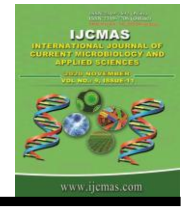
Int.J.Curr.Microbiol.App.Sci (2020) *9*(11): 1683-1691

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 11 (2020)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2020.911.201

Land Potentiality Investigation for Agroforestry Purpose using Remote Sensing and GIS

Firoz Ahmad[1], Mohammad Shujauddin Malik[1], Shahina Perween[1], Nishar Akhtar[1*], Nazimur Rahman Talukdar[2,3], Prakash Chandra Dash[4], Sunil Pratap Kumar[5], Laxmi Goparaju[5], Firoz Ahmad[5] and Abdul Qadir[6]

[1]*Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India*
[2]*Wildlife Conservation Laboratory, Department of Ecology and Environmental Science, Assam University, Silchar, India-788011*
[3]*Centre for Biodiversity and Climate Change Research, Udhayan, Hailakandi-788155, Assam*
[4]*Xavier Institute of Social Service (XISS), Ranchi, Jharkhand*
[5]*Vindhyan Ecology and Natural History Foundation, Mirzapur, Uttar Pradesh, India*
[6]*Department of Geography, Punjab University, Chandigarh-160014, Punjab, India*
**Corresponding author*

Keywords

Land potentiality, Remote sensing & GIS, Soil fertility, soil wetness, Jharkhand

Article Info

Accepted:
12 October 2020
Available Online:
10 November 2020

A B S T R A C T

The study applied the soil, land and topographic data for analyzing the potentiality of land for trees /crops suitability in the Gumla district of Jharkhand, India. The remote sensing, GIS and GIS modeling techniques were used to achieve the goal. The soil fertility, soil wetness, and slope map are scientifically produced and integrated to find out the landscape suitable categories for prioritization of trees/crops scaling in the agroforestry domain. Additionally, we have examined the drift of loss of soil wetness using satellite data from monsoon to post-monsoon period up to the village level. The analysis logically revealed the potentially suitable landscape (28%: high; 38%: medium; 25%: low and 9%: very low) for tree/crop farming. The seasonal drift of soil moisture loss after monsoon season was found highest in village Mahugaon followed by Pahladpur, Jalka, Itkiri, Shiwserang, and Gamhariya. Furthermore, 40% of the total villages of the study area showed soil wetness loss from medium to very high during the same base period which needs intensive soil and water conservation measures at the watershed level to conserve seasonal rainwater. These efforts will improve the soil moisture and water availability for plants and support significantly in extending agroforestry exercise/design/ management locally. Such analysis/results are one of the potential research gaps can be harnessed for the betterment of cultivators/farmers in the tribal-dominated region using local knowledge for designing appropriate agroforestry practices/models and can be incorporated in various ongoing and future projects.

Introduction

The ICRAF has defined the agroforestry as “the collective name for land-use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit.” (Leakey, 1996)

Why agroforestry is important?

It has the capacity to improve livelihood and mitigate poverty significantly among the rural people by enhancing the diversified output such as food, fruit, fodder, fuel, fertilizer and fibre by exploring the indigenous traditional knowledge. Additionally, it meaningfully support rural invention plan by addressing the multifunctional goal of income generation, employment and food security which is the backbone of Indian economy.

It's one of the successful environmentally positive alternatives to mitigation strategies to fight with the climate and environmental change impact.

Agroforestry bringing the resources of the forest onto the farmland thus prevent deforestation, enhance the soil quality, ameliorating air/water quality and magnify biodiversity.

Due to advancements in computer science, the availability of remote sensing and GIS datasets and improvement in various scientific/logical approaches in diversified studies in recent times has magnified the mapping technique several-fold. The application of computer science can be significantly supported in the agricultural revolution by encouraging farm management by improving production (Paarlberg and Paarlberg, 2000). A GIS-based database management approaches are used in the past for agroforestry planning and tree selection (Ellis *et al.,* 2000). Successful planning and design of agroforestry management practices link on the ability to pull together very diverse and sometimes large sets of several spatial scales information (Ellis *et al.,* 2004). Such design can be utilized in the decision-making process for modeling agroforestry related study at the local, regional and global levels (Ritung *et al.,* 2007; Reisner *et al.,* 2007; Zomer *et al.,* 2014; Ahmad *et al.,* 2018a). Such analysis /investigation/ results have the enormous potential to support crucially the agroforestry policy of India (NAP, 2014) and building resilient landscapes for achieving various sustainable development goals (SDGs) set by FAO (http://www.fao.org/sustainable-development-goals/en/).

The study area selected is the Gumla district of Jharkhand state of India because of the adequate dominance of ethnic tribes and the majority of people suffering from diminishing livelihood, poor income, and drought (Ahmad *et al.,*2018c) will be greatly benefited from our research findings if applied at the local level.

The objective of the study is to apply the soil, land and topographic data using remote sensing, GIS and GIS modeling techniques for analyzing the potentiality of land for trees /crops suitability towards agroforestry in Gumla district of Jharkhand, India. The study further investigated the seasonal drift of soil moisture up to the village level.

Materials and Methods

The study area

The study area Gumla is one of the tribal-dominated districts of state Jharkhand have geographical coordinates with latitude 22 º 42' 02" N to 23 º 36' 29"N and longitude 84º 01' 51"E to 85º 00' 56" E and surrounded by the districts of Latehar and Lohardaga in the north, by the districts of Ranchi and Khunti on the east, by the district of Simdega on the south and by the State of Chhattisgarh on the west. The study area is full of hills and a hillock with elevation varies from 385 to 1130 m from the mean sea level with the highest land area is Netarhat. The annual mean temperature is about 23 °C whereas annual rainfall varies from 1400 to 1600 mm (Kumar *et al.,* 2018). There are three main rivers such as South Koyel, the North Koel and the Sankh flow in this area. The majority of land soil is laterite with low soil fertility. The major occupation of the people is agriculture, animal rearing, NTFP, and mining activities. Agriculture activities in the farm are threatened due to drought/poor soil moisture/climate change impact. The climate changes have a significant impact on tribal people (Minj, 2013) because of their weak adaptive capacity. The agriculture activities are mainly monsoonal rain based supported by poor irrigation facility whereas the availability of fodder to the animal is low to very low especially in the villages which are away from the forest area. The migration of people from rural areas to the city is highest in this district (Singh *et al.,* 2007) because of the weak socio-economic condition mainly due to industrial backwardness with diminishing livelihood and poor income/ employment source. The approximately one-fourth of the areas are surrounded by forest which is gradually degrading due to continuous mining activity and/or conversion of the forest land to agriculture purposes. The major tree species are sal (*Shorearo busta*), mahua (*Madhuca longifolia*), asan (*Terminalia tomentosa*), gamhar (*Gmelina arborea*), simal (*Bombax ceiba*) mango (*Mangifera indica*), neem (*Azadirachta indica*), etc. are generally found whereas mahua and sal trees are deeply associated with the tribal life and their festival.

Data preprocessing and analysis

The data used for this study were Landsat satellite data, ancillary soil data (N, P, K, Organic Carbon and soil pH), and ASTER DEM.

For this study downloaded the soil data from the website provided by State Agriculture Management & Extension Training Institute, Jharkhand. (https://www.sameti.org/Soil_Inventory/Gumla_Soil_Map.pdf) and rest from the portal of the USGS website (https://earthexplorer.usgs.gov/.).

Additionally, we have used the village boundary (Meiyappan *et al.,* 2018) and the district boundary of Gumla (https://www.diva-gis.org/gdata) to carry out our analysis/result. All five types of soil maps were rectified with district boundaries and were brought into to GIS domain (Ahmad *et al.*, 2017a). In each soil map, the various soil categories were digitized and polygon ids were given (Ahmad and Goparaju, 2017b).

The soil fertility map (Figure 6) was generated by integration of all soil layers (Figure 1 to Figure 5) by giving equal weight to all. We have used the formula provided by Baig *et al.,* (2014) mentioned in Ahmad & Goparaju (2017a) for deriving the wetness map (Figure 7).

DEM was used to generate the slope map (Figure 8). The Erdas imagine and ARC/GIS software was used to bring various datasets to the right format to execute our objective meaningfully.

Land potentiality mapping for agroforestry

The potential layers such as soil fertility, soil wetness and slope map which play a significant role in plant nutrient regulation and their metabolic activity for adequate growth are integrated logically in the GIS domain for achieving the final agroforestry suitability map (Ahmad *et al.,* 2018a). The final map was categorized into few groups (high, medium, low and very low) based on the range (minimum to maximum) surface values (Ahmad *et al.,* 2018b). The higher value represents high tree/ crop suitability whereas the lower value least suitability.

Results and Discussion

Agroforestry planning in term of trees/crops harvesting are delicately linked to agro-climatic attributes (Ekka *et al.,* 2019) and can be delineated because of its spatial characterization. The potential spatial layers such as integrated soil fertility status map, satellite-derived wetness map and slope map which plays a significant role for trees/crop growth in various agroforestry set-up. The final integrated agroforestry suitability map (Figure 9) generated have 1527, 2012, 1317 and 472 square kilometer landscape area suitable as high, medium, low and very low respectively for trees/crops growth. A similar observation of potentially suitable sites for agroforestry was identified by Ahmad *et al.*, 2017b. The land potential areas concerning agroforestry suitability categories are given in the graph (Figure 10).

Table.1 Landsat 8 OLI data and its specification

Satellite	Sensor	Path/ Row	Dates
Landsat 8	OLI_TIRS	141/44	29-09-2018
Landsat 8	OLI_TIRS	141/44	30-01-2019

Fig.1 Soil Nitrogen map

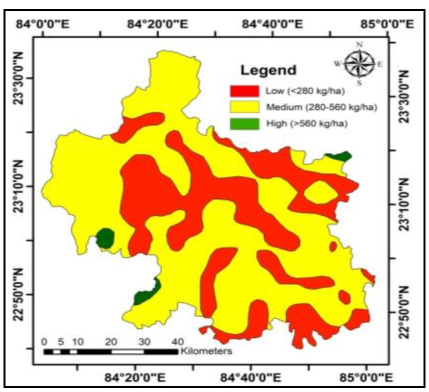


Fig.2 Soil Phosphorus map

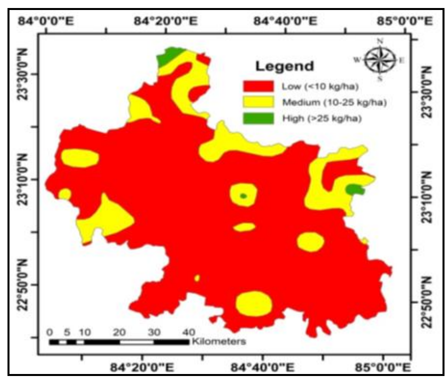


Fig.3 Soil Potassium map

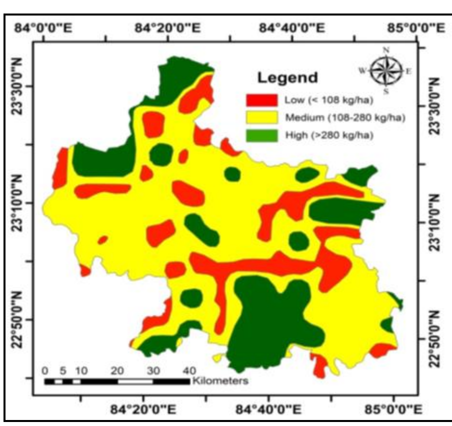


Fig.4 Soil Organic carbon % map

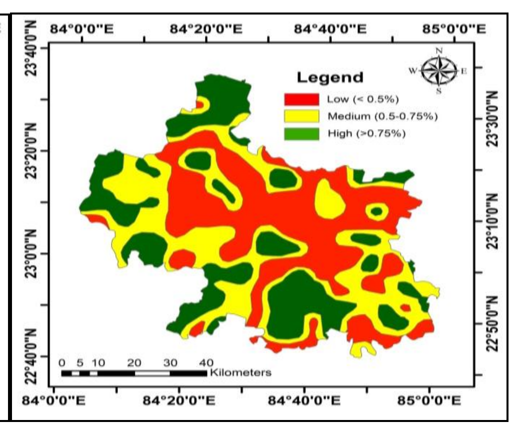


Fig.5 Soil pH map

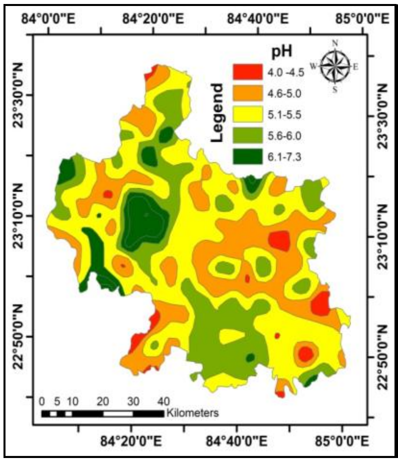


Fig.6 Soil Fertility map

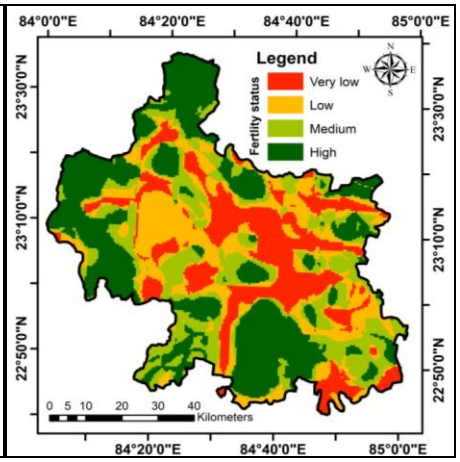


Fig.7 Wetness map

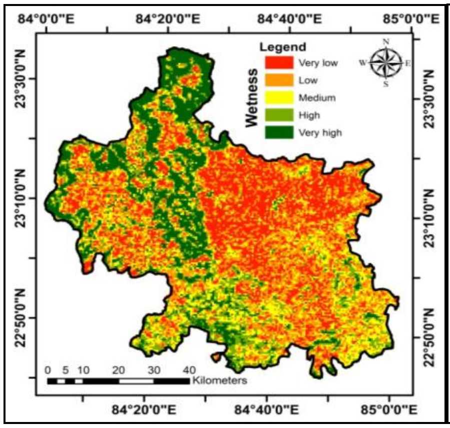


Fig.8 Slope map

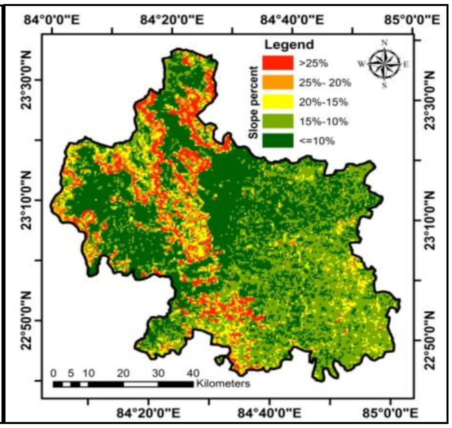


Fig.9 Tree crop suitability of the landscape for agroforestry

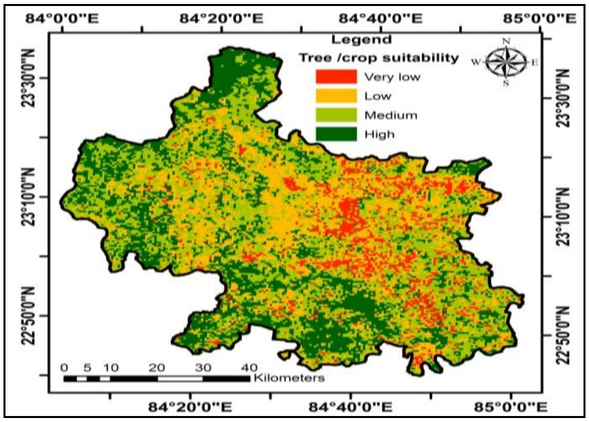


Fig.10 Landscape potentiality percent towards agroforestry

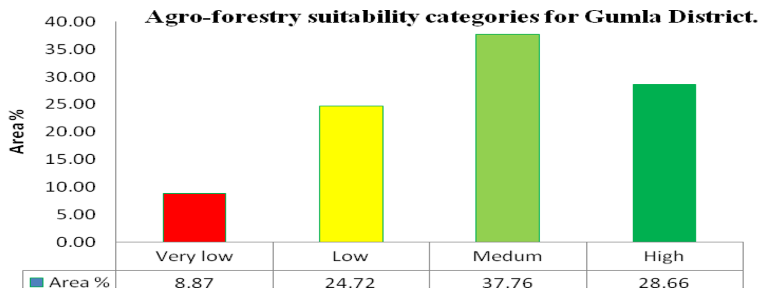
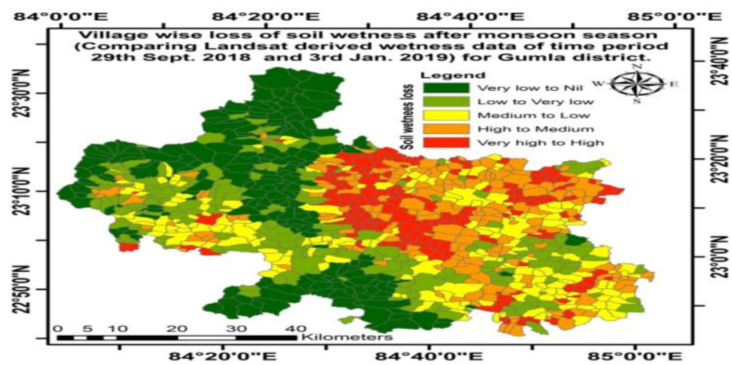


Fig.11 Post monsoon drift of soil wetness in term of loss at village level



The majority of potentially suitable landscape areas are found in plain (low slope) have high soil fertility with adequate soil wetness. The high soil fertility is due to the dominance of nitrogen (N), phosphorus (P) and potassium (K) which required by the plant in large amounts for their growth. Furthermore, adequate soil organic carbon % helps to releases nutrients for plant growth by improving the soil structure and function whereas suitable soil pH range facilitates the essential soil nutrient availability to the plants/crops. The soil wetness/moisture is a significant factor for plant growth whereas their optimal presence improves the nutrient uptake in it. The seasonal drift of soil moisture loss after the monsoon season is common although the study area receives adequate precipitation (> 900 mm) during the monsoon season (Ekka *et al.*, 2019). We have used two times (monsoon period and post-monsoon period) satellite data and evaluate their wetness spatial pattern up to the village level is given in figure 11.

The soil wetness loss was found highest in village Mahugaon followed by Pahladpur, Jalka, Itkiri, Shiwserang, and Gamhariya. Approximately 40% of the total villages (952 villages) showed soil wetness loss from medium to very high after the monsoon season is a matter of serious concern. There is a need for low cost appropriate relevant technology utilizing the indigenous knowledge of soil and water conservation at watershed management level such as small check dam and water harvesting structure will improve soil moisture and simultaneously conserve seasonal rainwater (http://www.fao.org/3/a-bl061e.pdf) which will change the cropping pattern on farmland for agroforestry practices (Dey, 2016; Ahmad and Goparaju 2017a). Such conservation effort by Simon Oraon a renowned environmentalist has already set the best example to bring the landscape area as horticulture hub in adjacent Bero block of Ranchi district of Jharkhand (Garg, 2019) which enhanced the livelihood/income among tribal people locally and reduced poverty significantly. Some of the villages such as Nagar, Pugu, Bharno, Chainpur and Bargaon have the high number of tribal population and suffering from poverty/diminishing livelihood need to be prioritized urgently for extending agroforestry practices. The high suitable landscape can be planned for the Agri-silvi-horticulture system. During kharif season with paddy crop various tree species such as *Gmelina arborea*, *Dalbergia sissoo*, *Acacia auriculiformis*, *Melia azadirachta*, *Schleicheraoleosa*, *Moringa oleifera*, *Terminaliaarjuna*, *Bamboo spp*. with fruit tree species such as *Mangifera indica*, *Psidium guajava* and *Carica papaya* etc. with vegetables such as french beans (*Phaseolus vulgaris*), potato (*Solanum tuberosum*), cauliflower (*Brassica oleracea*), brinjal (*Solanum melongena*), tomato (*Solanum lycopersicum*), cabbage (*Brassica oleracea*), okra (*Abelmoschus esculentus*) etc. can be grown in this landscape based on *in situ* topography and farmer's socio-economic needs (Kumar *et al.*, 2018). The medium suitable area can be utilized for Agri-silviculture system with some additional provision of irrigation in off monsoon season for adequate soil moisture to farm crops and trees. The low and very low suitable landscape can be utilized for Silvipastoral system with fast-growing tree species that suit the local arid climatic conditions because of the land have least soil moisture availability/soil fertility with complex terrain features.

In conclusion the successful planning and design of agroforestry management practices need to pull together very diverse and sometimes large sets of information at various spatial scales. GIS-based database management supported by high-end geospatial datasets and advance remote sensing/GIS software with logical approaches for modeling for agroforestry related study at the local, regional and global levels that need a highly skilled scientific perspective and support the significantly policy-related decision-making process.

Here in this study, we have examined the land potentiality for trees/crop suitability for agroforestry purposes utilizing the remote sensing/GIS and GIS modeling technique as a methodological approach with the use of soil, land and topographic data in tribal-dominated Gumla district of Jharkhand, India. The study further investigated the soil wetness loss up to the village level from monsoon to post-monsoon time.

The analysis revealed approximately two-third of the landscape of the study area is medium to high suitability for tree/crop farming. The analysis further revealed the soil wetness/moisture loss after the monsoon season is very significant. 40% of the total villages showed soil wetness loss from medium to very high between September to January. There is a need for conserving the seasonal rainwater by adequate soil and water conservation mechanism at a watershed level which in the majority of the case goes in vain and drained to the river during the monsoon period. Such an effort will enhance water in non-perennial river/streams and increase soil moisture for a longer period and will support water availability to different plants/crops in various agroforestry models at the local level. The appropriate agroforestry design needs the adequate endorsement of local community/farmers as per the socio-economic, cultural and environmental requirement to scaling up at village-based extension approaches which will provide diversified agroforestry products such as fruit, food trees, and fodder for livestock, that contribute significantly to enhance the rural livelihoods.

Acknowledgements

The authors are grateful to the USGS for free download of Landsat and DEM (ASTER) data and DIVA GIS website for required GIS layers.

References

Ahmad, F. & Goparaju, L. (2017b) Geospatial Approach for Agroforestry Suitability Mapping: to Enhance Livelihood and Reduce Poverty, FAO Based Documented Procedure (Case Study of Dumka District, Jharkhand, India). Biosci Biotech Res Asia; s14 (2). http://dx.doi.org/10.13005/bbra/2491

Ahmad, F. and Goparaju, L. (2017a) Land Evaluation in terms of Agro forestry Suitability, an Approach to Improve Livelihood and Reduce Poverty: A FAO based Methodology by Geospatial Solution: A case study of Palamu district, Jharkhand, India. Ecological Questions, 25(2017), pp.67-84. http://dx.doi.org/10.12775/EQ.2017.006

Ahmad, F., Goparaju, L. &Qayum, A. (2017b) FAO guidelines and geospatial application for agroforestry suitability mapping: case study of Ranchi, Jharkhand state of India Agroforest Syst 93: 531. https://doi.org/10.1007/s10457-017-0145-y

Ahmad, F., Goparaju, L. &Qayum, A. (2017a) Agroforestry suitability analysis based upon nutrient availability mapping: a GIS based suitability mapping. AIMS Agriculture and Food, 2017, 2(2): 201-220. https://doi.org/10.3934/agrfood.2017.2.201

Ahmad, F., Uddin, M. M., and Goparaju, L. (2018b) Assessment of remote sensing and GIS application in identification of land suitability for agroforestry: A case study of Samastipur, Bihar, India. Contemporary Trends in Geoscience, 7(2), 214–228. https://doi.org/10.2478/ctg-2018-0015

Ahmad, F., Uddin, M.M. and Goparaju, L. (2018a) Agroforestry suitability mapping of India: geospatial approach based on FAO guidelines AgroforestSyst 93: 1319. https://doi.org/10.1007/s10457-018-0233-7

Ahmad, F., Uddin, M.M. and Goparaju, L. (2018c) An evaluation of vegetation health and the socioeconomic dimension of the vulnerability of Jharkhand state of India in climate change scenarios and their likely impact: a geospatial approach. Environmental & Socio-economic Studies 6(4), 39–47. https://doi.org/10.2478/environ-2018-0026

Kumar, A., Sah, R.B., Singh, B. K. &Oraon, P.R. (2018) Socioeconomic Analysis of Tribal Farmers in the Gumla District of Jharkhand from Existing Agroforestry Practices. Int.J.Curr.Microbiol.App.Sci. 7(06): 595-604. doi: https://doi.org/10.20546/ijcmas.2018.706.068

Baig, M.H.A., Zhang, L., Shuai, T. and Tong, Q. (2014) Derivation of a tasselled cap transformation based on Landsat 8 at-satellite reflectance. Remote Sensing Letters 5: 423–431. https://doi.org/10.1080/2150704X.2014.915434

Dey, S., (2016) Jharkhand's waterman gets Padma Shri for waging war against drought. (http://www.hindustantimes.com/india/jharkhand-s-waterman-gets-padma-shri-for-waging-war-against-drought/story-7PgYljQmbDBeahSVg4gjrJ.html) Accessed on 15th May 2019.

Ekka, A P., Kumari, P., Kumar, S, B., Wadood, A. & Kumar P. V. (2019) Agroclimatic Characterization and Crop Planning for Gumla District of Jharkhand, Department of Agrometeorology and Environmental

Science, Birsa Agricultural University, Kanke, Ranchi, pp 44

Ellis, E., Bentrup, G. and Schoeneberger, M. (2004) Computer-based tools for decision support in agroforestry: Current state and future needs Agroforestry Systems 61: 401. https://doi.org/10.1023/B:AGFO.0000029015.64463.65

Ellis, E.A., Nair, P.K., Linehan, P.E., Beck, H.W. and Blanche, C.A. (2000) A GIS-based database management application for agroforestry planning and tree selection. Computers and Electronics in Agriculture27: 41-55. https://doi.org/10.1016/S0168-1699(00)00095-8

Garg, V. (2019) Meet Simon Oraon, Jharkhand's unsung waterman who alone fought water crisis and built canals in village. (https://newsd.in/meet-simon-oraon-jharkhands-unsung-waterman-who-alone-fought-water-crisis-and-built-canals-in-village/) Accessed on 25th October 2019.

Leakey, R.R.B. (1996) Definition of agroforestry revisited, *Agroforestry Today*, 8(1), 5-7.

Meiyappan, P., Roy, P. S., Soliman, A., Li, T., Mondal, P., Wang, S. and Jain, A. K. (2018). India Village-Level Geospatial Socio-Economic Data Set: 1991, 2001. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4CN71ZJ

Minj, H. P. (2013). Social dimension of climate change on tribal societies of Jharkhand. *International Journal of Social Science & Interdisciplinary Research*, 2(3), 34–41.

NAP (2014) National Agroforestry Policy, Government of India. (http://www.indiaenvironmentportal.org.in/files/file/Agroforestry%20policy%202014.pdf) Accessed on 10th October 2019.

Paarlberg, D. and Paarlberg, P.(2000). Agricultural Revolution of the 20th Century. *Iowa State University Press, Ames, IA.* 154 pp.

Reisner, *Y*., de Filippi, R., Herzog, F. and Palma, J. (2007) Target regions for silvoarable agroforestry in Europe. *Ecological engineering* 29: 401–418.

Ritung, S., Wahyunto, F.A. and Hidayat, H., (2007) Land Suitability Evaluation with a case map of Aceh Barat District. Indonesian Soil Research Institute and World Agroforestry Centre, Bogor, Indonesia.

Singh, A., Rout,N.R.&Pradhan.M.R (2007). Migration in Jharkhand: A District Level Analysis. Journal of Empirical Research in Social Sciences. 2. 63 - 81. https://www.researchgate.net/publication/252626926_Migration_in_Jharkhand_A_District_Level_Analysis

Zomer, R.J., Trabucco, A, Coe, R., Place, F., van Noordwijk, M., Xu, J.C. (2014) Trees on farms: an update and reanalysis of agroforestry's global extent and socio-ecological characteristics. Working Paper 179.Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. DOI: 10.5716/WP14064.PDF

How to cite this article:

Firoz Ahmad, Mohammad Shujauddin Malik, Shahina Perween, Nishar Akhtar, Nazimur Rahman Talukdar, Prakash Chandra Dash, Sunil Pratap Kumar, Laxmi Goparaju, Firoz Ahmad and Abdul Qadir. 2020. Land Potentiality Investigation for Agroforestry Purpose using Remote Sensing and GIS. *Int.J.Curr.Microbiol.App.Sci.* 9(11): 1683-1691.
doi: https://doi.org/10.20546/ijcmas.2020.911.201