows that 2330.77 sq.kms of land areais under the process of moderate to very high desertification vulnerability, whereas 2690.01 sq.kms of land area falls under low to very low desertification vulnerability. However comparing to other parts of the India, the rate of severity is low. *In this study settlement and water bodies are not taken as a part of vulnerable areas and labelled as level 8 (settlement) and level 9 (water body)*

To determine the efficiency of the method further the study hascompared the land degradation/desertification vulnerability index with desertification/land degradation status map of West Khasi Hills for the year 2011-2013 (Desertification and Land Degradation Atlas of Selected Districts of India Volume – 2, 2018), it is found that most of the moderate and high vulnerable areas covered by forest/plantation and scrubs i.e. undergoing vegetation degradation (level 2 & level 3). In terms very high vulnerability the result indicates areas fall under Nongstoin and Ranikor CD block covered by forest/plantation and scrubsi.e. undergoing accordingly vegetation degradation (level 2 & level 3) and water erosion (level 2). However the Mawkyrwat CD block i.e. primary scrubland and undergoing vegetation degradation level 3, according vulnerability index it falls under very low vulnerability index.

The study also has observed that as; MWI method prominently focused and weighted areas that are socio economically evaluated as less developed can actually manipulate the final result and also nullifies the method in some cases.

Thus one can say that the methodology and results of MWI (Modified Weighted Index)shows a probabilistic scenario regarding land degradation/desertification vulnerability but results may contradict in terms of ongoing current scenario. It needs further periodic observation,analysis and revised methodology to evaluate the severity of the degradation processes and assess the vulnerability to establish whether or not the land is actually converting to dry land and losing its original productivity.

References:

1. Agnew, C., & Warren, A. (1996). A framework for tackling drought and land degradation. *Journal of Arid Environments*, *33*(3), 309-320.
2. Assessment, M. E. (2005). Ecosystems and human well-being (Vol. 5, p. 563). United States of America: Island press.
3. Akbari, M., Ownegh, M., Asgari, H. R., Sadoddin, A., &Khosravi, H. (2016). Desertification risk assessment and management program. *Global Journal of Environmental Science and Management*, *2*(4), 365-380.
4. Arya, A. S., Dhinwa, P. S., Pathan, S. K., & Raj, K. G. (2009). Desertification/land degradation status mapping of India. *Current Science*, 1478-1483.
5. Barrow, C. J. (1991). *Land degradation: development and breakdown of terrestrial environments*. Cambridge University Press.
6. Blaikie, P., & Brookfield, H. (2015). *Land degradation and society*. Routledge.
7. Bullock, P., Le Houérou, H., Hoffman, M. T., Rounsevell, M. D. A., Sehgal, J., &Várallay, G. (1995). Land degradation and desertification. *Climate change*, 173-189.
8. Bora. A., Mipun. B.S., Parmar. M., (2021). Potency of Modified Weighted Index Analysis for Land degradation /desertification vulnerability Index: A case study on Golaghat District, Assam, India. *International Journal of Research Publication and Reviews. 2 (9),* 328-334
9. Dharumarajan, S., Bishop, T. F., Hegde, R., & Singh, S. K. (2018). Desertification vulnerability index—an effective approach to assess desertification processes: A case study in Anantapur District, Andhra Pradesh, India. *Land Degradation & Development*, *29*(1), 150-161.
10. Fleskens, L., & Stringer, L. C. (2014). Land management and policy responses to mitigate desertification and land degradation. *Land degradation & development*, *25*(1), 1-4.
11. Geist, H. (2017). *The causes and progression of desertification*. Routledge.
12. Higginbottom, T. P., &Symeonakis, E. (2014). Assessing land degradation and desertification using vegetation index data: Current frameworks and future directions. *Remote Sensing*, *6*(10), 9552-9575.

13. Hooke, J., &Sandercock, P. (2012). Use of vegetation to combat desertification and land degradation: Recommendations and guidelines for spatial strategies in Mediterranean lands. *Landscape and Urban Planning*, *107*(4), 389-400.
14. Imeson, A. (2012). *Desertification, land degradation and sustainability*. John Wiley & Sons.
15. Pashaei, M., Rashki, A., &Sepehr, A. (2017). An Integrated Desertification Vulnerability Index for Khorasan-Razavi, Iran. *Natural Resources and Conservation*, *5*.
16. Sapace application centre, Indian space research organization, Government of India, Ahmadabad (2018) *"Desertification and land degradation atlas of selected district of India"*. 2 (46-48)
17. Song, C., Lee, E. J., Yoo, S., Lim, C. H., Lee, S. J., & Lee, W. K. (2016, December). Land Degradation and Desertification Vulnerability Assessment under Land Changes with MEDALUS approach in Ethiopia. In *AGU Fall Meeting Abstracts*.
18. Stocking, M. A., &Murnaghan, N. (2013). *A handbook for the field assessment of land degradation*. Routledge.
19. Stringer, L. C., & Reed, M. S. (2007). Land degradation assessment in southern Africa: integrating local and scientific knowledge bases. *Land Degradation & Development*, *18*(1), 99-116.
20. Symeonakis, E., & Drake, N. (2004). Monitoring desertification and land degradation over subSaharan Africa. *International Journal of Remote Sensing*, *25*(3), 573-592.
21. Türkeş, M. (1999). Vulnerability of Turkey to desertification with respect to precipitation and aridity conditions. *Turkish Journal of Engineering and Environmental Sciences*, *23*(5), 363-380.
22. Türkeş, M., &Akgündüz, A. S. (2011). Assessment of the desertification vulnerability of the Cappadocian district (Central Anatolia, Turkey) based on aridity and climate-process system. *Journal of Human Sciences*, *8*(1), 1234-1268.
23. Warren, A., & Agnew, C. (1988). An assessment of desertification and land degradation in arid and semi-arid areas. *London: IIED 72p. En IIED Drylands Programme, Drylands Paper*, (2).