International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

Sustainable Gokul Dham Eco-Village Case Study: A Model for Environmental Management and Community Development

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Abstract **The need for sustainable living and community development has never been more pressing. Eco-villages offer a unique approach to addressing environmental and social challenges. This case study examines the sustainable practices and community development strategies of Gokul Dham Eco-Village, Belagavi, North Karnataka. The attempt has been made through a mixed-methods approach, combining surveys, interviews, and observational data, we assess the eco-village's environmental performance, social cohesion, and economic viability. Our findings demonstrate the eco-village's success in reducing carbon footprint, promoting renewable energy, and fostering a strong sense of community. We identify key factors contributing to its sustainability and recommend replication and scaling up. This research aims to investigate the potential of eco-villages as a model for sustainable agricultural growth and their contribution to the development of sustainability. The study seeks to explore the impact of the eco-village movement on rural development in the country, with a primary focus on examining, researching, and evaluating the patterns and challenges of eco-village development**

***Keywords* — Eco-village ,advancing sustainability, patterns and challenges, Vedic approach, ecological practices, technological innovations, Arc GIS , self-reliance.**

I. INTRODUCTION

Communities rely on a wide variety of natural materials and energy for their development. As they branch out, their demand for resources increases, leading to greater environmental degradation and a growing disconnect from nature. In this context, creating sustainable, self-sufficient communities is crucial for preventing the overexploitation of natural resources and securing a better future for present and future generations. As per the study of Agyeman, Roseland, Cureton, and Wornell (1998), "sustainability is comprised of interdependent ecological, economic, and social factors."

With rapid urbanization, industrialization, and agricultural expansion, it is vital to assess the current state of our ecological environment. In emerging nations like India, environmental degradation is driven by factors such as mass extinction, pollution, deforestation, soaring carbon footprints, and agricultural land degradation. The overuse of fertilizers, pesticides, sewage, and other pollutants contribute to 70 percent of the "dead zones" affecting globalecosystems.

Rapid industrialization poses a significant threat to the environment, and it leads to deplete natural resources and strain ecosystems. The major environmental issues such as global warming, the greenhouse effect, acid rain, and desertification contribute to ecological imbalance and pollution.

India is the fifth-largest producer of electronic waste, generating 20 to 50 million metric tons annually, with 70% of this waste is produced in just ten states. According to a UN report, E-waste in India was expected to increase by 500% by 2020, highlighting the urgent need for systematic collection, management, and recycling. Toxic pollutants like lithium, nickel, cadmium, and copper from devices such as mobile phones, batteries, and microwaves pose serious environmental and health risks. Therefore to address this, recent efforts focus on local interviews, site visits, and analytical tools like Arc GIS to assess ecological impacts and water quality.

II. PROBLEM DEFINITION ANDOBJECTIVES

A. *Problem Statement*

- Source Sustainability Evaluation
- The transition to sustainable living is hindered nethe

 DOI : 10.35291/2454-9150.2024.0378

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

following challenges Resource management, community engagement, and biodiversity preservation. Economic viability, social equity, education, awareness, and resilience to climate change.

- Despite advancements, challenges like global warming, reliance on non-renewable energy, andbiodiversity loss continue to threaten the environment. This research seeks to understand how the village's simple, mindful, conversantliving can serve as a guide towards achieving sustainability.

B. Research Purpose & Scope of the Study

- The purpose of this research is to explore Gokul Dham Eco Village as a model of sustainable ecological living.
- It aims to highlight the Vedic way of life through ecological practices, emphasizing self- sufficiency and sustainability. This research aims to showcase sustainable, eco-friendly practices in response to technological innovations and rapid urbanization that degrade the environment.
- The study focuses on Gokul Dham Eco Village, which follows the principle of “Simple living and high thinking” to promote self-reliance and sustainability. And It also addresses issues like climate change.
- The research explores the effectiveness of the Vedic approach, including practices like organic farming, water conservation, and alternative energy use, and uses tools like Arc GIS to analyze groundwater quality.
- This study focuses on understanding the self-sufficient and sustainable practices adopted by the inhabitants of Gokul Dham Eco Village to create an autonomous, eco-friendlyenvironment.

C. Objectives of the study

1. Gain insight into Gokul Dham Eco Village, an autonomous community initiative.
2. Critically analyse the village's Ecological Footprintand Biological Capacity.
3. Examine the agricultural practices at Gokul Dham Eco Village.
4. Assess groundwater quality through maps of treatedand untreated water using Arc GIS10.2.
5. Recommend strategies to improve and sustain the eco-village environment.
6. Explore ways to create sustainable human habitats.
7. To promote environmentally sustainable patterns ofconsumption.

III. STUDY AREA

- The following section addresses a brief site studyof the Gokul Dham Eco Village.
- Location – Belagavi, North Karnataka
- Area – 415 Acres
- Built–up area - 956.90m
- Established – 2003
- Surroundings – Lush green forest around, alongwith 10 small neighboring villages

The eco-village, located in North Karnataka, is asolitary and pioneering eco-hamlet that promotes sustainable living. It was founded in the year 2003 with a tiny population located at 40 km from Belgaum city province of Karnataka, spread over 14 acres of lush green forest & lies at 15º 40’ 36’.6528N and 74º 16’ 39.4644’’ E which is in the Mahadayi watershedarea.

IV. METHODOLOGY

In this paper both qualitative and quantitativeanalyses are described in detail below.

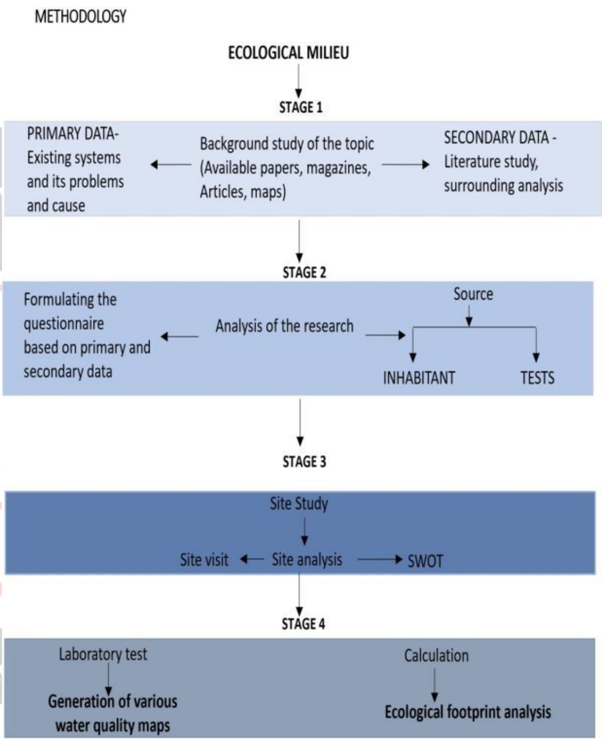
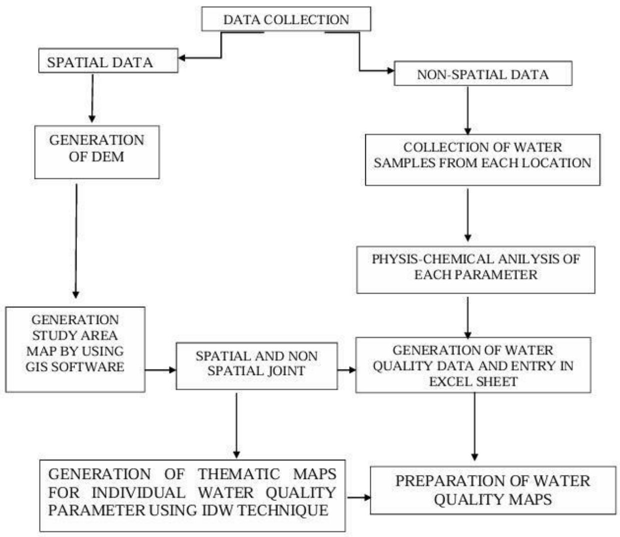


Fig.4.1 Methodology Flowchart



 DOI : 10.35291/2454-9150.2024.0378

Fig.4.2 Methodology Flowchart for Geo-statistical Approach using Arc GIS Spatial Analyst Tool

Water is a crucial resource for drinking, industry, and residential use. The Water Quality Index (WQI) assesses water quality to determine its suitability or potential harm. Geographic Information Systems (GIS) serve as an effective tool for evaluating water quality by integrating testing facility data with geographic maps through GIS and analytical tools. Water quality maps are generated using standard methods like Kriging and Inverse Distance Weighting (IDW). Key water safety indicators, such as pH, electrical conductivity (EC), total dissolved solids (TDS), and magnesium hardness, are thoroughly analyzed.

4.1 Sampling and Analysis: Water samples were collected from Gokul Dham Eco-village and surrounding areas. Plastic containers were used for sample collection. Variables analyzed included pH, EC, Ca, TDS, and Mg. Total hardness and parameter density were measured in the lab.

***4.2 Geostatistical Approach*:** GIS is a valuable tool for representing and analyzing geographic data related to aquatic resources. GIS technologies offer several advantages for data evaluation.

4.3 Arc GIS Spatial Analyst Tool: The spatial analyst tool is an optional extension for ESRI's ArcView and ArcGIS packages. It allows GIS practitioners to create studies for cell-based raster maps.

4.4 GIS Interpolation Technique: An interpolation technique generates a raster dataset from collected data.

The Inverse Distance Weighted (IDW) method was used to create continuous surface maps through multiple coordinates. This technique forecasts cell values at specific locations. The Arc GIS Spatial Analyst extension uses various interpolation algorithms to create surface grids. Arc GIS provides seven interpolation methods, including Inverse Distance Weighted (IDW), Kriging, Natural Neighborhood, Spline, and Topo to Raster. In this research, groundwater quality maps were produced using the IDW method, as shown in Fig. 4.3.

4.5 Assessment of Groundwater Quality Maps: *Groundwater quality is evaluated based on different parameters.Each parameter is ranked and weighted, with the most important given a higher rank.Integrated maps are then created based on these assessments.*

4.6 Preparation of Thematic Maps: Thematic maps display specific themes related to geographic areas, showing the spatial distribution of qualitative or quantitative data. The process involves two key steps: Geo-referencing the thematic map. Converting the map to raster format.

4.7 Geo-referencing: Geo-referencing assigns real-world coordinates to each pixel of the raster map. Coordinates are gathered through field surveys using GPS devices or mobilesoftware. This process allows the map to align with Earth's coordinates and is saved in formats like JPEG or TIF.

4.8 Converting Map to Raster Format: The map is converted to raster format, consisting of rows and columns that represent categories and magnitudes. The IDW technique is then applied to the raster map.

V. SUSTAINABILITY RESULTS

Ecological Footprint of Gokul Dham Eco-village:
Ecological footprint analysis calculates the community's resource consumption, waste production, and land use.

It measures how energy and material resources are consumed to meet basic needs and how they return to the environment as waste (Wackernyel M. et al., 2011).

***Ecological Footprint*:** The ecological footprint calculation for Gokul Dham differs from standard methods due to the community's small size and personal views. Nationwide data is not considered, and assumptions are made based on the community's unique context.

5.1 Consumed Land : Consequently, environmental impacts of each individual in regard to highways. i.e.0.0083 $ha/capita$.

5.2 Currently Used Land: The analysis includes garden, cropland, pasture, and woodland areas.

Instead of calculating per capita consumption, a general assessment was made to determine whether the available land meets the community's overall needs.

5.4 Gardening Procedure : This refers to the land used for growing vegetables and fruits, which sufficiently meets the community's needs. For ecological footprint calculation, an equivalence factor of 2.4 is applied. The orchard covers 0.404 ha, and the vegetable patch spans 0.607 ha. The ecological footprint of the vegetable land is calculated as: 0.0083ha/capita.

5.5 Crop Land : The total area available for planting crops is 1 hectare, but only 0.5 ha is required to meet the community's needs. The equivalence factor used is 2.04. The ecological footprint for arable land is calculated as: 0.067ha/capita.

5.5 Pasture: The grazing area for cattle is 1.61 ha, where they feed on forage. The equivalence factor used is 0.5. The ecological footprint for pasture land is calculated as: Pasture 0.04 ha/capita.

5.6 Forest : Since no cooking stoves or LPG are used, firewood is utilized for cooking (through the chulha system). A heat value of 17.0 MJ/kg is applied to determine the energy efficiency of the forest resources, with an analogy factor of 1.35 used in the calculation.

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***5.7 Waste**:* The waste generated in Gokul Dham Eco-village is minimal, contributing to its sustainability compared to conventional living. Waste from paper, metal, and glass is insignificant, and the energy data for producing this waste isunavailable, thus excluded from the calculation the Synthetic waste: (0.00076 ha/capita). From these calculations, Gokul Dham Eco-village stands as a model of sustainable living, meeting basic needs while maintaining a low ecological footprint. Though drastic changes may be challenging, gradual improvements can lead to a better, more sustainable lifestyle. The village demonstrates its commitment to ecological sustainability.

***5.8** Biological Capacity: The final step in the calculation involves estimating the biological capacity. This is done by determining the percentage of the examined territory assigned to different land use categories. The areas are calculated on a per capita basis, with the Eco Village having a biological capacity of 1.77 ha per person. However, due to insufficient information on the equivalence factor, calculating precise figures remains challenging.*

***5.9** Water Quality Mapping Using Arc GIS 10.2 The results from various field and laboratory experiments are detailed below. Thematic Maps To evaluate water quality in the study area using GIS, the following thematic maps were generated: pH, TDS, total hardness, calcium, magnesium, electrical conductivity (EC), and salinity.*

5.9.1 pH : The pH value of water indicates its acidity or alkalinity. In the research area, the pH levels ranged from 6.4 to 7.3, which fall within acceptable limits.

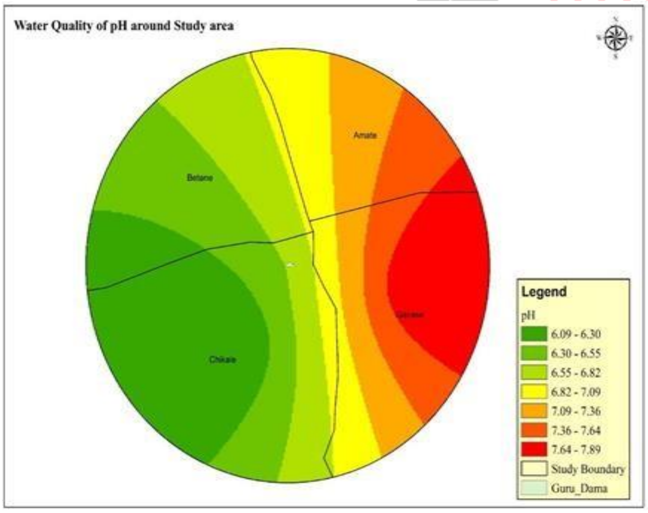

Fig.5.1 Spatial variation of pH

5.9.2 CALCIUM : The concentration of calcium in water is influenced by the residence time in calcium-rich geological formations. According to BIS (IS 10500-1983), the permissible limit for calcium is 75 mg/l, while the desirable limit is 200 mg/l. The exploratory analysis revealed a calcium concentration of 22 mg/l, indicating excellent potable water quality. The spatial variation of calcium is illustrated in the figure.

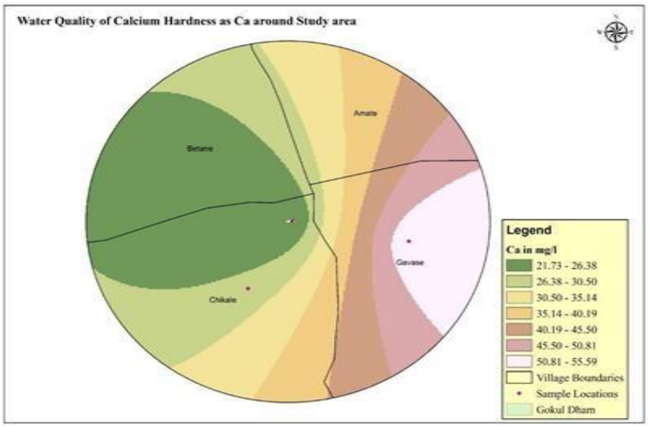

Fig.5.2 Spatial variation of Ca

***5.9.3. Magnesium*:** Magnesium is a key factor in assessing water quality, as higher concentrations can negatively impact human health and lead to pipe encrustation. The preferred range for magnesium is 50-100 mg/l, while the permissible limit is 300 mg/l.

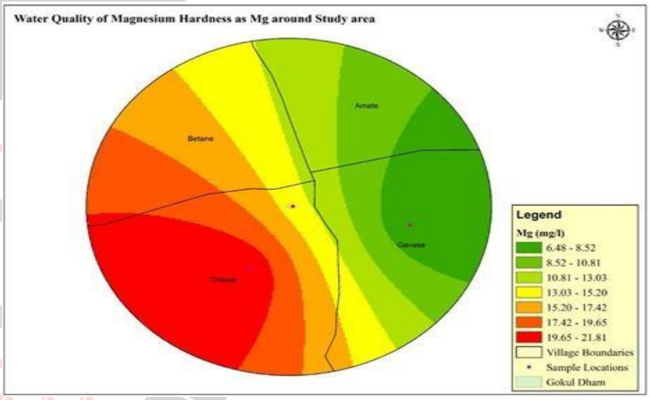

Fig.5.3 Spatial variation of Mg

5.9.4 Total Hardness : Total hardness in water is attributed to the presence of calcium and magnesium bicarbonates, as well as sulfates, chlorides, and nitrates. Based on these variations, a geographic variation map was created, showing that Gokul Dham village has soft water with a hardness value of 75.40 mg/l, compared to Chickla village, which hasa hardness value of 122.00 mg/l.

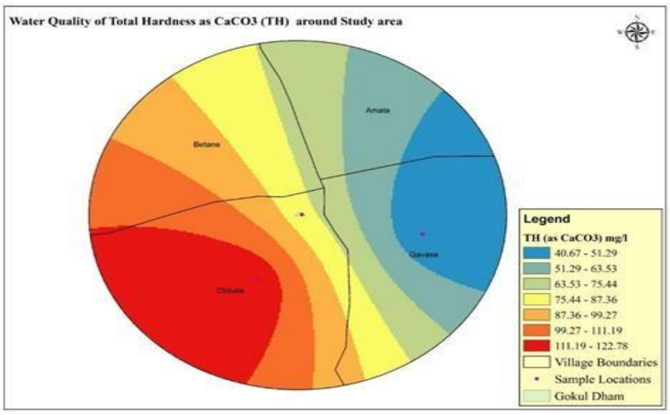

Fig.5.4 Spatial variation of Total Hardness

 DOI : 10.35291/2454-9150.2024.0378

Table 5.1 Water Quality Parameters

Parameters	Site 1	Site 2	Site 3
pH	7.9	4.6	6.1
EC	100.33	310	122
TDS	67.22	473.7	266.66
TH	40.67	239.33	122.87
Calcium	55.61	45.05	28.17
Magnesium	6.48	16.5	21.83
Iron	0.05	0.38	0.11
Fluoride	0.02	0.06	0.5
Turbidity	1.3	2.38	4.15

Table 5.1 shows various water quality parameters that were analyzed at three stations to determine the quality of water.

Table 5.2 Water quality index values

SITE	WATER QUALITY INDEX VALUE
SITE 1	15.23
SITE 2	97.82
SITE 3	42.32

The table 5.2 shows various water quality index values of the three sites after calculations and therefore directs that the water is of excellent quality (0-100). Therefore from Ecological communities help to protect the environment for future generations. Living in a self- sufficient community has several difficulties. This eco village are self-sufficient, so there is a need to acquire new skills and enhance your perspectives in areas .

2. The critical analysis of ecological footprint of the eco-village is represented by the way of Ecological Footprint analysis rendering it to be sustainable or not. The analysis's main purpose is to determine how much land is being used proficiently to meet the needs of mankind. By this study it was found that the ecological footprint of this farming community is very less and hence more sustainable.

3. Source of Water: Gokul Dham Eco village utilizes rainwater tanks and recycled water to meet residents' needs and comply with local consumption targets. Rooftop harvesting systems enhance water collection. Quality tests show excellent water quality, while treated sewage is repurposed for agriculture, supported by a well-designed sewage treatment plant above calculations it can be observed that the water available is excellent hence the various practices make it a Symbiotic model.

VI. OBSERVATION ANDDISCUSSION

Developing a sustainable ecological environment balances ecological, social, and economic needs. Gokul Dham Eco Village exemplifies this through its commitment to two coreprinciples: 1. Conservation: Community members rely on renewable resources, ensuring they can replenish naturally.

2. Preservation: The focus is on maintaining the environment in its natural state, promoting a lifestyle that respects ecological integrity.

This case study highlights Gokul Dham as a model of sustainability, showcasing its independence and the effective use of sustainable technologies. Key findings indicate that social dynamics and technology play crucial roles in achieving environmental sustainability.

The research suggests that Eco villages possess valuable knowledge that could benefit broader communities. Enhanced dialogue between Eco village residents and traditional societies could lead to significant improvements in resource management and social environments.

Overall, the commitment to eco-friendly practices helps reduce environmental footprints while fostering a sense of community.

VII. CONCLUSION

5. This study focuses on highlighting numerous instances when Eco villages may provide urban neighborhoods valuable lessons.

6. Energy: The eco-village has effectively planned local energy use, incorporating solar energy for water heating and cooking, significantly reducing greenhouse gas emissions. This model minimizes lifestyle impacts on villagers and therefore sets a benchmark for future developments, promoting water and energy efficiency along with waste separation as cultural norms.

7. Air Quality: The Chula smokeless cook stoves minimize smoke emissions by filtering carbon through water. Biogas plants are also being installed to trap methane, reducing greenhouse gas emissions and providing cost savings.

8. Soil: The Eco-village features primarily sandy loams with good drainage and moisture retention. Soil tests indicate healthy mineral and organic matter levels, ideal for horticulture, viticulture, and grazing. Therefore to enhance soil health, compost, mulch, and green manures are being added to counteract the decline in organic matter from agriculture.

ACKNOWLEDGMENT

I would like to express my profound gratitude to my esteemed project advisor, **Bhakti Rasamitra Swamiji and his team, Gokul Dham Eco Village.** His invaluable guidance, critical suggestions, and constructive feedback have been instrumental throughout our research work. we appreciate his good nature, dedication, and logical insights, which have made this research a rewarding experience.

Lastly, I would like to acknowledge the research scholars **Miss Shreya R Chougule,** Department of MBA who have directly contributed to the research work-study and the compilation of this report. Her support has been invaluable in facilitating my research journey. We also extend our gratitude to our family members and friends. We also extend our gratitude to our department and VTU, Belagavi

 DOI : 10.35291/2454-9150.2024.0378

for their support throughout our journey.

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 DOI : 10.35291/2454-9150.2024.0378