Satiprasad Sahoo ***Curriculum Vitae***

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RESEARCH INTERESTS

- Remote Sensing
- Geographic Information System
- Agricultural Hydrology
- Groundwater Hydrology
- Watershed Monitoring and Development
- Geomorphology
- Effect of Climate Change
- Environmental Impact Assessment

EDUCATION

Indian Institute of Technology Guwahati, Assam, INDIA (Aug' 19 - Present)

Pursuing Postdoctoral Fellow in the Centre for Environment

Supervisor:

- Dr Anamika Barua, Associate Professor, Department of Humanities and Social Sciences, Indian Institute of Technology Guwahati, Guwahati- 781039, INDIA.

Jadavpur University, Kolkata, INDIA (2017 -2019)

Doctor of Philosophy in the Department of Civil Engineering under Faculty of Interdisciplinary Studies, Law & Management

Thesis Title: Impact of Climate Change and Anthropogenic Interventions on Hydro-Environmental Regime of Dwarakeswar-Gandheswari River Basin

Supervisors:

- Dr. Anupam Debsarkar, Associate Professor, Department of Civil Engineering, Jadavpur University, Kolkata- 700032, INDIA

- Dr. Anirban Dhar, Associate Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur- 721302, INDIA.

Indian Institute of Technology Kharagpur, Kharagpur, INDIA

M.S. (by Research) in Water Resources (2013 -2016)

CGPA: 9.04/10

Thesis Title: Evaluating the Effectiveness of Methods for Identification of Groundwater Potential, Vulnerability and Environmental Vulnerability Zones

Supervisor: Dr. Anirban Dhar, Associate Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur- 721302, INDIA

C.S.J.M. University, Kanpur, INDIA

M.Sc. in Geography (2011 -2013)

Marks (%): 61.33

Division: First Class

Vidyasagar University, Midnapore, INDIA

M.Sc. in Remote Sensing & Geographic Information System (2009 -2011)

Marks (%): 75.58

Division: First Class

Dissertation Title: Remote Sensing & GIS Application for Hydrological Modeling of Lower Ganga River Basin

Supervisor: Dr. Anirban Dhar, Associate Professor, Department of Civil Engineering, Indian Institute of Technology Kharagpur, Kharagpur- 721302, INDIA

University of Calcutta, Kolkata, INDIA

B.Sc. in Geography (2006 -2009)

Marks (%): 51.25

Division: Second Class

WBCHSE HS (2004 -2006), West Bengal, INDIA

Marks (%): 68.10

Division: First Class

WBBSE (2004), West Bengal, INDIA

Marks (%): 65.25

Division: First Class

Professional Experience

June, 2016 - March, 2019: Project Officer in the consultancy project entitled "Morphological Studies of Rivers Mahanadi, Mahananda and Hooghly (RMAH)" sponsored by Central Water Commission Morphology Directorate, Government of India, 906 (S), Sewa Bhawan, R.K Puram, New Delhi, undertaken in the School of Water Resources, Indian Institute of Technology Kharagpur, INDIA.

May, 2013 - June, 2016: Project Assistant in the research project entitled "Efficiency Study of Damodar Left Bank Irrigation System and Strategies for Integrated Command Area Water Management (DIW)", sponsored by MWR, New Delhi, undertaken in the Department of Civil Engineering, Indian Institute of Technology Kharagpur, INDIA.

Field Experience

- Impact of Climate Change and Anthropogenic Interventions on Hydro-Environmental Regime of Dwarakeswar-Gandheswari River Basin, 2017-2018.
- Morphological Studies of Rivers Mahanadi, Mahananda and Hooghly using Remote Sensing Techniques, 2017-2018.
- The Decision Support System in coastal management use in Geoinformatics and Spatial analysis of coastal system along Puri, Chilika shoreline, 2010.
- Geo Cultural Landscape of Adivivaram at Simhachalam, Vishakhapatnam, Andhra Pradesh, 2008.

Software Skills

- Arc GIS
- ERDAS Imagine
- ENVI
- PCI Geomatica
- QGIS
- Arc View
- Adobe Photoshop

Modelling Skills

- SWAT (Soil & Water Assessment Tool)
- J2000 (Hydrological Model)
- MODFLOW (Modular Finite-Difference Flow Model)
- Dyna Clue (Land Use Model)
- SDSM (Statistical DownScaling Model)
- WEAP (Water Evaluation And Planning System)

Instrument Acquated With

- Total station
- Theodolite
- Prismatic Compass
- Stereoscope
- Global Positioning System (GPS)
- Eco-sounder
- Barometer
- Hygrometer

Computer Skills

- MATLAB

Professional training

- Foundation course in Remote Sensing & GIS (3 months), Twentyfirst Century Solutions, Kolkata

Communication Skills

- Fluency in English, Hindi & Bengali.

Book Publication

Sahoo, S. and Dhar. A. (2017). Index Based Groundwater Potential and Vulnerability Assessment. Scholar Press, Copyright @2017 OmniScriptum Gmbh &Co. KG, Heinrich-B @cking-str. Saarbr @cken, Germany, ISBN: 978-3-659-84398-3.

Refereed Journal Publications

1. **Sahoo, S.**, Dhar, A., Debsarkar, A., Kar, A. and Kayet, N. "Identification of water-stressed area based on the interrelationship of soil moisture and seasonal rice cultivation "*Paddy and Water Environment*, DOI:10.1007/s10333-019-00774-7, 2019.[**Springer, SCI Impact Factor: 1.264**]
2. Chakraborty, S., **Sahoo, S.**, Majumdar, D., Saha, S. and Roy, S." Future Mangrove Suitability Assessment of Andaman to strengthen Sustainable Development" *Journal of Cleaner Production*, 234, 597-614, 2019. [**Elsevier, SCI Impact Factor:- 6.395**]
3. Kayet, N., Pathak, K., Chakraborty, A., Singh, C.P., Chowdary, V.M., Kumar, S. and **Sahoo, S**. "Forest health assessment for geo-environmental planning and management in hilltop mining areas using Hyperion and Landsat data" *Ecological Indicators*, 106,105471, 2019. [**Elsevier, SCI Impact Factor:- 4.490**]
4. **Sahoo, S.**, Dey. S., Dhar, A., Debsarkar, A. and Pradhan, B. "On projected hydrological scenarios under the influence of bias corrected climatic variables and LULC"*Ecological Indicators*, 106, 105440, 2019. [**Elsevier, SCI Impact Factor:- 4.490**]

5. Kayet, N., Pathak, K., Chakraborty, A., Kumar, S., Chowdary, V.M., Singh, C.P., **Sahoo, S.** and Basumatary, S."Assessment of foliar dust using Hyperion and Landsat satellite imagery for mine environmental monitoring in an open cast iron ore mining areas"*Journal of Cleaner Production*, 218, 993-1006, 2019. [**Elsevier, SCI Impact Factor:- 6.395**]

6. **Sahoo, S.**, Dhar, A., Debsarkar, A., and Kar, A."Future Scenarios of Environmental Vulnerability Mapping using Grey Analytic Hierarchy Process "*Natural Resources Research*, DOI: 10.1007/s11053-019-09462-z, 2019.[**Springer, SCI Impact Factor: 2.00**]

7. Kayet, N., Chakraborty, A., Pathak, K., **Sahoo, S.**., Mandal, S.P., Fatema, S., Tripathy, Garai, U. and Das, T. "Spatiotemporal LULC change impacts on groundwater table in Jhargram, West Bengal, India"*Sustainable Water Resources Management*, 1-12, 2018. [**Springer, SCI Impact Factor:-**]

8. **Sahoo, S.**, Sil, I., Dhar, A., Debsarkar, A. Das, P. and Kar, A. "Future Scenarios of Land-Use Suitability Modeling for Agricultural Sustainability in a River Basin" *Journal of Cleaner Production*, 205, 313-328, 2018. [**Elsevier, SCI Impact Factor:- 6.395**]

9. Kayet, N., Chakraborty, A., Pathak, K., **Sahoo, S.**., Dutta, T. and Hatai, B.K. "Comparative Analysis of Multi-Criteria Probabilistic Frequency Ratio (FR) and Analytic Hierarchy Process (AHP) Models for Forest Fire Risk Mapping in Melghat Tiger Reserve Forest"*Journal of Forestry Research*, 1-15, 2018. [**Springer, SCI Impact Factor:- 1.115**]

10. **Sahoo, S.**, Dhar, A., Debsarkar, A. and Kar, A. "Impact of Water Demand on Hydrological Regime under Climate and LULC Change Scenarios"*Environmental Earth Sciences*,77:341, 2018. [**Springer, SCI Impact Factor:- 1.871**]

11. Patra, S., **Sahoo, S.**, Mishra, P. and Mahapatra, S.C. "Impacts of Urbanization on Land Use /Cover Changes and its Probable Implications on Local Climate and Groundwater Level" *Journal of Urban Management*, 7, 70-84, 2018. [**Elsevier, SCI Impact Factor:**]

12. Kayet, N., Pathak, K., Chakraborty, A. and **Sahoo, S.** "Mapping the distribution of iron ore minerals and spatial correlation with environmental variables in hilltop mining areas"*Environmental Earth Sciences*, 77:308, 2018. [**Springer, SCI Impact Factor:- 1.871**]

13. **Sahoo, S.**, Das, P., Kar, A. and Dhar, A."A Forensic Look into the Lineament, Vegetation, Groundwater Linkage: Study of Ranchi District, Jharkhand (INDIA)" *Remote Sensing Applications: Society and Environment*, 10, 138-152, 2018. [**Elsevier, SCI Impact Factor:**]

14. Kayet, N., Pathak, K., Chakraborty, A. and **Sahoo, S.** "Evaluation of soil loss estimation using RUSLE model and SCS-CN method in hilltop mining areas"*International Soil and Water Conservation Research*, 6, 31-42, 2018. [**Elsevier, SCI Impact Factor:-**]

15. **Sahoo, S.**, Munusamy, S.B., Dhar, A., Kar, A. and Ram, P."Appraising the Accuracy of Multi-Class Frequency Ratio and Weights of Evidence Method for Delineation of Regional Groundwater Potential Zones in Canal Command System" *Water Resources Management*,31:43994413, 2017. [**Springer, SCI Impact Factor: 2.987**]

16. **Sahoo, S.**, Dhar, A., Kayet, N. and Kar, A."Detecting water stress scenario by Land Use/Land Cover Changes in an Agricultural Command Area"*Spatial Information Research*,25(1), 11-21, 2017. [**Springer, SCI Impact Factor: -**]

17. Sahoo, M., **Sahoo, S.**, Dhar, A. and Pradhan, B. "Effectiveness Evaluation of Objective and Subjective Weighting Methods for Aquifer Vulnerability Assessment in Urban Context"*Journal of Hydrology*, 541, 1303-1315, 2016. [**Elsevier, SCI Impact Factor: 4.405**]

18. Kayet,N., Pathak, K., Chakraborty, A. and **Sahoo, S.** "Urban Heat Island explored by co- relationship between Land Surface Temperature vs Multiple Vegetation Indices"*Spatial Information Research*, 24 (5), 515-529, 2016. [**Springer, SCI Impact Factor: -**]

19. Mandal, U., **Sahoo, S.**, Munusamy, S.B., Dhar, A., Panda, S.N, Kar, A. and Mishra, P.K. "Delineation of Groundwater Potential Zones of Coastal Groundwater Basin using Multi-criteria Decision Making Technique" *Water Resources Management*, 30:4293, 2016. [**Springer, SCI Impact Factor: 2.987**]

20. Kayet,N., Pathak, K., Chakraborty, A. and **Sahoo, S.** "Spatial Impact of Land use/Land cover change on Surface Temperature Distribution in Saranda Forest, Jharkhand"*Modeling Earth Systems and Environment*, 2:127, 2016. [**Springer, SCI Impact Factor: -**]

21. **Sahoo, S.**, Dhar, A., Kar, A. and Ram, P. "Grey Analytic Hierarchy Process Applied to Effectiveness Evaluation for Groundwater Potential Zone Delineation" *Geocarto International*,1-31, 2016. [**Taylor & Francis, SCI Impact Factor: 2.365**]

22. **Sahoo, S.**, Dhar, A., Kar, A. and Chakraborty, D. "Index-based groundwater vulnerability mapping using quantitative parameters" *Environmental Earth Sciences*, 75(6),1-13, 2016. [**Springer, SCI Impact Factor: 1.871**]

23. **Sahoo, S.**, Dhar, A. and Kar, A. "Environmental vulnerability assessment using Grey Analytic Hierarchy Process based model" *Environmental Impact Assessment Review*, 56, 145-154, 2016. [**Elsevier, SCI Impact Factor: 3.749**]

24. Patra, S., Mahapatra, S.C., Mishra, P. and **Sahoo, S.**"A Quantitative Analysis of Groundwater Status of Hooghly District, West Bengal, INDIA" *International Journal of Current Research*, 7(7), 18810-18818, 2015. [**-, SCI Impact Factor: -**]

25. Dhar, A., **Sahoo, S.** and Sahoo, M."Identification of groundwater potential zones considering water quality aspect"*Environmental Earth Sciences*,74, 5663-5675, 2015. [**Springer, SCI Impact Factor: 1.871**]

26. Dhar, A., **Sahoo, S.**, Mandal, U., Dey, S., Bishi, N. and Kar, A. "Hydro-environmental assessment of a regional ground water aquifer: Hirakud command area (India)" *Environmental Earth Sciences*, 73:4165-4178, 2015. [**Springer, SCI Impact Factor: 1.871**]

27. Dhar, A., **Sahoo, S.**,Dey, S. and Sahoo, M. "Evaluation of recharge and groundwater dynamics of a shallow alluvial in central Ganga basin, Kanpur (INDIA)"*Natural Resources Research*, 23(4), 409-422, 2014. [**Springer, SCI Impact Factor:- 2.00**]

28. **Sahoo, S.**"Monitoring urban Land use land cover change by Multi-Temporal remote sensing information in Howrah city, India"*International Research Journal of Earth Science*, 1(5), 1-6, 2013. [**ISCA, SCI Impact Factor: -**]

29. **Sahoo, S.** "Assessing Hydrological Modeling of Bandu River Basin, West Bengal, (India)" *International Journal of Remote Sensing & Geoscience*, 2 (5), 2013. [**-, SCI Impact Factor: -**]

30. Chakraborty, S., Majumdar, D. and **Sahoo, S.** "Comparative analysis of different supervised classification techniques using linear regression model" *ZENITH International Journal of Multidisciplinary Research*, 3(7). [**-, SCI Impact Factor: -**]

Conference Publications

1. Kayet, N., Pathak, K., Chakraborty, A. and **Sahoo, S.** (2017).Hyperspectral Image Analysis for Iron Mineral Exploration and Spectral Unmixing Study in Kiriburu and Meghahataburu Mining Areas, West Singbhum, Jharkhand. 38th Asian Conference of Remote Sensing, New Delhi, India.

2. **Sahoo, S.,** Dhar, A. and Kar, A. (2017). Terrestrial Water Storage Changes Over the Damodar River Basin from GRACE Observations and Rainfall Variability. Regional workshop under Jal Kranti Abhiyan 2016-2017 on Ground Water Resources Management Issues In View of Climate Changes In west Bengal, Sikkim and Andaman & Nicobar Island, Vidyasagar Auditorium, Barasat Municipality, 24 Pgs (N).

3. Sil Saha, I. and **Sahoo, S.** "Comparison of Forest Cover Classification Based on Different Spectral Vegetation Indices using Spatiotemporal Multiple Satellite Sensor Data" *National Seminar on Geoinformatics for Environmental Issues and Management*, Department of Remote Sensing & GIS, Vidyasagar University, 2017.

4. Kar, A., Dhar, A., **Sahoo, S.**, Bhattacharya, A and Ram, P."Post tsunami salinity rise in a small inhabited island in Nicobar, A&N islands: need for large scale rainwater harvesting and artificial recharge" *National Conference on Water, Environment & Society (NCWES-2017)*, JNTUH, Hyderabad, 2017.

5. **Sahoo, S.** and Dhar, A. "Identifying Potential Sites for Groundwater Recharge using Integrated Remote Sensing and GIS Techniques in Hirakud Canal Command Area (INDIA)" *19th International conference of Hydraulics, Water Resources, Coastal and Environmental Engineering (HYDRO 2014 International)*, December 18-20, 2014.

6. **Sahoo, S.**, Chakraborty, S. and Majumdar, D. "Remote Sensing & GIS based hydrological modeling using SWAT (Soil and Water Assessment Tool)" *International Exhibition and Conference on Water Technologies, Environmental Technologies, and Renewable Energy. 92nd OMICS Group Conference*, Bombay Exhibition Centre, Mumbai, India, Hydrology: Current Research, volume 4(1), 2013.

7. Patra, S., **Sahoo, S.**, Mahapatra, S.C. and Mishra, P. "Urban growth and land use / land cover change detection analysis using remote sensing & GIS techniques of Howrah City, West Bengal" *International Exhibition and Conference on Water Technologies, Environmental Technologies, and Renewable Energy. 92nd OMICS Group Conference*, Bombay Exhibition Centre, Mumbai, India, Hydrology: Current Research, volume 4(1), 2013.

8. Chakraborty, S., **Sahoo, S.** and Majumdar, D. "A geospatial analysis for assessing the impact of environmental degradation on land cover change through satellite images - A case study of Lothian Island, Sundarban, India" *International Exhibition and Conference on Water Technologies, Environmental Technologies, and Renewable Energy. 92nd OMICS Group Conference*, Bombay Exhibition Centre, Mumbai, India, Hydrology: Current Research, volume 4(1), 2013.

9. Sur, K., **Sahoo, S.**, Majumdar, D. and Chakraborty, S. "Municipal solid waste management planning using remote sensing & GIS: A case study of Kharagpur, West Bengal, India" *International Exhibition and Conference on Water Technologies, Environmental Technologies, and Renewable Energy. 92nd OMICS Group Conference*, Bombay Exhibition Centre, Mumbai, India, Hydrology: Current Research, volume 4(1), 2013.

10. Mandal, I., **Sahoo, S.** and Bandyopadhyay, J. "Remote sensing and GIS techniques for monitoring the coastal environmental changes: A case study in Sundarban coastal belt, India" *International Exhibition and Conference on Water Technologies, Environmental Technologies, and Renewable Energy. 92nd OMICS Group Conference*, Bombay Exhibition Centre, Mumbai, India, Hydrology: Current Research, volume 4(1), 2013.

Workshop

- Author Workshop jointly organized by Springer and IIT Kharagpur conducted by Central Library, Indian Institute of Technology Kharagpur, 12th February, 2014.
- The Indo-German Partnering Post Kolleg Workshop On 3D GIS and Hydrogeological Flow Modelling conducted by The School of Environmental Sciences, Jawaharlal Nehru University, New Delhi held during February 10-12, 2013.

Reviewer of Journals

- Journal of Cleaner Production: Published by Elsevier
- Applied Ocean Research: Published by Elsevier
- Physics and Chemistry of the Earth: Published by Elsevier
- The Egyptian Journal of Remote Sensing and Space Sciences: Published by Elsevier
- Sustainable Cities and Society: Published by Elsevier
- Journal of Hydrology: Regional Studies: Published by Elsevier
- Data in Brief: Published by Elsevier
- Journal of King Saud University - Engineering Sciences: Published by Elsevier
- Water and Environment Journal: Published by Wiley
- Engineering Report: Published by Wiley
- Geocarto International: Published by Taylor & Francis
- International Journal of Remote Sensing: Published by Taylor & Francis
- Cogent Environmental Science: Published by Taylor & Francis
- Water Resources Management: Published by Springer
- Natural Resources Research: Published by Springer
- SN Applied Sciences: Published by Springer
- American Journal of Climate Change: Published by Scientific Research Publishing

Member of Professional Bodies

- Life Member : Indian Society of Remote Sensing (L-4195)
- Life Member : Indian Society of Geomatics (ISG-L-1578)

References

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- Dr. Anupam Debsarkar, Associate Professor, Department of Civil Engineering, Jadavpur University, Kolkata- 700 032, INDIA, Email: anupamju1972@gmail.com
- Dr. Biswajeet Pradhan, Distinguished Professor, Faculty of Engineering and IT , University of Technology Sydney, 15 Broadway, Ultimo NSW 2007, Australia, Phone (office): +61 2 95147937, Email: Biswajeet.Pradhan@uts.edu.au.

Declaration

I do hereby declare that all the information provided above is true to the best of my knowledge and belief.

Date: 14.10.2019
Place: Guwahati

Satiprasad Sahoo

Paddy and Water Environment
https://doi.org/10.1007/s10333-019-00774-7

ARTICLE

Identification of water-stressed area based on the interrelationship of soil moisture and seasonal rice cultivation

Satiprasad Sahoo[1] · Anirban Dhar[2] · Anupam Debsarkar[3] · Amlanjyoti Kar[4] · Narayan Kayet[5]

Received: 15 October 2018 / Revised: 6 August 2019 / Accepted: 9 August 2019

Abstract

The present study identifies water-stressed areas based on linkages between NOAH model-based soil moisture and seasonal paddy rice cultivation in the Dwarakeswar–Gandheswari river basin. Soil moisture provides information about crop water stress distribution. A new analytic hierarchy process (AHP)-based index is proposed for water stress evaluation. The spatially distributed paddy rice cultivation is essential from the water resource management point of view. Temperature vegetation dryness index (TVDI), regional water stress index, standardized water level index, and vegetation health index (VHI) are considered for detecting water-stressed area. Water stress indices, soil moisture, and paddy rice cultivation are considered on a seasonal basis (Boro, Aus, and Aman) for the period 2011–2016. The spatial patterns of TVDI, VHI, and rice cultivation are derived from Landsat 7 Enhanced Thematic Mapper Plus and Landsat 8 Operational Land Imager satellite images. Kendall's tau is considered for correlation analysis. Sensitivity analysis is performed for the generation of AHP-based new water-stressed zone map. The results show that the downstream portion of the river basin has low water stress compared to the upstream part. Ultimately, the results are validated using 20 field sample points. This analysis will be helpful for the irrigation water management framework.

Keywords Water stress · AHP · Paddy rice · Soil moisture · Groundwater · NOAH · Kendall's tau · Remote sensing

Introduction

Water scarcity is a very important issue for most of the countries because of insufficient water availability (Nilsalab et al. 2017). This crisis affects both human and environmental activities. Irrigation has a direct impact on water stress (Pfister and Bayer 2014). Crop cultivation can alter irrigation water consumption pattern. However, it is an essential indicator for measuring the stress on water resources. Thus, construction of the water treatment plants and distribution network are required for water supply to meet water demand (Uche et al. 2015). Dwarakeswar–Gandheswari river without any hydraulic structure(s) is a water-deficient basin (EIA-EMP-Report 2007). Two reservoirs and one barrage structures are proposed to control water resources in the river basin. Thus, a proper water management plan is required for this relatively small river basin. In this research, water stress scenarios are identified for the Dwarakeswar–Gandheswari river basin.

Water stress scenarios can be identified based on rice cultivation, soil moisture, vegetation, land surface temperature (LST), and evapotranspiration (ET) factors using remote sensing technique and land surface modeling. Only a few studies are available on water stress scenario identification using integrated hydrological parameters. Identification of mixed paddy rice agricultural patterns based on the enhanced vegetation index and land surface water index using MODIS data is available in Peng et al. (2011).

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10333-019-00774-7) contains supplementary material, which is available to authorized users.

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Original Articles

On projected hydrological scenarios under the influence of bias-corrected climatic variables and LULC

Satiprasad Sahoo[a,*], Saumava Dey[b], Anirban Dhar[b], Anupam Debsarkar[c], Biswajeet Pradhan[d,e]

[a] Faculty of Interdisciplinary Studies, Law & Management, Jadavpur University, Kolkata, India
[b] Department of Civil Engineering, Indian Institute of Technology Kharagpur, India
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ARTICLE INFO

Keywords:
Land use change
Climate change
Bias correction
Dyna-CLUE
SWAT
GIS

ABSTRACT

Assessing the impact of climate variability is important for water resources planning and management. In the present study, climate model data were utilized in conjunction with the hydrological model to analyze the effect of climate change on projected streamflow and groundwater recharge values for the Dwarakeswar-Gandherswari basin, India. Regional Climate Model (RCM) data [Representative Concentration Pathway (RCP 2.6, RCP 4.5, RCP 6 and RCP 8.5)] were considered for future climate change scenarios. Five bias correction methods [linear scaling (LS), local intensity scaling (LOCI), power transformation (PWTR), distribution mapping (DM) and variance scaling (VARI)] were applied for RCM based precipitation and temperature data. Projected Land Use and Land Cover (LULC) values were obtained from Dyna-CLUE model. Discharge data (1990–2016) was utilized for model calibration and validation purpose. Total twelve scenarios (4 RCPs per year for the years 2030, 2050 and 2080) were considered. The results showed increasing trend in simulated discharge for the months June to September and reverse trend for the months October to December. The results also showed that groundwater recharge increased for the maximum number of sub-watersheds for the interval 2016–2030 compared to 2016–2050 and 2016–2080 under all RCPs. Uncertainties in streamflow were quantified in terms of exceedance probability and recurrence interval. ALPHA_BF was the most sensitive parameter for the river basin. However, gross increase in groundwater recharge was observed for all the scenarios. These results can be effectively utilized for irrigation planning purpose.

1. Introduction

Climate change is expected to cause water shortage over the next century due to uncertain behavior in precipitation pattern (Acharjee et al., 2017). General Circulation Models (GCMs) are commonly used to assess the impact of climate change on the hydrological cycle (Smitha et al., 2018). GCM is a large-scale circulation pattern. Downscaling techniques are available for converting the coarse resolution (GCM) climatic variable values to the fine resolution (RCM) level. However, neither GCM nor RCM can be used directly for hydrological simulations (Zhang et al., 2014). The statistical concepts are very important for risk analysis (Haerter et al., 2011). Therefore, global or regional climate models were used to create future scenarios of hydrological variables. All hydrological models suffer from systematic error. However, pre-processing is necessary to remove the biases from climate data for future hydrological simulations. Four RCPs (Representative Concentration Pathways) data were used for future climate change scenarios using five bias-correction methods. In this research, a combined framework has been proposed that includes RCM data, Dyna-CLUE to simulate future hydrological variables for predicting the changes in water availability in Dwarakeswar-Gandheswari river basin.

Various researchers have investigated the use of RCP scenarios to estimate the impacts of different anthropogenic forcings on the response of the hydrologic regime. Leander et al. (2008) estimated changes in flood counties of the river Meuse from RCM data using nearest neighbor technique. Li et al. (2010) studied quantile-based method for bias correction of monthly temperature and precipitation data under global circulation model. Haerter et al. (2011) performed a probability density function (PDF) for climate model bias correction of future components of the hydrological cycle. The delta change approach and a statistical bias correction for large-scale modeling of flood flow under global climate projections were presented by Eisner et al.

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Original Paper

Future Scenarios of Environmental Vulnerability Mapping Using Grey Analytic Hierarchy Process

Satiprasad Sahoo,[1,5] **Anirban Dhar**,[2] **Anupam Debsarkar**,[3] **and Amlanjyoti Kar**[4]

Received 4 September 2018; accepted 22 January 2019

Any sustainable resource utilization plan requires evaluation of the present and future environmental impact. The present research focuses on future scenario generation of environmental vulnerability zones based on grey analytic hierarchy process (grey-AHP). Grey-AHP combines the advantages of grey clustering method and the classical analytic hierarchy process (AHP). Environmental vulnerability index (EVI) considers twenty-five natural, environmental and anthropogenic parameters, e.g. soil, geology, aspect, elevation, slope, rainfall, maximum and minimum temperature, normalized difference vegetation index, drainage density, groundwater recharge, groundwater level, groundwater potential, water yield, evapotranspiration, land use/land cover, soil moisture, sediment yield, water stress, water quality, storage capacity, land suitability, population density, road density and normalized difference built-up index. Nine futuristic parameters were used for EVI calculation from the Dynamic Conversion of Land-Use and its Effects, Model for Interdisciplinary Research on Climate 5 and Soil and Water Assessment Tool. The resulting maps were classified into three classes: ''high'', ''moderate'' and ''low''. The result shows that the upstream portion of the river basin comes under the high vulnerability zone for the years 2010 and 2030, 2050. The effectiveness of zonation approach was between ''better'' and ''common'' classes. Sensitivity analysis was performed for EVI. Field-based soil moisture point data were utilized for validation purpose. The resulting maps provide a guideline for planning of detailed hydrogeological studies.

KEY WORDS: Environmental vulnerability, Grey-AHP, MIROC5, Dyna-CLUE, SWAT, GIS, Remote sensing.

INTRODUCTION

Environmental vulnerability assessment is an important step for sustainable environmental planning and management framework. The effective assessment of environmental condition is important for the regional environmental system (Sahoo et al. 2016; Mitsova et al. 2018; Shah et al. 2018). Development of global and regional scale vulnerability measurement approaches is difficult to conceptualize under varying uncertainty. Natural (e.g. soil, geology), environmental (e.g. groundwater) and anthropogenic (e.g. population) impact-related

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Future scenarios of land-use suitability modeling for agricultural sustainability in a river basin

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ABSTRACT

The present study focuses on future scenarios of land-use suitability zone (LSZ) mapping based on the analytic hierarchy process (AHP) for agricultural sustainability. Proposed case study area is Dwarakeswar - Gandheswari river basin, India. Future estimation of LULC and climate scenarios has been performed. Dynamic Conversion of Land-Use and its Effects (Dyna-CLUE) model and Statistical DownScaling Model (SDSM) are used for this analysis. CLUE model performs the dynamic simulation of land use conversion based on competition between land uses. Future LULC maps are utilized for LSZs mapping. Future LULC scenarios are developed starting from the year 1990. Various hydro-meteorological and geological parameters (Elevation, slope, rainfall, soil, geology, future LULC, groundwater level, evapotranspiration (ET), soil moisture and NDVI) are considered for LSZs. Overall LULC classification accuracy of 1990, 2000 and 2010 is 94.29%, 95.70% and 95%. The LSZs (poor, moderate, good, very good and unsuitable) are evaluated with four scenarios (for the years 2010, 2030, 2050 and 2080). The results reveal a maximum conversion of cultivated land to urban built-up land. The accuracy of the predictive LULC model is tested using receiver operating characteristic (ROC: Built-up- 0.985) curves. Moreover, the unsuitable zones for agricultural sustainability are on the downstream portion of the river basin. Finally, LSZs are validated by using 20 soil moisture field sample points in the proposed command area. These analyses provide valuable information to land use planners for taking a preliminary decision.

1. Introduction

India is bestowed with valuable natural resources consisting of forests, mineral deposits, wetlands, rivers, surface water bodies and vast areas of agricultural serving the needs of around a billion population and varied ecological functions. Due to increase in population, industrialization and with large variations in climate and natural disasters, the natural resources management has become very complex (Hoeppe, 2016). The present land use system shows that there is a very few landscapes which belong to their original state. This land use system plays a key role in establishing a link between the biosphere and the socioeconomic structure. Anthropogenic factors have significantly altered the land use and with the passage of time man is leaving behind a profound change in the environment which is ultimately resulting in an observable changed pattern of land use over time. Observational and modeling studies involving the presence (or absence) of large dams and their associated LULC change should be the key to understanding how the historical impact of dams on climate will play out in the future for better dam building and operations. Water management requires a good understanding of the geographical and spatial information (e.g., rainfall, temperature, Land use/cover, soil, geology, elevation, and watershed). Dwarakeswar-Gandheswari river basin is a water-scarce basin. It is proposed that two reservoirs will be constructed on Dwarakeswar and Gandheswari rivers respectively. Upon construction, farmers will be able to utilize the water from

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ORIGINAL ARTICLE

Impact of water demand on hydrological regime under climate and LULC change scenarios

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Abstract
The present study focuses on an assessment of the impact of future water demand on the hydrological regime under land use/land cover (LULC) and climate change scenarios. The impact has been quantified in terms of streamflow and groundwater recharge in the Gandherswari River basin, West Bengal, India. dynamic conversion of land use and its effects (Dyna-CLUE) and statistical downscaling model (SDSM) are used for quantifying the future LULC and climate change scenarios, respectively. Physical-based semi-distributed model Soil and Water Assessment Tool (SWAT) is used for estimating future streamflow and spatiotemporally distributed groundwater recharge. Model calibration and validation have been performed using discharge data (1990–2016). The impacts of LULC and climate change on hydrological variables are evaluated with three scenarios (for the years 2030, 2050 and 2080). Temperature Vegetation Dyrness Index (TVDI) and evapotranspiration (ET) are considered for estimation of water-deficit conditions in the river basin. Exceedance probability and recurrence interval representation are considered for uncertainty analysis. The results show increased discharge in case of monsoon season and decreased discharge in case of the non-monsoon season for the years 2030 and 2050. However, a reverse trend is obtained for the year 2080. The overall increase in groundwater recharge is visible for all the years. This analysis provides valuable information for the irrigation water management framework.

Keywords Streamflow · Groundwater recharge · SWAT · Dyna-CLUE · SDSM · Uncertainty analysis · Sensitivity analysis · Remote sensing

Introduction

Water demand is key information for any sustainable development planning framework. River basins are most vulnerable to the LULC and climate change scenarios. The Gandheswari River basin is a water-scarce basin. It is proposed that one reservoir will be constructed on Gandheswari River. Water Resources Information System (WRIS, INDIA) does not provide information about this relatively small watershed. Thus, a sustainable, integrated water management plan is required for the Gandheswari River basin. Integrated framework combines SWAT, Dyna-CLUE, and SDSM to simulate future scenarios (LULC and climate) and to predict the changes in water availability in the Gandheswari River basin. In the present work, a methodology is proposed for simulation of future streamflow and groundwater recharge scenarios in the Gandheswari River basin.

Numerious studies are available on integrated hydrological modeling for estimation of future streamflow scenarios. Minihane (2012) studied future streamflow estimation based on index-gauge method and a micro-scale hydrological model in the Rovuma River. Narsimlu et al. (2013) performed an uncertainty analysis based on Sequential Uncertainty Fitting (SUFI− 2) method using the SWAT model for the Upper Sind River Basin, India. Estimation of groundwater recharge based on the combined hydrological model using GIS techniques is available in Awan et al. (2013). The hydrological responses to climate change analysis using regional climate model

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