

Smart Innovation, Systems and Technologies 135

Amaresh Chakrabarti *Editor*



Research into Design for a Connected World

Proceedings of ICoRD 2019 Volume 2

The logo for KES International, featuring the letters 'KES' in a stylized blue font above the word 'International' in a smaller blue font.

The Springer logo, which consists of a stylized chess knight icon followed by the word 'Springer' in a serif font.

Smart Innovation, Systems and Technologies

Volume 135

Series editors

Robert James Howlett, Bournemouth University and KES International,
Shoreham-by-sea, UK

e-mail: rjhowlett@kesinternational.org

Lakhmi C. Jain, University of Technology Sydney, Broadway, NSW, Australia;
University of Canberra, Canberra, ACT, Australia; KES International, UK

e-mail: jainlakhmi@gmail.com; jainlc2002@yahoo.co.uk

The Smart Innovation, Systems and Technologies book series encompasses the topics of knowledge, intelligence, innovation and sustainability. The aim of the series is to make available a platform for the publication of books on all aspects of single and multi-disciplinary research on these themes in order to make the latest results available in a readily-accessible form. Volumes on interdisciplinary research combining two or more of these areas is particularly sought.

The series covers systems and paradigms that employ knowledge and intelligence in a broad sense. Its scope is systems having embedded knowledge and intelligence, which may be applied to the solution of world problems in industry, the environment and the community. It also focusses on the knowledge-transfer methodologies and innovation strategies employed to make this happen effectively. The combination of intelligent systems tools and a broad range of applications introduces a need for a synergy of disciplines from science, technology, business and the humanities. The series will include conference proceedings, edited collections, monographs, handbooks, reference books, and other relevant types of book in areas of science and technology where smart systems and technologies can offer innovative solutions.

High quality content is an essential feature for all book proposals accepted for the series. It is expected that editors of all accepted volumes will ensure that contributions are subjected to an appropriate level of reviewing process and adhere to KES quality principles.

More information about this series at <http://www.springer.com/series/8767>

Amaresh Chakrabarti
Editor

Research into Design for a Connected World

Proceedings of ICoRD 2019 Volume 2

 Springer

Editor
Amaresh Chakrabarti
Centre for Product Design and
Manufacturing
Indian Institute of Science Bangalore
Bangalore, India

ISSN 2190-3018 ISSN 2190-3026 (electronic)
Smart Innovation, Systems and Technologies
ISBN 978-981-13-5976-7 ISBN 978-981-13-5977-4 (eBook)
<https://doi.org/10.1007/978-981-13-5977-4>

Library of Congress Control Number: 2018966842

© Springer Nature Singapore Pte Ltd. 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Sponsors

Centre for Product Design and Manufacturing, Indian Institute of Science,
Bangalore, India
Indian Institute of Science, Bangalore, India
Springer

Endorsers

The Design Society, UK
Design Research Society, UK

Part III
Design Management, Knowledge
Management and Product
Life Cycle Management

Chapter 14

A Critical Study of Choke Point in Sustainable Recycling of Household Waste in an Assamese Village Setting



Shiva Ji and Ravi Mokashi Punekar

Abstract Stigma around consumable products and impact on local sustainability has led us to choke point. Paper examines household waste disposal into a small pond called Pukhri. After certain intervals, the pond would be dredged out to clean up the pond, which subsequently ended in agricultural fields. Today, other household waste items including material constituting laminated papers, plastics, inorganic waste etc., are being dumped into Pukhri. In order to establish a familiarity with situation, paper discusses imperative need for new order of waste management in village through data assessment and analysis and finding relations between actors, activities, and dependent phenomenon for a sustainable waste management system. It was found that levels of interconnections between various actors are facing blockage and impacts on domestic fowls, fish, and cattle were noticed. The paper elaborates on vernacular system, change in the system and impacts over stakeholders, etc.

14.1 Introduction

The Industrial Revolution has succeeded in its goal of meeting requirements go materials and goods to the masses but has left its widespread devastating effects on environments. The same can be seen in forms of pollutions in cities like Beijing, Mexico City, and New Delhi. The impact of industrialization has also spread to small towns and rural areas now. The solid wastes and chemical compounds have found their ways to enter self-sustainable cycles of elements in rural areas too. This mindless distribution of commodities has of course facilitated but has taken its toll on natural cycles of organic-based lifestyles of people. The advent of material

S. Ji (✉)
Indian Institute of Technology, Hyderabad, India
e-mail: shivaji@iith.ac.in

R. M. Punekar
Indian Institute of Technology, Guwahati, India
e-mail: mokashi@iitg.ac.in

culture is called as development but has degraded environment at an exponential scale which has not happened earlier since the last ice ages.

The same was evaluated in the context of village Barduwa, district of Nagaon, in the state of Assam, India. At the social level, a great majority of the people are the Vaishnavites Hindus. Shrimant Shankar devji, the great saint, social reformer, and equalizer of Bhakti movement era was born here. Nestled in the middle of green paddy fields in vast distances, it is at a distance of 15 km from district headquarters of Nagaon. The main occupation of people here is derived from agriculture and allied activities. The society has remained agrarian for centuries and is still prefers the same. The mighty River Brahmaputra flows in the north at a distance of approximately 10 km where there are vegetable growing marshlands. This has the direct bearing on the higher water table in the region. The level of water has given birth to this kind of biosphere. These are the areas from where Barduwa and Dumdumia market receives bumper produce of paddy, vegetables, and mustard etc. The district of Nagaon is in the center of Assam is one of the largest paddy and vegetable producing districts. It has fertile alluvial soil and nearby forested hills. It lies on the main highway from Guwahati to Dibrugarh, Tezpur, and Tinsukia etc.

14.2 The Scenario of Barduwa Village

The village was mapped on aspects of environment, economics, culture, and society. Further it was assessed on finer points such as construction techniques, materials, waste disposal, consumption pattern, food habits, etc., to get performing insight into the place.

14.2.1 *Environmental*

Building construction techniques: Building structures are single storied and follow simple construction techniques which people undertake themselves for their own use. Shallow foundation footings to install wooden columns in ground for approximately 2'-0" deep which carries the structural load to the earth. Wall surfaces are broken in sections at sill (2'-6") and lintel level (6'-6" to 7'-0") for accommodating windows and modularity in fabrication. The lightweight of materials creates an earthquake friendly structure which in seismic situations doesn't create much damage and harm to occupants.

Building construction material: Buildings are largely of one story only buildup of bamboo, thatch, straw, timber, jute, and coconut rope. The materials are sourced locally from bamboo bushes and trees, etc. By using simple carpentry tools etc., they get it dressed in shape and size for final fitting in the structure. The materials have almost nil foreign element in them apart from steel nails and fittings. Even regular repairs and maintenance is largely a one-man job and requires little

intervention. Sourcing of materials is seasonal as they get harvest of stars and thatch every year in stock which they store for yearlong use. Bamboo and timber come from the felling of trees and sometimes log of coconut tree and beetle nut is also used for use as column, beam, etc. After say, demolition and discard of materials they go back to nature's cycle of decay and disintegration and leave almost no residue which is of prime concern from the point of view of sustainability.

14.2.2 Waste Disposal

Kitchen: People throw kitchen waste in a small pond called Pukhri which is smaller in size and situated right behind the toilets in the backyard of the house. The organic waste disintegrates and decomposes in that and goes back to being manure. After certain intervals, they dredge out the pond to clean it up.

Other household items: There is no provision of garbage collection from village management; hence all waste items constituting papers, plastics, organic waste etc. goes to Pukhri only.

Synthetic (foreign) materials: Polymer-based substances.

Plastic: With advent of new products and specially latest packaging materials made up of plastics and other polymers (to keep liquids and retain items away from atmospheric air) in hygienic condition with a long shelf life, the problem of their collection and disposal has taken a new turn as these villages do not have such systems in place and have remained like this since ages. Mostly people don't know what to do with these and throw them in garbage ponds along with kitchen waste, it doesn't disintegrate on its own and rather hinders with the natural cycle of the pond.

Chemicals: Soft harmful chemicals present in soaps, toiletries, toilet cleaners, insect killers, sprays, and cosmetics are ultimately harmful for microbial life, aquatic life, and amphibians. After the flush from our use, they go to water bodies and a concentration of these harmful chemical occurs resulting in pollution to the chain and irreversible damage to the other life forms.

14.2.3 Economics and Sociocultural Issues

Consumption pattern: People use largely local grains and vegetables, etc. Little use of processed items but it has penetrated in the village and people are unaware to how to deal with it.

Food habits: Mainly consume locally grown fruits such as coconut, Beri, and vegetables as they come cheap and fresh. Little of use of processed items such as biscuits and cakes etc. or only on occasions. Meals comprise fish and chicken and seldom milk as they fulfill neutron requirements from non-vegetarian items. Highly processed items such as pizzas are still far from this place.

Occupation: Hesitation to scale up businesses and enterprises.

14.2.4 *Cultural*

Festival: Like Holi is celebrated with big fanfare as it coincides with spiritual thoughts and deliveries of Srimant Shakardev ji which has a big following from Vaishnav Hindus of Assam. They congregate in very large numbers on the day of Holi to celebrate.

Prayers: Srimant Shankerdev ji has started Nāām Ghar which is a place of common congregation for open collaboration and dialog. It's a very relevant concept in today's concept to communicate with masses and establish an open bond. It has become more relevant in today's intrinsic society.

Dramatics: These play an important role to integrate people from all sections and delivers thoughts via a strong medium which helps in social uplift. Dramatics helps in keeping people busy and gives a sustainable way of entertainment in comparison with concentrated entertainments like TV etc.

Mobile theaters: These are a very strong medium of moving theatrics across the state of Assam. They entertain, employ artists, preserve cultural heritage, and deliver prevalent message to masses. It's a unique concept on Assam and needs to be preserved and nurtured.

14.2.5 *Issues*

Infrastructural

Administrative apathy: despite existing railway connection and network, this is almost lying unused. The same can be integrated with the day-to-day life of people, agriculture, traders, suppliers, fisheries, vegetables, producers, etc. Ignorance about potential use of place and its productivity. The place has huge potential interns of agricultural, vegetable and fishery without any promotion or technological intervention. The same sectors can be enhanced further giving organized help and support. The place produces the largest volume of vegetables.

Social

Religious divide between Hindu and Muslim community: Population of Muslim community is growing exponentially and was unable to maintain pace with social, technological, economical, and education growth due to lack of resources and inability to divide among large numbers of family. The attitude of raising many children has resulted in stagnation and deceleration of Muslim families.

Personal: Lack of interest in growth citing pitfalls of fast pace life. Which is in a way right but needs to be addressed with utmost care to not to disturb in their thinking. Lack of interest in growth of family economic activities

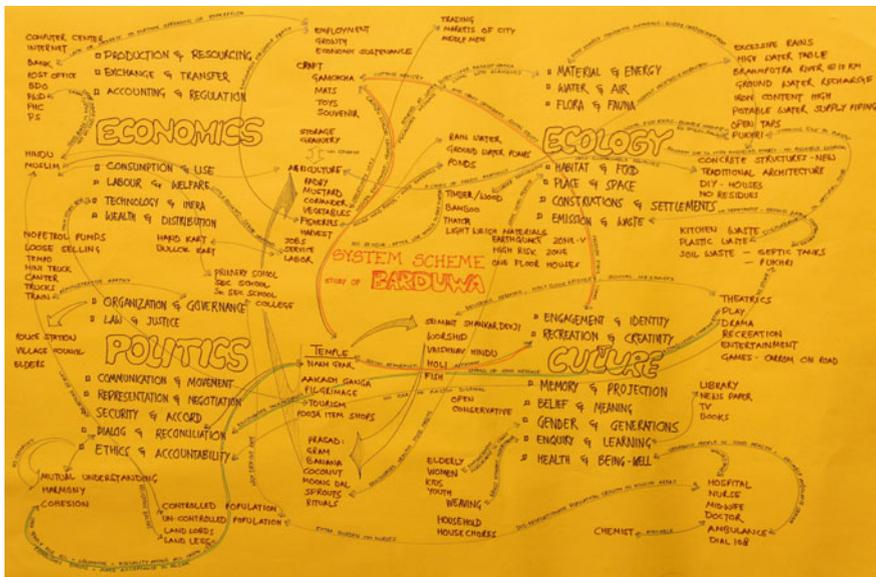


Fig. 14.1 Systems scheme at Barduwa on economics, ecology, politics, and culture poles

14.3 System, Its Domains and Their Interconnectivity

The eight domains of mapped system at village Barduwa are agriculture, education, health, cottage industry, habitat, water, sanitation, and transport. The interconnection among all 8 was explored and 3 issues were fore identified. The issues of product life cycle, waste disposal, and cultural propagation were found to be taken up urgently.

Further a systemic model map of Barduwa village was drawn on four poles of economics, ecology, politics, and culture. These issues could give an objective intervention point to the system of Barduwa. It bears an influence over the policy decisions and implementation strategies for the place (Fig. 14.1).

The system was divided into eight groups which became the eight nodes and further classified into four poles of economics, ecology, politics, and culture. The internal points within poles were marked and their interrelationships were established. Further a unit habitat was chosen to assess the points and help of LeNS tool was taken, assessment is given below.

14.4 Synthesis Index

An analysis was carried out with help of LeNS tool to assess impacts on surroundings, people and the system of place. LeNS is Learning Network on Sustainability, it is an EU-funded multi-institute research project which works

toward understanding of sustainability-related studies. It has undertaken several case studies across globe and has brought experts and students on the common platform. It has developed certain tools to carry out mapping, assessment, and evaluation of sustainability. Paper assesses sustainability of designs from village of Barduwa using Synthesis Index tool given by LeNS. LeNS provides comprehensive set of evaluation criteria which may be used in qualitative research of this kind and draw inferences.

Learning Network on Sustainability (LeNS) provided tool used here to assess impacts of various elements of structure (combination of resultant ideas and inputs to form a theory or system): On a scale of (YES | PARTIALLY | NO) /100:

Priority high (A)

Choosing low impact resources and processes:

- Reducing toxicity and harmfulness of materials 73% 18% 9%;
- Reducing energy resources toxicity and harmfulness 100% 0% 0%;
- Optimizing biocompatibility and conservation of materials 67% 33% 0%;
- Optimizing biocompatibility and conservation of energetic resources 0% 33% 67%.

Conclusion: Resources used are less toxic in nature, require biocompatibility. Optimizing product life:

- Designing an appropriate life span 25% 57% 14%;
- Designing reliability 33% 67% 0%;
- Facilitating renewability and adaptability 29% 29% 43%;
- Simplifying maintenance 11% 11% 78%;
- Simplifying repair 0% 29% 71%;
- Simplifying reuse 11% 22% 67%.

Conclusion: High to average product life, needs to be designed for maintenance, and repair.

Priority medium (M)

Extending material life:

- Adopting a cascade approach 50% 50% 0%;
- Adopting high recyclable materials 43% 43% 14%;
- Simplifying collection and transportation after usage 33% 44% 22%;
- Identifying the materials 17% 0% 83%;
- Minimizing the number of incompatible materials 80% 20% 0%;
- Simplifying cleaning 20% 30% 50%;
- Simplifying composting 75% 25% 0%;
- Simplifying combustion 100% 0% 0%.

Conclusion: Recyclable, homogenous but combustible materials used. Simplifying disassembly:

- General architecture 27% 18% 55%;

- Shape of parts and components 57% 43% 0%;
- Shape and accessibility of joints 0% 38% 63%;
- Using reversible joints 0% 0% 100%;
- Using easily opening permanent joints 13% 13% 75%;
- Predicting technologies and elements for destructive disassembly 0% 14% 86%.

Conclusion: Architecture, parts and components, shapes and joint detailing require revision.

Low (B)

Minimizing resources:

- Minimizing the material content of a product 38% 25% 38%;
- Minimizing scraps and waste 33% 33% 33%;
- Minimizing the packaging 25% 50% 25%;
- Choosing the most efficient material consumption system 22% 56% 22%;
- Adopting flexible material consumption systems 0% 0% 100%;
- Minimizing material consumption in product design 0% 25% 75%;
- Optimizing energy consumption for pre-production and production 14% 21% 64%;
- Minimizing transportation and storage consumptions 30% 40% 30%;
- Choosing the most efficient energy resources consumption systems 33% 8% 58%;
- Adopting flexible energy consumption systems 20% 20% 60%;
- Minimizing energy consumption in product design 0% 0% 100%.

Conclusion: Resource use requires some justification, and requires flexible material use techniques.

Overall Conclusion: The results confirm areas for improvement: Biocompatibility, maintenance and repair, architecture, parts—components, shapes and joints etc., require design and detailing intervention. The items which are proving to be the choking agents are the main targets for biocompatibility such as plastics, coated plastics; this intrusion is breaking the closing of the cycle. In fact, the same is the case almost everywhere in general but the same is validated on the ground. Maintenance and repair would elongate the life span of habitats and may reduce resource requirements.

LCA Tool used: The LCA was carried out using tool for the “design of low impact for the environment” by Laboratory of Design for Sustainability (De.SOS) by Carlo Proserpio and Prof. Carlo Vezzoli from Durando 10 Edificio 7 (POLItca) 20158 Milano, Italy under an EU-funded research project.

14.5 Conclusion

A field base study of sustainability in a rural context to check on household waste disposal was carried out to get to know the chokepoints in the cycle of conventional practices. A systemic analysis using LCA tools shows resource materials used in the habitat design of the chosen system were not toxic in nature but require biocompatibility in decomposition. Some materials were found with chemical treatment like powder coatings and complex layering of paper with plastics, alloys which are hard to galvanize, and some plastics with very long duration for decomposition, etc., which were acting as choke point in the smooth functioning of the system. Further longevity, repair, and maintenance were the issues found which are in need to be addressed. Complex material systems require handling and maintenance to remain working for longer times. These issues should be resolved at local level itself to minimize on indirect emissions. Some materials were found to be recyclable and homogenous in consistency such as iron/galvanized iron/tin in metals, timber/wood, and bamboo/reed, but combustibility was an issue. In cases of fire, it is hazardous to live in all combustible material houses. Joint detailing was also in need of revision keeping in mind component design and maintenance, etc., and flexibility in use. These were the findings of this field-based study which found some points which are behaving to choke the system and should be resolved to maintain the spontaneous nature of sustainability in the chosen system. Further, the study can be improved by conducting similar field-based case studies at different places to check on the phenomenon in other places as well. It may help in establishing the commonality and generalization of the results of the study.

14.6 Summary

The place has spiritual linkage and people of this place have shown remarkable empathy and humility in maintaining social peace and harmony for many generations. It has been running for centuries and has derived its own ways of living. Further with the advent of industrialized solutions in everyday life, some points have become resistive in the system and are resulting into blocking the system as minute levels. Wastewater cycle needs to be checked and corrected of foreign elements like plastic. Soil wastewater needs to be treated to check water contamination, and education sector needs to work toward higher education side to attract students from nearby areas who go to city for higher studies.

A better way of designing houses is required which can adopt from traditional Assam type architecture and incorporates the same in contemporary construction methods which suits the people's requirement otherwise it's on the verge of being left out in the race of being left out to the concrete mortar structures. The vernacular Assam-type house provides with earthquake protection, sustainable local materials, and self-made techniques, completes the material life cycle, etc. It has survived all

the highs and lows of environment and social domains and has potential to do so if can be redesigned for current times. The place is significant on the map of Assam in terms of tourism, agriculture, and crafts. The same can be designed, developed, and promoted as sustainable—Cultural Hub of Assam.

Acknowledgements We'd like to thank Mr. Brajen Kalita, Mr. Gajen Kalita, Mr. Pranjal Hazarika and Barduwa Satra Pratisthan, Barduwa who facilitated our field study and visit to Barduwa, Assam.

References

1. Chakraborty, P., et al.: PCBs and PCDD/Fs in soil from informal e-waste recycling sites and open dumpsites in India: levels, congener profiles and health risk assessment. *Sci. Total Environ.* **621**, 930–938 (2018)
2. Vezzoli, Carlo: *System Design for Sustainability. Theory, Methods and Tools for a Sustainable “Satisfaction-System” Design*, 2nd edn. Maggioli Editore, Milan (2007)
3. Mathijs, E.: *Transition to a Sustainable Agro-Food System in Flanders: A System Analysis*. Philippe D’Hondt, VMM D/2013/6871/009 ISBN 9789491385193 (2012) (March 2013)
4. Emanuel, W. et al.: Clarifying societies need for understanding sustainable systems. *J. Appl. Glob. Res. JIBMR* **2**(4), 29–39 (2011)
5. UNEP DTIE *Sustainable Consumption and Production Branch: Sustainable Events Guide Give Your Large Event a Small Footprint*. United Nations Environment Programme, Paris (2012). ISBN: 978-92-807-3277-1
6. Fiksel, J.: Sustainability and resilience: toward a systems approach. *Sustain. Sci.* **2**(2), Practice, & Policy (2006)