THE UNIVERSITY OF MELBOURNE

Proceedings of The 6th International Conference on Smart Villages and Rural Development COSVARD 2023

04-05 December 2023
Webinar Mode

Editor:

A/Prof Hemanta Doloi

Smart Villages Lab
Culture • Construction • Capacity • Community

The University of Melbourne
Victoria 3010, Australia

The 6th International Conference on Smart Villages and Rural Development (COSVARD 2023) hosted by the Smart Villages Lab (SVL) of the Faculty of Architecture, Building and Planning of the University of Melbourne.

Date: 04-05 December 2023
Venue: Webinar

Publication Data
This Proceedings contains the double-blind peer-reviewed research papers presented at the COSVARD 2023 Conference, hosted by the Smart Villages Lab (SVL) of the Faculty of Architecture, Building and Planning of the University of Melbourne, held as Webinar on 04-05 December 2023.

Publication title
Proceedings of the 6th International Conference on Smart Villages and Rural Development (COSVARD 2023)

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Associate Prof Hemanta Doloi (Chair)
Editor-in-Chief (COSVARD 2023), Smart Villages Lab (SVL), The University of Melbourne.

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The University of Melbourne

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Preface

As a Chairman of COSVARD 2023, I wish a very warm welcome to all the authors, presenters, keynote speakers, attendees and support persons of the 6th International Conference on Smart Villages and Rural Development (COSVARD 2023).

Having had success in the five consecutive COSVARD conferences and in between with the hiatus of COVID-19 pandemic over 2020-21, yet again successful hosting of COSVARD 2023 as a Webinar is great testament towards the commitment and growing interests in our Smart Villages mission globally. Keeping in mind of the flexibility and unrestricting borders for wider participation and building on the premise of general acceptance of the online mode, entire proceedings of COSVARD 2023 was conducted as Webinar. It is truly pleasing the see that COSVARD 2023 was yet a great success once again with over 100 enthusiastic attendees participated from over twelve countries.

COSVARD 2023 provided a global platform for researchers, policy makers and industry professionals to share relevant knowledge and examples from practice associated with new forms of rural development. With over 40% of world's nearly 8 billion population still living in rural and ever-increasing discrepancies between urban and rural, the role and significance of COSVARD in promoting a mission for paving a distinctive "**Urban-Rural Share"** rather than fixing the **"Urban-Rural Divide"** is highly pivotal. With now six consecutive years of COSVARD, a visible roadmap has already been laid for building the much-needed capacity underpinned by relevant knowledge and theories in a new form of rural development widely known as "Smart Villages". In addition to the annual COSVARD conference, for continuity of the debate and development among Smart Villages community, a monthly Global Seminar Series on Smart Villages (GSSV) was initiated in late 2022.

Smart Villages is a relatively new concept where multiple interrelated dimensions are integrated for developing rural communities with a bottom up approach. While in the smart village creation, smart Information-Communication Technology (ICT) may be one of the important facilitating agents, the underlying principle of the smart villages is the context-specific planning and management for creating need-based solutions and uplifting the specific community. Traditional top-down approaches where decisions on interventions are based on the grand national and state level public schemes, proven to be ineffective in terms of delivering direct benefits to the community targeting their needs and requirements at the grass-roots levels.

COSVARD conference continues to impart new ideas and initiate debates among the academia, practitioners and public officials across a range of different issues associated with the community development. The research and development initiatives at the Smart Villages Lab (SVL) at the University of Melbourne striving to create a value-based sustainable rural community which is distinctive and complementing to the urban communities residing in the cities. With increasing popularity globally, it is our intention that COSVARD becomes a yearly event for creating necessary awareness of this area of critical need among the broader international community, expanding engagements with potential future partnerships from other parts of the world, especially developing economies and harnessing funding opportunities for conducting sustained research and expanding disciplinary knowledge.

Expanding the scope of COSVARD 2023 conference for an all-round rural development and aligning many of the Sustainable Development Goals (SDGs), the key focal areas under which the research papers were sought were, 'Rural Housing', 'Rural Infrastructure', 'Rural Economy', 'Sustainability' 'Smart Governance', Circular Economy', 'Social Procurement, Social Value and Value-for-Money', 'Rural Enterprises and Rural Entrepreneurship and 'Rural Culture and Experience'. A "Smart Villages Design Poster Competition" was again a part of COSVARD 2023 to promote emerging design ideas in Smart Villages.

Under the Rural Housing theme, the key focus was on housing affordability, low-cost housing, materials selection, energy and water solutions, sanitation, reusability and recycling of waste, skill development, environmental design, disaster resilience and other relevant topics.

The focus of the Rural Infrastructure was on construction and maintenance of roads and other forms of infrastructure, access to education and health care, provision of services, including energy, potable water, waste and sewage management, creation of public spaces, ICT applications and operations, and other related topics.

Rural Economy section was to deal with the building social capital, micro and community-led finance, income generation, farming support, crop selection and improvement, market access, pricing, various forms of tourism and other related topics.

Sustainability theme focused on Environmental, Social, and Economic sustainability of all aspect of rural development.

Smart Governance section comprised the research and development associated with the Information Communication and Technology (ICT) and data-driven solutions, machine learning applications, alternative forms of governance and other relevant topics.

Circular Economy theme was focused on the framework for local manufacturing, local production, local consumption, use and re-use, repairing, refurbishing, re-cycling products and services including other relevant topics.

The theme, Social Procurement, Social Value and Value-for-Money was included for promoting localised trades and contracts, evaluation of community specific social benefits, value for money assessments, alternative forms of procurement strategies and other relevant topics.

The focus of Rural Enterprises and Rural Entrepreneurship was for supporting people to build their entrepreneurial capability and capacity to leverage on new opportunities and empowering rural communities at large.

Finally, the Rural Culture and Experience entails the appreciation, preservation, characterisation, comparison or contrast of the rural culture and experience with a solid connection to land, agriculture, and nature which encompass the way of living, values, habits, and traditions of people living in remote or rural areas.

The research papers received from broad audience across all five themes were accepted for COSVARD 2023 following the double-blind review process. The scientific committee of the conference comprised over 35 experts from diverse disciplinary background recruited globally. A total of 14 final papers and one design poster were included in the conference proceedings. Nine selected keynotes were presented by nine distinguished academic and professional members with relevant background. The keynotes presenters were Prof Mohan Kumaraswamy (Editor-in-Chief, Emerald Journal of Built

Environment Asset and Project Management, BEPAM), Prof George Ofori (Sustainability Lead at the School of the Built Environment and Architecture, London South Bank University, London, UK), Prof VK Vijay, National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan), Prof Hemanta Hazarika (Kushyu University, Japan), Prof Mark Burry, Director Smart Cities Research Institute (Swinburne University of Technology, Australia), Prof Chandan Ghosh (Head, National Institute of Disaster Management (Ministry of Home Affairs, Government of India), Prof Piyush Chuansali (IIT Madras), Dr Samir Baruah, Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India and Associate Professor Hemanta Doloi (The University of Melbourne).

Last but not least, I sincerely appreciate the support of University of Melbourne for providing the necessary infrastructure support for hosting COSVARD 2023 as a Webinar. I also extend my sincere gratitude for the dedication and commitment of every single member of the scientific committee, distinguished reviewers and colleagues who have been instrumental for taking the COSVARD to entirely a new height. Without their selfless support and good wishes, COSVARD 2023 would not have been possible.

With warm regards

Associate Professor Hemanta Doloi
Convenor and Chair (COSVARD 2023)
Director (Smart Villages Lab)

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The 6th International Conference on Smart Villages and Rural Development (COSVARD 2023)

Online Mode
04-05 December 2023

University of Melbourne Organising committee:
A/Prof Hemanta Doloi (Chair)
A/Prof Robert Crawford
Dr Hannah Robertson
Dr Gao Shang

Assam Engineering College Organising Committee:
Prof Atul Bora (Co-Chair)
Prof Jayanta Pathak, A/Prof Bipul Talukdar,
Dr Sasanka Borah, Dr Pradip Baishya,
Prof S. K. Deb, Dr Plabon Kakoti,
Dr Manjuri Hazarika, Dr Purobi Patowary

Key Affiliating Partners
Indian Institute of Technology, Guwahati
Smart Cities Research Institute (SCRI) - Swinburne University of Technology, Australia
Indian Institute of Technology, Delhi
Indian Institute of Technology, Tirupati
Indian Institute of Technology, Madras



Topic: **COSVARD 2023**
Time: Dec 04, 2023 02:30 PM Canberra, Melbourne, Sydney
9:00am (Indian Standard Time, IST)
Registration Link:
https://unimelb.zoom.us/webinar/register/WN_YIXRWkUJR52QKBtly6r1nA

(Or Scan the QR to visit the link)

After registering, you will receive a confirmation email containing information about joining the webinar.

Webinar ID: **852 3790 1572**
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With over 40% of the world's population now living in rural areas, there is global interest in research associated with the creation of "Smart Villages" to address the ever growing urban-rural divide. Smart Village research being undertaken in the Faculty of Architecture, Building and Planning at the University of Melbourne is exploring rural community development, practices and relevant policies with a focus on community-centric planning of affordable housing, infrastructure, sustainable development and growth, community empowerment and other issues related to the creation of Smart Villages.

About the conference
This will be a peer-reviewed conference with a scientific committee comprising global leaders and experts. Full papers will be subject to a double-blind review before acceptance.

Themes
Conference themes include, but are not limited to:

Rural Housing
Housing affordability, low-cost housing, materials selection, energy and water solutions, sanitation, reusability and recycling of waste, skill development, environmental design, disaster resilience and other relevant topics.

Rural Infrastructure
Construction and maintenance of roads and other forms of infrastructure, access to education and health care, provision of services, including energy, potable water, waste and sewage management, creation of public spaces, ICT applications and operations, and other related topics.

Rural Economy
Building social capital, micro and community-led finance, income generation, farming support, crop selection and improvement, market access, pricing, various forms of tourism and other related topics.

Sustainability
Environmental, Social, and Economic sustainability.

Smart Governance
ICT and data-driven solutions, machine learning applications, alternative forms of governance and other relevant topics.

Location
The Conference will be held as Webinar on 04 - 05, *2023 starting on the 04th at 02:30 PM Canberra, Melbourne, Sydney, 9:00am (Indian Standard Time, IST). For registration visit*
https://unimelb.zoom.us/webinar/register/WN_YIXRWkUJR52QKBtly6r1nA

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Keynote Speakers

1. **Professor Mohan M Kumaraswamy,** *Editor-in-Chief (Emerald Journal of the Built Environment Project and Asset Management – BEPAM)*
   Theme: "Potential for Public Private People Partnerships in developing Smart Villages and Rural Infrastructure"

2. **Professor George Ofori**, *Sustainability Lead for LSBU Group, London South Bank University, London, UK*
   Theme: "The Body of Knowledge in Project Management for Developing Countries: Context shapes content"

3. **Prof Hemanta Hazarika** *(Kyushu University, Japan)*
   Theme: "Sustainable Early Warning System against Landslide Disasters"

4. **Prof V.K. Vijay,** *National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)*
   Theme: "Connecting Higher Educational institutes with villages for Rural Development and Livelihoods"

5. **Prof Chandan Ghosh,** *National Institute of Disaster Management, Ministry of Home Affairs, India*
   Theme: "Bioengineering for the rural livelihood regenerations"

6. **Prof Mark Burry,** *AO, Director (Smart Cities Research Institute), Swinburne University of Technology, Victoria, Australia*
   Theme: "New materials and construction methods for remote indigenous communities"

7. **Dr Samir Baruah,** *Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India*
   Theme: "Inclusive Growth: an attempt in reshaping the Pyramid shaped economy of India"

8. **Prof Piyush Chaunsali,** *IIT Madras, India*
   Theme: "Mapping and Utilization of Indian Biomass Ash in Structural Materials"

9. **A/Prof Hemanta Doloi,** *The University of Melbourne, Australia*
   Theme: "Alternative development models for rural community and contribution to Global Sustainability Initiative (GSI)"

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Scientific committee

- Professor Craig Langston, Bond University, Australia
- Professor Mark Burry, Swinburne University of Technology, Australia
- Professor Anthony Mills, Deakin University, Australia
- Professor Bishwajit Bhattacharjee, Indian Institute of Technology, Delhi, India
- Dr Yoshiki Higuchi, Nippon Institute of Technology, Japan
- Dr Siddhartha Singha, Indian Institute of Technology, Guwahati, India
- Professor Shaila Bantanur, BMS School of Architecture, Bangalore, India
- A/Professor Masa Noguchi, The University of Melbourne, Australia
- Assistant Professor Sajal Chowdhury, Chittagong University of Engineering and Technology, Bangladesh
- Dr James Helal, University of Melbourne, Australia
- Professor Anu Gokhale, Illinois State University, U.S.
- Professor Reeta Sarmah, Jorhat Engineering College, India
- Professor Benny Raphael, Indian Institute of Technology, Madras, India
- Dr Dominique Hes, University of Melbourne, Australia
- A/Prof Peter Raisbeck, University of Melbourne, Australia
- Professor Koshy Varghese, Indian Institute of Technology, Madras, India
- A/ Professor Arup Bhattachajee, Jorhat Engineering College, Assam, India
- Dr Mehdi Amirkhani, University of Melbourne, Australia
- A/Professor Manjuri Hazarika, Assam Engineering College, India
- Geoff Kimm, Swinburne University of Technology, Australia
- Dr Citra Ongkowijoyo, Deakin University, Australia
- Professor Boeing Singh, Indian Institute of Technology Guwahati, India
- A/ Professor Nithyadharan Mokkaiyan, Indian Institute of Technology Tirupati, India
- Dr Salman Shoostarian, RMIT University, Australia
- A/ Professor Essam Almahmoud, Qassim University, Saudi Arabia
- Dr Mohammad Arif Rohman, Sepulah Nopember Institute of Technology, Indonesia
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- A/Professor Pradip Baishya
- Professor Bipul Talukdar, Assam Engineering College, India
- Dr Medalson Ronghang, Bineswar Brahma Engineering College, India
- Dr Kiran Shinde, La Trobe University, Australia
- Dr Hannah Robertson, The University of Melbourne
- Dr Alessandro Liuti, The University of Melbourne
- Dr Rakhee Das, National Institute of Technology, Rourkela, Odisha, India
- Dr Sally Donovan, Research Fellow, The University of Melbourne
- Dr Arif Rohman, Institut Teknologi Sepuluh Nopember (ITS), Indonesia
- Dr B. Mahesh, IIT Madras, Chennai, India
- Ms Dwijomala Hanjabam, Mizoram University, India
- Mr Abdullatif Abdallah (Smart Villages Lab), The University of Melbourne

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Agenda for Opening Ceremony and Inauguration
Day 1 – Monday 04 December 2023

2:30pm (AEDT#) – 3:30pm (AEDT) : 9:00am (IST*) – 10:00am (IST)

*#Australian Eastern Daylight-Saving Time (AEDT), *Indian Standard Time (IST)*

Anchored by: Mr Murali SwayambuNathan (Melbourne, Australia)	
2:30pm (AEDT) **9:00am (IST)**	**Notionally, official opening of COSVARD 2023, Lighting of Lamp and Felicitation of Guests**
2.40pm (AEDT) **9:10am (IST)**	Opening COSVARD 2023, Welcome and Introduction **A/Prof Hemanta Doloi (Chairman)**
2:55 pm (AEDT) **9:25am (IST)**	**Prof Chandan Ghosh, National Institute of Disaster Management, Ministry of Home Affairs, Govt of India**
3:05 pm (AEDT) **9:35am(IST)**	**Dr Hannah Robertson, The University of Melbourne**
3:15 pm (AEDT) **9:55am(IST)**	**Dr Samir Baruah, Ex- Banker, Mentor & Advisor, Laghu Udyog Bharti, NE**
3:25m (AEDT) **9:55am (IST)**	**Prof Robert Crawford, The University of Melbourne**
3:35m (AEDT) **10:05am (IST)**	**Dr Pranjal Kumar Phukan,** Brand Ambassador, Mentor & Advisor ***Author of the book- Limits to Infinity***
3:45pm (AEDT) **10:15am (IST)**	**Mr Sanjib Sabhapandit, Entrepreneur and Film Director, India**
3:55pm (AEDT) **10:25am (IST)**	**Dr Gao Shang, The University of Melbourne**
4:00 pm (AEDT **10:30am (IST)**	**Vote of Thanks [A/Prof Hemanta Doloi]**
Technical Session starts at 4:30pm (AEDT) **11:00am (IST)**	

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Technical Session
Day 1 - Monday 04 December 2023

4:30pm (AEDT) **11:00am (IST)**	**Keynote 1: Professor Mohan M Kumaraswamy** *Editor-in-Chief (Emerald Journal of the Built Environment Project and Asset Management – BEPAM)* *Honorary Professor, The University of Hong Kong, Hong Kong Honorary Professor, University of Moratuwa, Sri Lanka* **Topic: Potential for Public Private People Partnerships in developing Smart Villages and Rural Infrastructure** **Chair: A/Prof Hemanta Doloi**	
6:00pm (AEDT) **12:30pm (IST)**	**Session 1: Sustainability and Resilience**	
	Chair: Prof Robert Crawford [UoM]	**Authors**
Paper 20 (*15 mins*)	Exploring traditional timber houses of Bangladesh through the perspective of rural culture and environmental experience	Rezuana Islam Islam *Chittagong University of Engineering & Technology, Bangladesh*
Paper 22 (*15 mins*)	Policy analysis and way forward for a sustainable rural community	Dwijomala Hanjabam *Mizoram University, India*
Paper 21 *(15 mins)*	Analysis of Willingness to Pay for Sea Transportation Services in Indonesia	Hengki Purwoto *Universitas Gadjah Mada, Indonesia*
Paper 10 *(15 mins)*	The use of digital layers in post-growth communities - an exploratory study	Åsa Isacson, Marco Adelfio, *Chalmers University of Technology, Sweden*
7.00pm (AEDT) **1:30pm (IST)**	**Break**	
7:15pm (AEDT) **1:45pm (IST)**	**Session 2: Rural Housing**	
	Chair: Dr Gao Shang [UoM]	**Authors**
Paper 6 (*15 mins*)	Inner rural areas entrepreneurship Italian community cooperatives & smart proposal for Sicilian Mountain Madonie District	Luisa LOMBARDO *University of Palermo, Italy*
Paper 17 (*15 mins*)	Sustainable Energy Management and Microgrids in Smart Villages	Tanmay Saikia *Assam Engineering College, India*
Paper 9 (*15 mins*)	Salinity's shadow: sustainable modular resilience for the Munda Community, Satkhira	Shajib Paul *Chittagong University of Engineering & Technology (CUET), Bangladesh*
8:30 pm (AEDT) **3:00pm (IST)**	**Break**	

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Technical Session
Dav 1 - Mondav 04 December 2023

8.45pm (AEDT) **3:15pm (IST)**	**Keynote 2: Prof V.K. Vijay** *National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)* Topic: Unnat Bharat Abhiyan - a program of ministry of education, government of India for development of villages through higher educational institutes **Chair: A/Prof Hemanta Doloi**	
9.45pm(AEDT) **4:15pm (IST)**	**Session 3: Infrastructure-I**	
	Chair: Sajal Chowdhury, Bangladesh	**Authors**
Paper 12 (*15 mins*)	AI AND AQUAPONICS for sustainable farming: Challenges faced by farming in coastal regions of Bangladesh	Israt Jahan *Brac University* *Bangladesh*
Paper 14 (*15 mins*)	Smart irrigation for sustainable rural development: a study of Nalbari Irrigation Circle	Rajat Kamal Kakati *Assam Engineering College, India*
Poster 1 (*15 mins*)	Envisioning Smart Villages: A Path to Progress with the Local Marketplace	Madhuryya Kumar Bhattacharyya *Assam Engineering College, India*
10:30pm(AEDT) **5:00pm (IST)**	**Break**	
10.45pm(AEDT) **5:15pm (IST)**	**Keynote 3: Professor George Ofori** *Sustainability Lead for LSBU Group, London South Bank University, London, UK* Topic: The Body of Knowledge in Project Management for Developing Countries: Context shapes content **Chair: A/Prof Hemanta Doloi**	
11.45pm(AEDT) **6:15pm (IST)**	**End of Day 1**	

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Technical Session
Day 2 - Tuesday 05 December 2023

2:30pm (AEDT) 9:00am (IST)	**Keynote 4: Prof Hemanta Hazarika (Kyushu University, Japan)** Topic: Sustainable Early Warning System against Landslide Disasters **Chair: A/Prof Hemanta Doloi**	
3.30pm (AEDT) 10:00am (IST)	**Session 4: Infrastructure-II**	
	Chair: Dr Sally Donovan **Melbourne, Australia**	**Authors**
Paper 23 (*15 mins*)	Dynamics of local and foreign contractors in developing countries: The case of Tanzania	Abdullatif Abdallah *Smart Villages Lab (SVL)* *The University of Melbourne, Australia*
Paper 8 (*15 mins*)	Rural housing module to improve survival amidst cyclones	Syeda Tahmina Tasnim *Chittagong University of Engineering & Technologyz, Bangladesh*
Paper 13 (*15 mins*)	Barriers to implementation of sustainable construction in India	Nayanika Bora *The University of Melbourne, Australia*
Paper 4 (*15 mins*)	Studies on the use of locally available (Coxs Bazar and Saint Martin) renewable seaweed wastes as compost organic fertilizer resources	Durlave Roy *Bangladesh Open University, Bangladesh*
	Chair: Prof Jayanta Pathak (AEC, Guwahati)	
4.45pm(AEDT) 11:15am (IST)	**Keynote 5: Prof Mark Burry, AO** *Director (Smart Cities Research Institute)* *Swinburne University of Technology, Victoria, Australia* **Topic: New materials and construction methods for remote indigenous communities**	
	Chair: Mr Abdullatif Abdallah (University of Melbourne)	
5:30pm(AEDT) 12:00pm (IST)	**Keynote 6: A/Prof Hemanta Doloi** *Smart Villages Lab (SVL), The University of Melbourne* **Topic: Alternative development models for rural community and contribution to Global Sustainability Initiative (GSI)**	

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Day 2 - Tuesday 05 December 2023

	Chair: Prof Shyamanta M. Hazarika (IIT Guwahati)
6:30pm(AEDT) **1:00pm (IST)**	**Keynote 7: Dr Samir Baruah** *Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India* **Topic: Inclusive Growth: an attempt in reshaping the Pyramid shaped economy of India**
	Chair: A/Prof Hemanta Doloi (The University of Melbourne)
7.15pm(AEDT) **1:45pm (IST)**	**Keynote 8: Prof Chandan Ghosh** *Professor and Head* *Resilient Infrastructure Division* *National Institute of Disaster Management, Ministry of Home Affairs, Govt of India* **Topic: Bioengineering for the rural livelihood regenerations**
	Chair: Prof Bipul Talukdar (AEC, Guwahati)
8.00pm(AEDT) **2:30pm (IST)**	**Keynote 9: Prof Piyush Chaunsali** *(IIT Madras)* **Topic: Mapping and Utilization of Indian Biomass Ash in Structural Materials**
8.45pm (AEDT) **3:15pm (IST)**	**Awards announcements** **A/Prof Hemanta Doloi**
9.00pm (AEDT) **3:30pm (IST)**	*Closing remarks* **A/Prof Hemanta Doloi**
End of Conference	

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For Registration

Follow the link below:

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Organising Committee

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Prof Robert Crawford, The University of Melbourne
Dr Hannah Robertson, The University of Melbourne
Dr Gao Shang, The University of Melbourne

Scientific Committee members:

Professor Craig Langston, Bond University, Australia
Professor Mark Burry, Swinburne University of Technology, Australia
Professor Anthony Mills, Deakin University, Australia
Professor Bishwajit Bhattacharjee, Indian Institute of Technology, Delhi, India
Dr Yoshiki Higuchi, Nippon Institute of Technology, Japan
Dr Siddhartha Singha, Indian Institute of Technology,Guwahati, India
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A/Professor Masa Noguchi, The University of Melbourne, Australia
Assistant Professor Sajal Chowdhury, Chittagong University of Engineering and Technology, Bangladesh
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Keynotes Speakers and topics

1. Professor Mohan M Kumaraswamy, Editor-in-Chief (Emerald Journal of the Built Environment Project and Asset Management – BEPAM)
    - **Theme:** *"Potential for Public Private People Partnerships in developing Smart Villages and Rural Infrastructure"*

2. Professor George Ofori, Sustainability Lead for LSBU Group, London South Bank University, London, UK
    - **Theme:** *"The Body of Knowledge in Project Management for Developing Countries: Context shapes content"*

3. Professor Hemanta Hazarika (Kyushu University, Japan)
    - **Theme**: *"Sustainable Early Warning System against Landslide Disasters"*

4. Professor V.K. Vijay, National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)
    - **Theme**: *"Connecting Higher Educational institutes with villages for Rural Development and Livelihoods"*

5. Professor Chandan Ghosh, National Institute of Disaster Management, Ministry of Home Affairs, India
    - **Theme**: *"Bioengineering for the rural livelihood regenerations"*

6. Professor Mark Burry, AO, Director (Smart Cities Research Institute), Swinburne University of Technology, Victoria, Australia
    - **Theme**: *"New materials and construction methods for remote indigenous communities"*

7. Dr Samir Baruah, Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India
    - **Theme**: *"Inclusive Growth: an attempt in reshaping the Pyramid shaped economy of India"*

8. Professor Piyush Chaunsali, IIT Madras, India
    - **Theme**: *"Mapping and Utilization of Indian Biomass Ash in Structural Materials"*

9. Associate Professor Hemanta Doloi, The University of Melbourne, Australia
    - **Theme**: *"Alternative development models for rural community and contribution to Global Sustainability Initiative (GSI)"*

Prizes

Research Papers

1st Prize

Åsa Isacson and Marco Adelfio, “The use of digital layers in post-growth communities - an exploratory study”, Chalmers University of Technology, Sweden.

2nd Prize -1

Luisa Lombardo and Tiziana Campisi, “Inner rural areas entrepreneurship Italian community cooperatives & smart proposal for the Silician Mountain Madenie District”, University of Palermo, Italy.

2nd Prize -2

Rezuana Islam, Khandaker Shabbir Ahmed and Sajal Chowdhury, “Exploring traditional timber houses of Bangladesh through the perspective of rural culture and environmental experience”, Chittagong University of Engineering and Technology (CUET), Bangladesh.

2nd Prize -3

Abdullatif Said Abdallah and Hemanta Doloi and Dominik Holzer, “Dynamics of local and foreign contractors in developing countries: The case of Tanzania”, The University of Melbourne, Australia.

3rd Prize - 1

Syeda Tahmina Tasnim, Shajib Paul, Abeg Rahman, Nazia Zaman, Rifat Al Ebrahim and Nusrat Nasrin Ananna, “Rural housing module to improve survival amidst cyclones”, Chittagong University of Engineering & Technology, Bangladesh.

3rd Prize - 2

Israt Jahan[1], Mahabubur Rahman[2], Farzana Faiza[3] and Tunazzina Rahimu[4], “AI and Aquaponics for sustainable farming: Challenges faced by farming in coastal regions of Bangladesh”, [1,4]Brac University, [2]University of Asia Pacific, [3]Bangladesh University of Engineering and Technology, Bangladesh.

3rd Prize - 3

Tanmay Saikia, “Sustainable Energy Management and Microgrids in Smart Villages”, Assam Engineering College, India.

Research Papers

Alternative Development Models for rural community and contribution to Global Sustainability Initiative (GSI)

Hemanta Doloi

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Abstract: *In the advent of rapid global warming, the need for alternative development models targeting the rural community is all time high. The established development models from past practices can't be extended towards development of the good 40% plus global population who are still living in rural conditions and who are currently going through an exponential transformation in the modernisation ladder. However, wrongly or rightly, the current trend, knowledge, skills and development processes which are being applied in the rural transformation do not add much value in achieving the global sustainability target as stipulated in the UN's Sustainable Development Goals (SDGs). While the cities and the urban communities are the worst offenders of the climate due to the prevailing high-carbon footprint lifestyle, rural communities which count good 40% of the global population presents a huge opportunity with alternative development models. The alternative development models should be value-based bottom-up and vernacular solutions with perhaps minimal overlapping of modern tools, techniques, processes and expertise. In this paper, the authors argue that traditional urban-rural divide is perhaps not a bad thing and in the name of modernisation of the rural, there should be the sole target of addressing this urban-rural gap. Instead, a purpose-based harmonisation needs to be created for balancing the urban-rural share so that the 40% rural communities are able to counter balance the urban lifestyle in the context of the carbon-footprints and contribute towards meeting the global sustainability target including decarbonisation of the planet.*

Keywords: *Smart Villages, rural development, urban-rural share, sustainability target*

1 Introduction

With over 40% of the world's population now living in rural areas, there is global interest in research associated with the creation of "Smart Villages" to address the ever growing urban-rural divide. In a state like Assam where 86% of the 35 million population still lives in very rural areas, the need for smart interventions is even greater in an attempt for rapid upgradation of the community. Smart Village research being undertaken in Smart Villages Lab (SVL) at the Faculty of Architecture, Building and Planning of the University of Melbourne has been exploring rural community development, practices and relevant policies with a focus on community-centric planning of affordable housing, infrastructure, sustainable development and growth, community empowerment and other issues related to the creation of Smart Villages. The idea of smart villages is highly significant for not only to appreciate the potentials of the rural community for contributing to the local and national economy but also stemming the migration to the already crowded cities for seeking better economic opportunities (Doloi *et at* 2019a).

While Smart Villages could be a novel concept enabling the rural communities to modernise and establish at the same level as the urban counterparts, unlike traditional development models, the concept promotes a complete new bottom-up approach. In the bottom-up approach, the community takes a leading role and the needs and requirements of the grass-roots level people take the precedence in planning of the interventions in the development modalities (Doloi *et al* 2019b). One of the key enablers is thus the process of engagement of the grass-roots level community for contributing towards their own plans of development. Such development plans are based on their immediate needs and priorities in reference to an available benchmark being applicable in the location specific context. In order to engage the relevant local community for imparting in collaborative discussion forums, contributing ideas for achieving common objective in a particular village context and develop sustainable outcomes, appropriate framework is required (Doloi and Donovan 2020). The framework needs to facilitate the collaboration, generate interests and provide a clear roadmap for realising the values being created out of the entire community engagement exercise leading the creating a smart village. In this paper, for the first time, the author aims to establish the Smart Villages Workshop as one of the key enabling framework for engaging rural community in the villages especially in an Indian context.

2 Why Smart Villages

Smart Villages is a relatively new concept that refers to the processes of supporting rural community with context-specific solutions and empowered by harnessing the potentials within them. Depending on the community size, location and underling potentials, level of smartness in the upgradation processes may vary from one community to the other. The rationalisation of the Smart Villages is summarised in the following few points.

- Majority of the population live in villages with less than standard living conditions
- Some of the basic facilities like electricity, running water, road connectivity, playgrounds, library, banking and medical assistance are not readily available even at a convenient proximity from the villages in most cases
- The lack of the conveniences in the village is also a reason for lack of opportunity for income generation and independencies among the community
- Arranging better living conditions for the rural community results in stemming migration to the cities which removes the burden of continuous adaption due to increased population in already overcrowded cities

- Retention and reflection of the rural culture, rural eco-system, social settings including history, heritage and value is highly crucial in the digital waves and rapid transformation process so that the rural areas are points of attraction for urban communities. Such trends will provide the opportunities for supporting rural economies and enabling empowerment among the rural communities.

3 Broad areas of focus in Smart Villages design

While designing a smart village, context-specific considerations are highly significant. "Smart solutions" is a relative term and one solution does not fit all. For instance, in a place where people are relatively poor and struggles to earn a regular income, some sort of steady and accessible income source could be one of the smartest solutions for that community. Similarly, in a place where clean water is not available, any sort of localised solutions for securing a potable water supply system could be one of the smart solutions in its own right.

In the development process of a community, an integrated approach is required encompassing a range of fundamental necessities and needs. Some of these necessities may include:

- Income generation ideas and potentials
- Education and skills – needs and development
- Agriculture – needs, potential and development
- Housing – needs, potentials, skills and development
- Energy – needs, requirements and potential for alternative sources
- Waste – current practice, improvement potentials
- Water and sanitation– current practice, improvement potentials
- Transportation - needs and development
- Health and wellbeing - current issues, existing facilities, improvement potentials
- Environment – current issues, improvement potentials
- Governance - needs and development

In any attempt for developing community in the smart villages, emphasis should be placed on in all of the above areas so that a holistic development model can be established for the target communities. An idealised Smart Villages model and interconnected areas are shown in Figure 1 below.

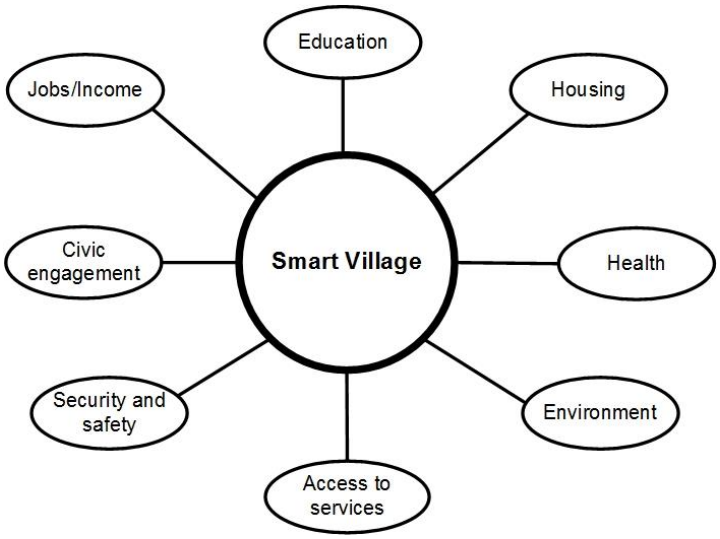

Figure 1: Idealised Model of a Smart Village
(*Source: Doloi et at 2019a: Planning, Housing and Infrastructure for Smart Villages, Routledge, UK*)

In order to develop action plans across all these interconnected areas, every aspect needs to be explored. The action plans must be developed with practical and feasible implementable strategies with clear potential for showing results on the ground. The Smart Villages workshop is one of the very first steps to explore each of these areas as individual modules and develop practical and implementable strategies with the help of Special Interests Groups (SIG) within the participants.

4 Urban-Rural Share or Urban-Rural Divide

Due to the lifestyle of urban community globally, generally per capital carbon emissions of urban population is significantly higher than the rural counterparts. According to the publication of the International Energy Agency, a person living in a Western or developed country generally emits 11 times more energy-related CO2 compared to a person living in the developing countries. Within the community itself, there is a significant variation of the consumption of energy and volume of emissions between the rich and the poor people. For instance the top 1% of the rich people on average emit 50 tonnes CO2 times person which is 1000 times more than the bottom 1% poorer people globally (IEA, 2023). Given such a disparity in carbon emission among the population distribution, with the current 60-40 split of urban and rural community globally and the trend of rapid urbanisation of the 40% rural community to bring to the same or similar standards as urban, the process needs a complete overhaul. Traditional concept of rapid urbanisation towards the reduction of the gap of urban-rural divide, there will be literally no chance that energy related carbon emission can be contained in the near future. Instead, this is perhaps the high time to appreciate the purpose-based lifestyles of both urban and rural communities and then redefine the share of both for balancing or harmonious outcomes as far as the carbon emission is concerned.

4.1 Significance of "Urban-Rural share" concept in Smart Villages

Given the climate change and rapid global warming, the research program at the Smart Villages Lab (SVL) at the University of Melbourne strives to create an alternative way of developing the 40% rural community without having to extend the traditional urban-centric developing models. The traditional urban-centric development models are fundamentally unsustainable and may not be the right development models for the rural communities generally.

Figure 2 highlights the clear division of urban and rural population with purpose-based lifestyle. While the urban community in the city centers have specific needs and requirements in relation to the urban amenities, the rural communities also have specific characteristics and content-based needs for complementing the urban centers. Due to the virtue of the rural community being indigenous villagers, the values, culture, heritage are unique from one community to the others. The need and design of shelters and perceptions of spaces inside and outside the homes vary from one community to the other. Also such variations are even greater in comparison to the urban and semi-urban communities. So essentially the no rural communities are same and they are vastly different when comparing the amenities and lifestyle between the urban and semi-urban settings.

Traditionally due to the agriculture-based activities and localised availability of resources, rural communities live quite naturally. Their housing and infrastructure solutions are usually nature-based and highly sustainable from the carbon footprints perspectives. Evidently per capita carbon footprint among the rural communities is extremely small, if not nil. In the advent of the climate change and global warning, thus the rural community

which accounts to good 40% globally has a lot to offer in countering the increasing footprints in the urban centers. Hence, conceptually while developing the rural communities, current trend of rapid urbanisation needs be altered with rural-centric alternative and sustainable development models.

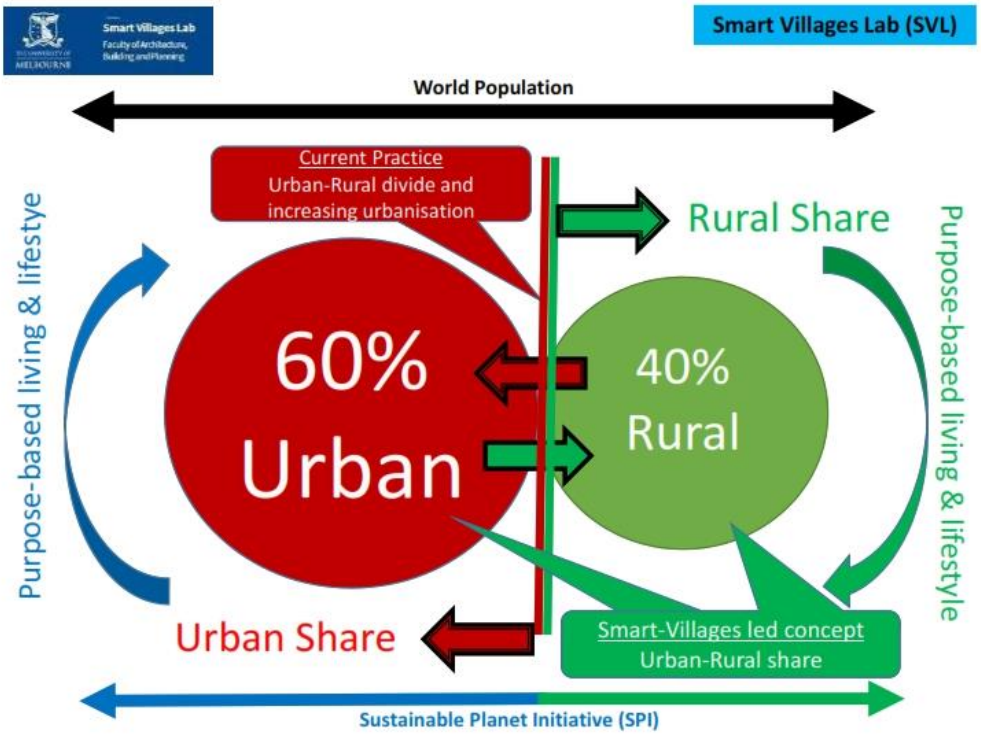

Figure 2: Urban-rural share as a concept toward Sustainable Planet Initiative (SPI) (*Source: Doloi 2023*)

In the effort of such a shift in the flow of development and the underlying potential for contributing to the containment of the global warming due to man-made activities, the concept of Smart Villages Workshop has been developed. The idea of the Smart Villages workshop is the bring the concept into action by taking the village communities at the core in the context-specific interventions. The remainder of the paper is discussing some of key steps in conducting the Smart Villages workshops as a catalyst for alternative development models for rural community and contribution to Global Sustainability Initiative (GSI).

4.2 Aim of the Smart Villages workshop

The aim of the workshop is to design practical and implementable solutions to solve real-world problems in the context of specific communities. One of the key concepts of the Smart Villages workshop is the grass-roots level community-specific idea elicitations with a bottom-up approach. A typical schedule of a workshop comprises three full day activities including site visits, final presentations and award ceremonies. Based on the expertise and interests, the participants are required to form the Special Interest Groups (SIG) to work in one specific area or theme within the case study villages.

For instance, in a selected village, some of the key issues could be dilapidated public temple, muddy local roads, ill-maintained local park or unused cultivated lands etc. Taking into consideration of interests and expertise associated with each of these issues, the Special Interest Groups (SIG) will need to work one selected issue with necessary depths and breaths and devise feasible solutions through the workshops.

As all the specific issues in a given village are not possible to ascertain at the beginning, workshops on individual modules may be difficult organised. However, with a first workshop on a particular village, numerous issues will emerge. Depending on the scale of such issues, the needs for the individual modules-based workshops will come into surface where size of SIG will grow to tackle the issues in depths and breaths with appropriate action plan. The action plan will need to be implemented for realising the benefits and empowering the community.

The workshop on the same village may need to be conducted more than once. The master plan developed in the first workshop will form the basis for extending the scope and knowledge in the subsequent workshops. Any field-based implementation records need to be updated on the master plan over time. A natural custodian of the master plans developed through the Smart Villages workshop would be the local coordinating institution and the materials should be carefully kept either in the library or in the office of the principals.

By way of participating in one or more modules in the workshop, the participants are required to be part of a Special Interests Groups (SIG) and share their academic, professional or visionary knowledge and ideas for understanding the context-specific issues and devise implementable solutions.

The solutions from the SIGs are then integrated to develop master plans for specific villages with clearly defined scope, cost and budget, source of funding, execution timeline including control, monitoring, operations, impacts and realisation of benefits.
Objectives include:

By way of participating in one or more modules in the workshop, the participants are required to:

- select one or more specific village(s) with clear demarcation of boundaries as case study
- contribute their ideas, render their academic and professional services focusing on the key areas of development in the selected village
- explore individual areas and devise range of feasible solutions considering specific contexts
- contribute towards development of the master plans at the village levels by integrating the best possible solutions from all the interconnected areas
- develop execution, monitoring and control and completion plans including funding and cash flow considerations
- establish clear roadmaps ensuring short, medium and long term outcomes and meeting the development target of the entire community.

4.3 Setting up the workshops

Smart Villages Workshops are conducted in partnerships between the local collaborating institutions and the Smart Villages Lab (SVL) at The University of Melbourne, Australia. A local coordinator or a coordination team is required to be formed at the collaborating institution for conducting the workshops with all supporting facilities and resources. The

lead coordinator at the facilitating institution requires to establish the targets and objectives of each workshop based on the location or village being considered and preliminary understanding of the immediate needs and requirements of the community concerned.

4.4 Qualifications and roles of the participants

The success of the workshop depends on how the like-minded and relevant groups for participants are being recruited and how it facilitates generating interests with genuine participations and undertakings for tackling real issues in the context of the subject village. Thus, setting-up of clear objectives, curbing the scope in one or two deliverables, clarity in instructions and ambience are some of the key factors for promoting positivity and getting them engaged with respect to the interests and expertise among the participants.

Ideally the participants for Smart Villages workshops should be drawn from a range of roles associated with the specific locations of the villages including relevant jurisdictions. Example of some of the participants are:

- senior level students of the coordinating institution(s)
- academic staff members of the coordinating institution(s)
- representatives (e.g. headman) from the case study villages
- office bearers from the local governments
- officials from local banks
- other professionals from community such as planners, engineers, volunteers from NGOs
- teachers from local schools
- representatives from municipality
- representatives district offices

4.5 Key processes of the Smart Villages Workshops

This section discusses about some of the key processes for steering the workshops and undertaking the necessary investigations for deriving the outcomes. In order to deriving practical and feasible solutions to the problems, the processes should be based on relevant scientific principles. Thus both theoretical underpinnings and applicability in practice are important considerations while exploring the processes in a particular village context. Seven key processes are briefly discussed below:

1. Establishing the context

Setting up the context is one of the very first processes in Smart Villages workshop. Under this process, some of the key considerations include identification of the village(s), geographical boundaries demarcating the village(s), number of houses, size of population, land area and type and other demographic information. Contexts also include the considerations under which a particular issue may be listed such as environmental, social, economic and so on.

2. Understanding the World-Views of the village

Under this process, SWOT analysis (e.g. Strength, Weakness, Opportunity and Threat) of the selected contexts should be undertaken. SWOT analysis helps in not only to understand the context well but also identify the internal and external factors associated with both risks and opportunities of the issues being considered under each context.

Adopting the Soft Systems Methodology (SSM) (Doloi 2011, Checkland and Scholes 1990), the world views of the specific contexts under the selected contexts should be evaluated and picturised using the Rich Pictures required by the SSM method. The Rich Pictures include all the actors and functions and their causal relations in directional line

diagrams. Based on the Rich Picture and by undertaking necessary analysis (e.g. CATWOE analysis as required by SSM), concept maps are developed with a clear identification of actors and processes. This concept maps will then add significant input in the process of developing master plans of the selected site.

3. Identification of the issues

Upon developing the Rich Picture and concept maps on the selected contexts through SSM, range of underlying issues are identified. The issues are then categorised for aligning the interests and expertise of the SIGs among the participants. Examples categories may include *streetscape and beatification*, *restoration of places of culture and heritage significance*, *education and skills*, *roads and drainage*, *agriculture*, *job creation and income growth*, *safety and security*, *health and well-being*, *water and sanitation*, *waste management* etc. Once the issues are identified, necessary action planning including benefit analysis will need to be undertaken (Ackoff 1984, Cazorla *et. al.* 2013, Carmemark et al 1976).

4. Role and Responsibility Analysis

One of the important processes in any development planning is the identification of role and responsibilities of the stakeholders who directly or indirectly support the project and contributes to make it happen. Based on the identified stakeholders and their associations with respect to project planning and implementation, responsibility planning is conducted and appropriate responsibility matrix is designed to highlight the activities, authorities including communication formalities over the project lifecycle.

5. Effort-Analysis

Effort analysis process entails the effort in terms of man-hours required to perform the project activities from a practice context. Effort plans are contingent of the resources being available at any particular stage of the project. Both effort and resources plans are required to be reviewed and analysed from the financial obligations and cash flow perspective as well.

6. Project-based Execution Planning

Project based execution plan is developed following the best practice processes available in the mainstream literature (PMBOK 2017). The PMBOK Guide provides the guidelines and processes on twelve key knowledge areas required for executing projects. These knowledge areas are scope management, cost management, schedule management, risk management, quality management, procurement management, communication management, human resources management, integration management, financial management, stakeholder management and environmental, health and safety management. Focusing at the master plans levels, relevant plans are required for each of these knowledge areas with respect to the project context.

7. Review and Finalisation of the Master Plan

Under this final process, setting up the milestones against the deliverables and highlighting the objectives to achieve over short, medium and long run is highly critical from execution and controlling aspects of the project. Appropriate documentation archival needs to be setup for timely access of the plans and processes, review and upgrades over time as required.

4.6 Awards and recognition

Awards and recognition is paramount in most projects and the effort expanded over Smart Villages Workshops by the participants is crucial to be appreciated in a formal settings. Upon successful completion of the Smart Villages Workshop, the participants should be awarded with participation certificates issued jointly by the Smart Villages Lab (SVL) of The University of Melbourne and the local coordinating institution. Effort will be made to award the certificates to the participants by organising a closing ceremony in the presence of the eminent members of the participating organisations. Based on the work produced in the workshop, the participants may be invited to contribute research papers or present design-posters at relevant forums such as The International Conference of Smart Villages and Rural Development (COSVARD) organised annually by the SVL.

4.7 Typical schedule of the workshop

A typical schedule of a workshop comprises three full day activities including site visits, final presentations and award ceremonies. Based on the expertise and interests, the participants are required to form the Special Interest Groups (SIG) to work in one specific area or theme within the case study villages.

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5 Conclusion

In this paper, a unique concept of urban-rural share has been introduced as a way forward for achieving sustainable outcomes in the transformation process of rural community especially in the developing economies. A clear distinction has been made against the traditional “urban-rural gap” which usually acts as a driving force for transforming rural community into the urban centers by extending the unban-centric knowledge, skill and development processes without taking into consideration of the value-based rural lifestyle. This paper is clearly making a strong conviction for containing the rural communities in the rural settings and making a clear distinction in the differential requirement of the development models from the urban centres. With the promotion of community-led vernacular and sustainable development models would clearly support lowering the

carbon footprints while uplifting the rural communities globally and become a combating force towards the fights against global warming and climate change.

References

Ackoff, R. L. (1984). On the nature of development & planning. In D.C. Korten and R. Klauss (Ed.) People Centered Development: Contributions Toward Theory & Planning Frameworks. West Hartford, CT: Kumarian Press.

Akram, S. and Routray, J.K. (2013), "Investigating causal relationship between social capital and microfinance", International Journal of Social Economics, Vol. 40 No. 9, pp. 760-776.

Basargekar, P. (2010), "Measuring effectiveness of social capital in microfinance: a case study of urban microfinance programmer in India", International Journal of Social Inquiry, Vol. 10 No. 3, pp. 25-43.

Carmemark C, Biderman J. and Bovet (1976), The economic analysis of rural road projects (English). Staff working paper; no. SWP 241 Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/531961468740445027/The-economic-analysis-of-rural-road-projects (accessed on 11 Sept 2020)

Cazorla, A., De los Ríos, I., & Salvo, M. (2013), Working With People (WWP) in Rural Development Projects: a Proposal from Social Learning. *Cuadernos de Desarrollo Rural*, 10 (70), 131-157.

Doloi, H. (2023), Keynote 12: Smart Data-driven approach for developing resilient society, *in the Proc of the 2nd International Conference on Construction Resources for Environmentally Sustainable Technologies (CREST 2023)*, 20-23 Nov 2023, Fukuoka, Japan (https://www.ic-crest.com/).

Doloi H, Green R and Donovan S (2019a), Planning, Housing and Infrastructure for Smart Villages, Routledge, UK.

Doloi H and Donovan S (2020), Affordable Housing for Smart Villages, Routledge, UK.

Doloi, H. (2011), Understanding stakeholders' perspective of cost estimation in Project Management, *International Journal of Project Management*, Vol.29(5), pp.622-636.

Doloi H., Bora A and Donovan S. (2019b), Government of Assam - Policy Framework for Smart Villages, published by the University of Melbourne (36 pages) ISBN 978 0 7340 5560 6 (print).

Checkland, P., Scholes, J., (1990), Soft Systems Methodology in Action. Wiley,Chichester.

Gkartzios, M., & Scott, M. (2009). Planning for Rural Housing in the Republic of Ireland: From National Spatial Strategies to Development Plans. European Planning Studies, 17(12), 1751-1780. doi:10.1080/09654310903322298.

PMBOK Guide (2017), Project Management Body of Knowledge Guide, Project Management Institution, USA.

International Energy Agency (2023) - https://www.iea.org/commentaries/the-world-s-top-1-of-emitters-produce-over-1000-times-more-co2-than-the-bottom-1

EXPLORING TRADITIONAL TIMBER HOUSES OF BANGLADESH FROM THE PERSPECTIVE OF RURAL CULTURE AND ENVIRONMENTAL EXPERIENCE

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Abstract: *Traditional houses, as metaphors of shelter and security for humanity, which must interact to distinct natural features as well as are driven by culture and experiences. Southern coastline plains of Bangladesh hold a rich tradition in terms of evolution and growth of settlement. Local people developed their unique timber house form which is a two-storied timber-framed structure having wood as wall envelope and C.I. (corrugated iron) sheet as roofing material. These houses are culturally and environmentally adaptive in nature. The purpose of this paper is to illustrate on the cultural influences and insights in the architecture of rural traditional timber houses found along Bangladesh's southern coast. The methodology used two main tools: a literature survey and field investigations. The current study considers fifteen two-storied traditional timber houses from which one exemplary house has been presented in detail in terms of culture and environmental experiences of occupants in planning and space organization, structural system, environmental passive features, etc. The findings revealed that traditional timber houses of Bangladesh are the reflection of local culture in practice which further gets shaped by the environmental experience gained through course of times. Cultural influences are more evidenced by the hierarchical organization of spaces, where one must pass through changing spaces to get from public to private zones, whereas environmental influences are more visible in the house's planning, three-dimensional form, and construction details in terms of conventional ecological and technological means of defence. The outcomes will serve as background study for the concerns and will assist professionals and policymakers in advancing architectural design recommendations for enhancing occupant wellbeing.*

Keywords: *Traditional Timber House, Rural Culture, Environmental Experience, Coastal Area, Tropics.*

1 Introduction

A house is a man-made structure which is the metaphors of shelter and security for humanity (Zukin, 1995). House, being individual's personal environment and belongings, primarily emphasizes not only its function as a shelter, additionally unites to emotional ideas about mankind's origins. Again, regional architecture is characterized by its people's traditions, culture, and real-life experiences where environmental impact is included in the cultural dimensions of setting [Rapoport 2004; Gustafson 2001; Rapoport 1976]. This corresponds to the idea that geographical connection signifies culturally shared personal views as well as place-related behaviours influenced by cultural, traditional and socio-political influences. The diversity in our surroundings can reflect an array of culture that distinguishes a particular community from the others. A traditional house in Bangladesh has significant cultural effects in architectural forms because traditional houses are tailored to meet the specific needs of users. The organization of spaces within the house reflects not only the practical requirements of daily life, but also social norms, traditions, and expectations. Rural Bangladesh has a remarkable variety of traditional houses. In Bangladesh, physical and cultural factors, or a combination of the two, primarily influence house types. These variables may result in either compacted or scattered houses depending on how they are arranged. Only the most important physical variables are included, such as topography, climate, natural disasters, and construction resources while cultural influences include people's economic status, traditions and social contexts, beliefs, legal framework, and materials used to build houses (Mandal 2001). Cultural, socioeconomic, and environmental factors all have a profound effect on people's lifestyles. The current research focuses on 'traditional timber' house, which is primarily located in the south-eastern zone. Construction and layout of this traditional house evolved meticulously over time in a trial error method as a result of multiple considerations such as landscape, culture, surroundings, and natural assets etc. where rising patterns in human interest remain an actual challenge in the practice of this housing, particularly in individuals who have endured residing close to nature for centuries. People in such a setting also need to adapt themselves to become accustomed to their house forms. For centuries, successive generations lived while upholding their culture and customs, demonstrating the flexibility and durability of traditional design. It is an inheritance from earlier times that still exists present-day and holds potential for future endeavours. However, because of challenges such as industrialization and economic benefits brought about by advances in design, we have lost sight of the true essence of traditional house. The growing popularity of manufactured materials coupled with mass customization allows for the development of houses in the shortest time possible with a limited number of materials. Additionally, a sense of worth and purchasing power contributes to the decline of traditional timber houses. However, research into the effects of rural culture and environmental experience on the development of this house form is still marginal. Therefore, the objective of this paper is to focus on the traditional two-story timber house found near Bangladesh's south-eastern coastal areas. This research clarifies cultural effects and environmental experiences that shaped the development of traditional timber houses in Bangladesh.

2 Traditional Timber Houses in Bangladesh

Traditional timber houses can be found throughout Bangladesh, particularly in rural regions. These houses are detached dwellings found in Bangladesh's south-eastern,

north-eastern, and south-western climatic zones. Timber houses are common due to the abundance of bamboo and timber as well as supplies is comparatively cheap, particularly in rural regions where advanced building materials are not always as accessible or economical. In recent times, there has emerged an increasing grasp of the requirement for durable and less vulnerable houses, especially when faced with the threat of extreme weather events like tropical cyclones and flooding in Bangladesh. Therefore, there is an increasing shift in house construction regarding advanced and resistant resources such as brick, steel and concrete. In general timber framed houses with different envelope materials i.e. wood, C.I. (corrugated iron) sheet, bamboo fence etc are locally known as timber house but the current study focus on the traditional timber houses characterized by wooden structure and envelope, found exclusively in most of the areas of Barisal and South part of Khulna districts.

Traditional vernacular houses cannot be seen in isolation from settlement but should be considered concerning the way of life, settlement, and yet landscape (Rapoport 1969). There have been differences in settlement patterns in Bangladesh in various physiographic regions with diverse characteristics. In the formation of unique forms and patterns of settlements, various physical, cultural, and local contexts have also played a vital role. Diverse settlement patterns have emerged throughout the country from the outset, i.e. linear, scattered, clustered and nucleated, dispersed and isolated, etc. (Choudhury and Zaman 1976). Traditional timber house settlements found near coastal and offshore land, follow linear patterns near the river levees and the reason for following the rivers is transportation facility. But scattered pattern is also found. Fig.1 illustrates settlement pattern of traditional double-storied timber house.

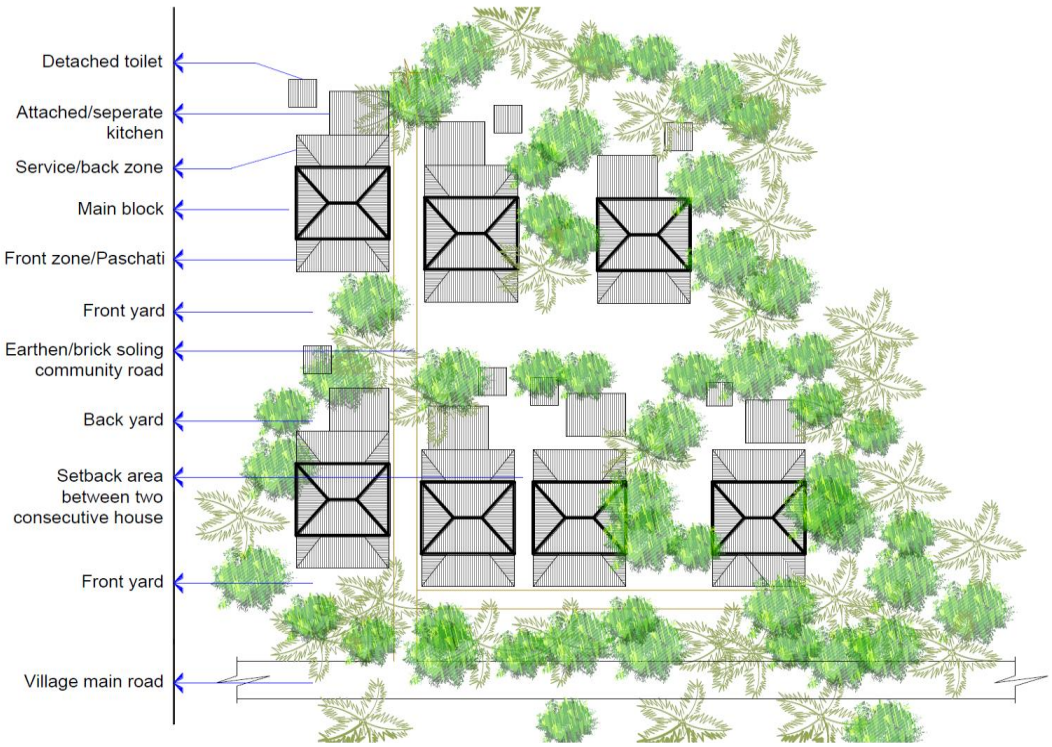

Figure 1: Settlement pattern timber house
(Source: literature survey and field survey, Illustrated by Author) (Islam R. 2021)

Family structure is mostly a joint family. Occupation is agriculture dominated but because of the vast network of the river trading, fishing, boating is also common among people. The size, construction material, and technique, etc. of the house varies according to the socio-economic status of the inhabitants but the basic concept of the timber house remains the same for all. Double-storied houses are common among the rich people but single-storied are popular among poor for constraints of land and minimizing maintenance cost.

3 Methodology

The research method used two primary strategies to clarify the effects of cultural and environmental experiences on the formation of traditional timber houses in Bangladesh: literature review and fieldwork. The objective of the literature review is to investigate cultural aspects in relation to house formation. Fieldwork used personal observation where initially 15 traditional timber houses have been surveyed and from which one exemplary house has been selected to explore emphasizing the details, such as building form, space organization, and environmental passive cooling features relevant to culture and climate as well as simultaneous interviewing local builders and occupants regarding traditions, lifestyle within house, norm of construction and techniques etc. Finally, information has been analyzed and synthesized in order to draw up final remarks.

4 Field Study

The history of this traditional house is very old and it is hard to mention an accurate date or year. But people are living here from generation to generation. There are many buildings in this area which are more than 100 years old. In the rural building tradition, there were and still are many skilled and creative woodworkers locally called ‘Kaarigor’ constructs this house keeping entire dimensions in mind where the house form is the result of a practice. They are not only craftsmen, but also artisans and designers with a deep understanding of wood structural issues. They do not have any institutional knowledge regarding house construction. Over time the construction techniques are handed over to their successors. Therefore, these traditional houses lack paper drawings and documentation. For detailed field survey an exemplary traditional two-storied house (Fig. 2) of village Athghar Kuriana, Swarupkathi union, Pirojpur district, Barisal Division has been selected. The case study house has been constructed nearly 80 years ago in 1944 (Bengali year 1351). House pattern is of single square shape house form facing east. Generally, the house has three parts: front, middle and back (Fig. 3). Front and back parts are locally called ‘Hytona’ and middle part is the main living area called ‘Shaalghor’. Front part is used as formal guest receiving zone which is provided with seating area called ‘Allishha’ whereas the back part is female-oriented serve as dining or service zone.

The most important part of traditional timber house is shared courtyards. Several houses share this courtyard, hence, serves as a social interactive space. Every house provided with two separate courtyards: front and back. Front yard is a place of formal and informal meeting place whereas the backyard is a socializing space for females. Female-oriented functions, toilet and kitchen are placed in this part but keep detached from the house (Fig. 1). Each house has its private shared pond at back zone and water from this pond is used for cooking, especially for female bathing. Excavated mud is used to raise the

plinth, locally known as ‘Potaa’. The house form starts from the basic one-room unit and then attains a complex shape with the addition of space in ‘hytona’.

The size of house has a unique measurement system where the dimension of ‘Shaalghor’ (width and length) refers to size of the house, locally expressed as ‘Bondo’. In traditional measurement system ‘hath’ (hand) is the unit of length where ‘one-hand’ is equivalent to 450mm (1.5ft.) and for more precise dimension ‘angul’ (width of single finger) is used where ‘one-angul’ approximates 12mm (half inch). In case study house length and width of the ‘shaalghor’ is 24 hath x 8 hath (11m x 3.7m), hence, the size of the house is ‘32-bondo’ (24+8). However, the actual width of the case study house is 18 hath (8.2m) with the front and back similar size ‘hytona’ measuring five hath (2.4m) each. Therefore, the total plinth area of the house is 94sqm. Depending on land size, socio-economic facts house size can vary where smallest house size generally starts from ’17-bondo and vary as ’19-bondo’, ‘21-bondo’ and can be as large as ‘27/29/32-bondo’.

Figure 2: Case study traditional two-story timber house: entry view, hanging balcony, indoor-outdoor connectivity and folded door-window (left to right)

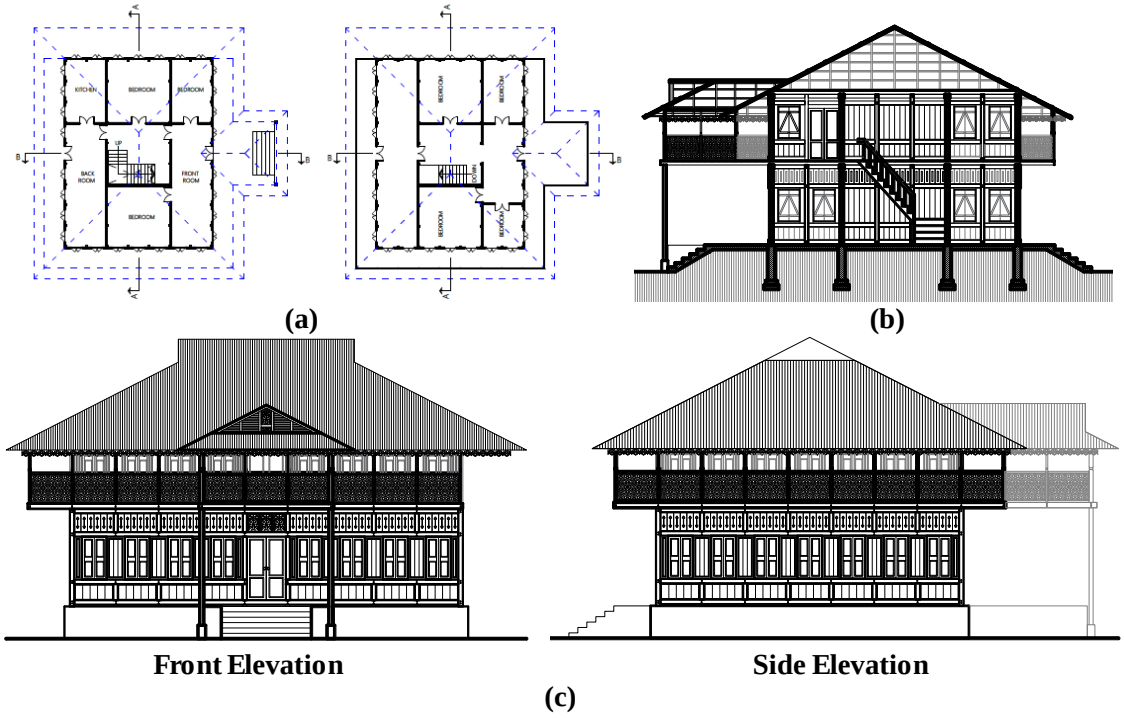

Figure 3: Case study: (a) Plan; (b) Section and (c) Elevations
(Source: field survey, Illustrated by Author)

The height case study house is 16 hath (7.5m) constructed over a 1m high CC (cement-concrete) plinth to protect it from high-tide. The lower floor height is 6 hath (2.7m) whereas the upper floor is 10 hath (4.6m). This upper flooring is known as ‘Afaar/pataton’ which is connected with the lower one with a wooden stair from shaalghor. This floor is used for storing agricultural products as well as sleeping area. Upper floor is always made of timber whereas the lower floor can be of CC or earthen. The whole house is supported by timber frame (Fig. 4) constructed with locally available timber: teak, shundori, jack-fruit tree, shegun etc. Timber post of 100mm x 88mm and are placed @ 2.5-4 hath c/c. Corner posts have slightly large cross-sectional area and nearly 13.5 hath long. This post is placed on a 200mm dia. circular terracotta plate (locally known as a 'pata') 50mm thick inserted in a plinth and most interestingly, the whole structure remains on the plinth untied with its self-weight. These posts are connected with roof rafters (locally called ‘rua/ara/chera/matam’) (Fig. 4) size of which varies between 50-75mm x 63-88mm and forms the skeleton of the house. The joints are pinned with a strong nail locally known as ‘gojal’ whereas for pieces of wood joints traditional joining systems like half-lap, bladed/keyed-hook scarf-joint, tennon and mortice etc. are used. Once skeleton is formed then a kind of oil locally known as ‘mete tel’ is applied evenly on the timber frame which protects the timber from insect’s attack. A roof is then placed over the structure to protect it from harsh weather.

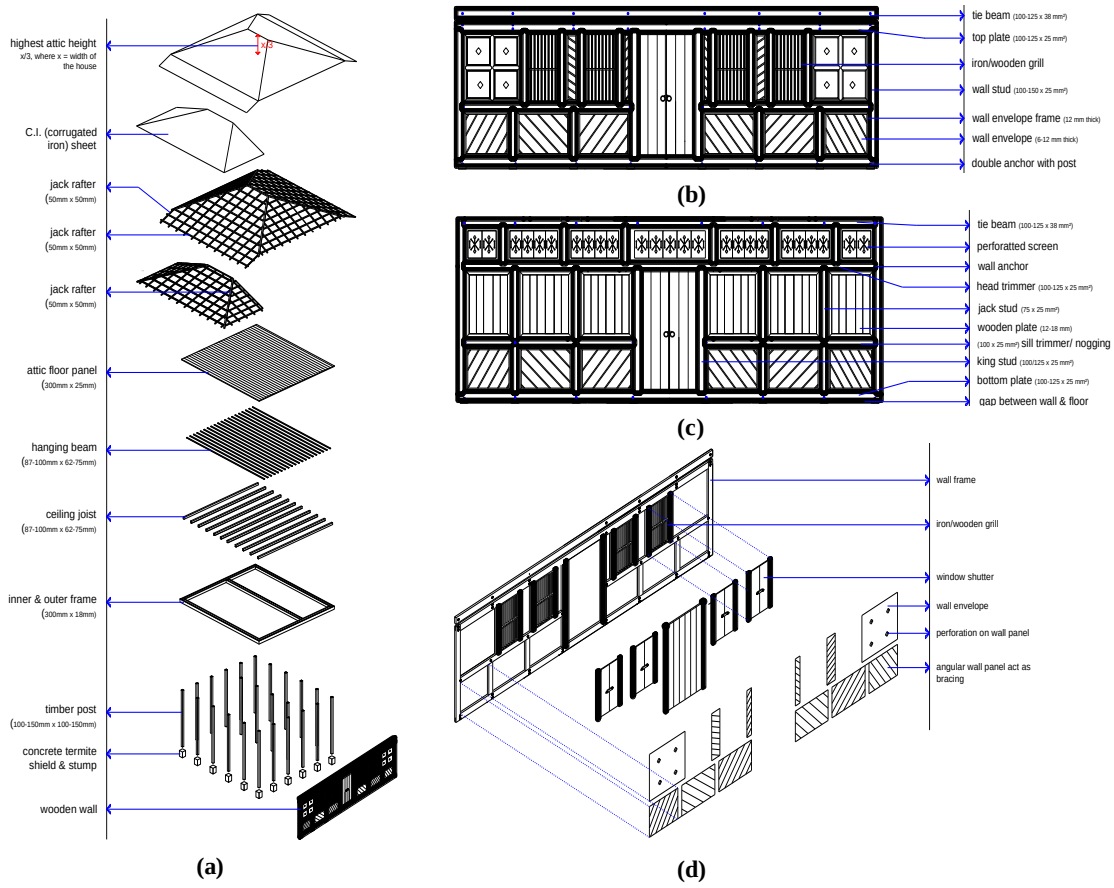

Figure 4: Envelope details: (a) components of house; (b) front wall; (c) mid-zone partition wall and (d) wall elements (Source: field survey, Illustrated by Author)

Prefabricated walls are installed on each side of the house to complete it. In the whole process occupants work along with the craftsmen and it takes nearly 1-1.5 months to construct a house. Six wooden windows and one large door create the front view of the traditional timber house. To optimize the use of space, doors and windows incorporate folded slashes. When the door and windows are left open, they merge with the front courtyard, establishing an inviting ambience for visitors. Similarly, large windows are provided on the other sides of the house to connect it to the site and neighbouring houses. But, the most intriguing feature of this house is its' crown-like sloped roof of a triangular attic space at the entry top and hanging cantilever balcony entirely made of timber which enhances the house's three-dimensional appearance. The installation of windows with colourful railings enhances the dramatic appeal of this attic space. Moreover, the three-hath (1.5m) wide quadrilateral hanging balcony facilitates occupants to enjoy the site from every angle. The entire house is decorated with plenty of wood carvings; particularly in the design of the four-sided veranda's timber fencing as well as hanging components and wall facade (Fig. 5).Indigenous folk elements have been combined with floral, vase, leaves and geometric motifs in the designs. This perfect craftsmanship creates beautiful artistic impression inside by introducing play of light through the gaps and renders lightweight architectural appearance. All natural colours such as bright red, blue, yellow or green are applied in these crafts for both internal and external spaces, which is a further distinctive trait making the house more engaging and eye-pleasing.

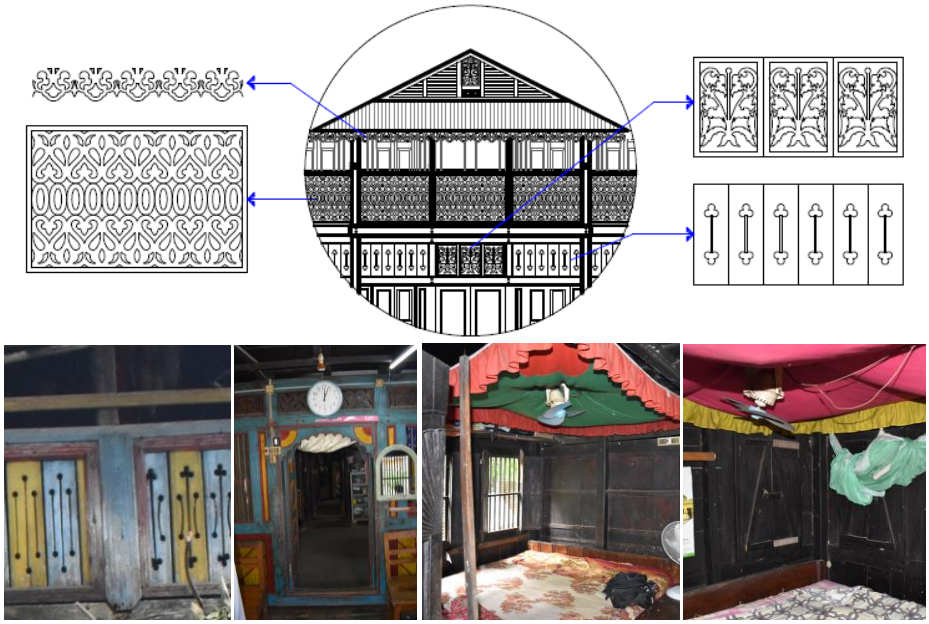

Figure 5: Screening Details and colourful interior-exterior

5 Environmental Experiences

Bangladesh, a deltaic country, is shaped by a rich network of rivers where natural disasters such as cyclones and sea surges are common occurrences for people who live close to nature. Generally, in rural areas of Bangladesh, considering socio-economic, climatic, technological, and other factors, local craftsman develops unique and resilient construction techniques and details. People have developed indigenous understandings

of cyclones and adopted the centuries-old lessons learned through several generations, which have been integrated by means of a cycle of socialization.
In traditional-two storied timber house, as a result of survival and protective experiences, people have evolved their own approaches to dealing with the situation, allowing them to form a century-long distinct cultural identity. However, these houses possess sustainability and cultural importance; there have been some difficulties, especially in light of shifting climate trends and the desire for more resistant housing approaches. The architectural landscaping of Bangladesh, reconciling cultural significance with sustainable development is a continued attention. Traditional timber houses are built to accommodate the region's climate, including a warm-humid climate for much of the time. Elevated houses with pitched roofs enable air to move through and create comfortable indoors. These houses make use of readily accessible local timber. Material is long-lasting and appropriate for Bangladesh's climate. It is compact and constructed on elevated foundations to reduce the detrimental effect of flooding. This layout protects the building's frame and enables rainwater to pass below, lowering the chance of structural problems while rendering it appropriate for development in flood-prone areas. Again, the upper storey is an effective solution for sea surge as it provides shelter for the occupants. Additionally, traditional two-story timber houses are vulnerable to natural disasters (i.e., flood, cyclone, tidal surge etc.), so they were designed as a prefabricated structure that people could easily split up, transport to a safe location, and reconstruct. Local craftsman demonstrates an intriguing expertise of dealing with harsh weather conditions by means of constructing tactics that range from setting up house to the smallest detail of wood carvings.

The position of the study house reveals that heavy landscaping is planted on every side of the house, particularly on the south or south-western edges, which is the typical storm path. The pace of the wind is greatly reduced by the presence of these surrounding trees. Plants with greater resistance against wind effect, such as plum, coconut, betel nut, and so on, are planted in these corners at an offset of 3-4.5m from the house to shield it from damage resulting from uprooted trees during a storm. These trees also serve as a physical barrier for residents. The square plan house is built on an elevated mud plinth with a concrete border protecting it from flooding. The square shape provides formal balance against wind effect, preventing it from tipping over. The roof is the most susceptible to wind because it readily grasps the gusts of the wind. In the study house, a hipped shape roof at an angle of 30-35º with a low overhang is used to reduce the wind impact on the roof. Again, introduction of ‘hytona’ and hanging balcony around the house protects the main block from storm/rainwater. Moreover, to keep the post off the ground and protect the timber post from damage caused by ground moisture, the posts are placed on ‘pata’. The balanced placement of windows and doors, as well as gaps between the floor-wall-roof and perforated wood carving on the wall, make the structure less prone to cyclones by allowing wind gusts to flow through the house. This also aids in maintaining a comfortable indoor environment for the residents (Islam R. 2022).

Traditional timber house architectural elements, such as wooden carvings in the shape of jali, encourage natural ventilation which is critical in a humid and hot environment. This porous form permits fresh air to circulate freely, aiding in maintaining a comfortable atmosphere inside. Modernizing and advancement, on the other hand, have had major effects on traditional timber houses in Bangladesh, impacting several facets of their development, application along heritage. The process of globalization may cause the

move away from conventional timber construction toward cutting-edge materials such as mortar and bricks. Although these materials have benefits in relation to resilience along with durability, they might additionally lead towards the reduction of traditional methods of construction and resources, traditional craftsmanship associated with timber construction in addition to the distinctive architecturally unique characteristics that define traditional timber houses in Bangladesh. As per local people's perspective and environmental experience:

> *".....We are not afraid. We are habituated with the natural phenomena. These houses are capable enough to withstand heavy storm. We have houses aged more than 50-60 years even 100. Our houses are raised on platform, since, during tide, courtyard floods and it's quite normal....."*
>
> *".....Timber is readily available material and it's our tradition to build with timber. We do not repair our house frequently. Maybe after 9-10 years a little repair will need.....Moss on the wall actually forms during rainy season. As we applied 'mete' oil on the wall nothing will happen. It protects the wall from damage....."*
>
> *".....This house is prefabricated in nature and kept untied with the ground. It rests on the base with its self-weight. We can dismantle the house and carry it to a safe place in case of an emergency....."*
>
> *".....While placing the house we generally place the smallest length towards the storm wind direction: South-South-west. We have practiced it since our ancestor's time. It is safe....."*
>
> *".....Every house has betel nut, coconut, plum trees. It provides physical boundary to the site. The soil is perfect for these species and storm wind cannot break/uplift them easily....."*
>
> *".....Generally 'hytona' is placed around the house and it protects the main block from damage.....Instead of gabled we use hipped roof as it can drain out the rain water easily and additionally from our experience we saw that it is less prone to storm wind....."*
>
> *".....Timber houses are no longer seen as before. Materials are available here: brick, C.I./plain sheet etc. Price of timber is relatively high....."*
>
> *".....Today's craftsman are not that capable to build house as strong as before.....Moreover brick houses are less prone to damage during storm....."*
>
> *".....Even skilled craftsman are rare this time. Where detail timber works are time consuming construction with nail joint, plain sheet materials takes half of the time compared to it. People have increased and more houses are needed. Space is also limited....."*

Traditional houses tend to be climate-adapted, employing recyclable materials for insulation and defence from severe climate incidents. These houses are built with

indigenous materials that are sustainable while having less of an environmental effect than advanced building materials. It includes design elements such as open outdoor spaces and raised frameworks, which promote ventilated air and reduce the demand for resource-intensive cooling solutions. However, people are turning toward advanced building techniques and materials due to a shortage of traditional expertise among new developers and generations. Yet it needs to be noted that, during modernization, there is frequently an evolution towards the use of masonry, steel and different supplies that could result in greater environmental effects.

6 Rural Culture and Argument

The relationship between architectural characteristics and culture is extensive while complex. In general, architecture acts as a physical manifestation of cultural belonging as well as an avenue for societies to define and share their beliefs and ways of everyday life. The extent and nature of house in different region create an array of cultures that over time become integrated into the neighbourhoods. Therefore, culture is an extremely important consideration for developing houses. Whenever a house's space organization breaks cultural standards, it is deemed ineffective. Having separate areas for each gender and age group, or defining public and private areas in the house, for example, allows one to meet cultural needs (Masaeli, 2009).

Traditional timber houses in Bangladesh are more than just functional structures; they also reflect the cultural diversity and traditions of the people who live there. House size may vary depending on the socioeconomic status of the people, but every house must share a certain basic function, such as a pond, front and back courtyards, and so on, which forces people to remain social and associated by keeping them vitally connected with the action and reaction of collective life. From the construction to operation of house which is evident from their activity and living pattern. For example, even if experts are hired to build the house, users participate in the construction process alongside the craftsmen. This traditional house cannot be assumed to be an independent entity apart from its settlement. They share no physical boundaries with their surrounding properties. Space separating two successive houses serves as a communal area for backyard entrances, kitchen gardens, or shared working space, among other things. As a result, prior to construction, collaborative decision-making is required.

Designs and layouts take into account cultural behaviour related to cooking, sleeping setups, along with other features of everyday conduct in order to promote social connections and improve familial ties, which aligns with societal norms emphasizing interconnectedness. The goal of emphasizing culture in everyday life appears to raise living standards. It is observed in traditional two-story timber houses that several cultural concerns shape the way occupants living within the house. The spatial organization considers separate public-private zones for male and female, where the entrance part is primarily male-oriented and public in nature, while the back part is essentially private and functions a female-centred activity zone. As a result, the rear zone has all of the necessary amenities, such as a separate pond, courtyard, kitchen, and toilets. Although this tradition evolved from Muslim religious practice, it is now an integral component of culture; consequently, rural communities of different religions embrace the same pattern of zoning. Verandas and courtyards are shared areas where people can socialize, gather for social occasions and participate in different events of culture and religion. The house's appearance, particularly the large openings on all four sides, expresses

interrelationships within the neighbourhood, blending the lines of egocentric lifestyle, which is unusual in urban living.

Architectural elements depict the lifestyles, social norms and adaptations of the communities in this region. Carvings and artistic details in architectural elements are common. These design components have a religious and cultural origin and they serve as a means of creative endeavour and symbolic meaning prompted by regional customs, as well as promoting the individuality of each house. The 'Jali,' or detailed latticework, is a common artistic component in Bangladeshi timber houses. It functions as an effective artwork, providing airflow while adding cultural sophistication to walls and fenestrations. The architecture not only responds to tropical climates, but it also encourages interaction with the natural surroundings. As local people shared:

> *"..... In our rural areas our houses share similar spatial organizations. Rear zones are dedicated for females and no outsiders are allowed in this zone. For visitors we have our front zone ('allishha/ hytona') and all the formal and informal meetings are arranged here....."*
>
> *".....Every house has seating accommodation in front of the house. It can be small or made of mud/concrete/wood but it's a must having component of every house....."*
>
> *".....However, size of the house varies depending on economic class and solvency but you will find the same zoning despite of the economic class, even different religion. It's not because of religious practice, but for our social norms and generation over generation we are living in this way....."*
>
> *".....Though use of courtyard is declining day by day because of changing lifestyle still serves as a major part of neighbourhood. One has to pass court before entering house, hence, becomes the meeting place for neighbourhood people....."*
>
> *".....We never feel to build boundary for privacy or other purpose. Though we all know the boundary of our own house, but we do not have physical boundary instead we have trees in our boundaries. Having no boundary is beneficial as we can use the space as entrances or for other collective purposes....."*
>
> *".....We have grown up seeing this type of traditional house and become a part of our life. In our village we have houses more than 100 years old. These are attractive and have meticulous wood carvings. We decorate our house with different colours: red, yellow, green, indigo. We have grown up seeing this type of attractive house and become a part of our life....."*
>
> *".....We use carvings in roof, railing, wall, doors etc. These decorations hold the owners' taste, status and tradition. Those who cannot effort such details at least have colourful painting on the wall.....But it is not ashamed2to say that ancestors were much more skilled than present craftsman. Experts are disappearing due to advent materials and construction techniques....."*

Navigating the consequences of modernity and internationalization on traditional timber houses requires striking an acceptable compromise between adopting beneficial developments and maintaining the cultural significance rooted in these architectural landmarks. Measures to blend traditional components with contemporary methods can help promote sustained growth and a sense of culture conservation. Innovation may provide prospects to strengthen traditional houses' resiliency in the changing climate. Building techniques and architectural advances can be used to render traditional timber houses less susceptible to severe climate events.

7 Study Limitation & Future Research Direction

The current study focused on the impact of culture and environmental experience of people in formation of traditional timber houses. The economic impact, structural stability, thermal comfort air-leakage, energy related issues, fire safety, security, etc. is out of scope of the research. Due to time and resource restrictions, a very little house has been surveyed. Moreover, outlining the lost and followed culture of the study area and prospects were left for future investigations.

8 Conclusions and Recommendations

Architecture is influenced by environmental and cultural issues, which are thought to be crucial for designing the environments we inhabit. The purpose of this paper is to illustrate on the environmental experiences and cultural influences and insights of in the architecture of rural traditional timber houses found along Bangladesh's southern coast. From the study it is seen that traditional timber houses of Bangladesh are reflection of local culture in practice which further get shaped by the environmental experience gained through course of times. Cultural influences are more visible in the hierarchical organization of spaces, where one must pass through changing spaces to get from public to private zones, whereas environmental influences are more visible in the house's planning, three-dimensional form, and construction details in terms of conventional ecological and technological means of defence. However advancements in lifestyle and technology lead to the exclusion of several important ideas, spaces, and subjective principles. The reflecting features of traditional houses allows us to gain an in-depth knowledge of the house, that makes it possible in developing no replication of traditional houses whereas corresponding with the sense of technological advances. To maintain the environmental advantages, it is critical to incorporate traditional construction methods and resources into contemporary layouts. Participation of the community at large in the transformation process and taking into account their centuries-old wisdom can help ensure that new buildings adhere to native environmental standards. Furthermore, enacting and upholding laws that encourage environmentally conscious building methods and prevent ecologically detrimental techniques will aid in navigating the effects of modernity along with globalization on traditional timber houses. It is a worthwhile endeavour to educate craftspeople, homeowners, and policymakers about the negative environmental consequences of various construction options and to promote environmentally conscious alternatives. Balancing technological advancement and environmental protection necessitates meticulous planning and community collaboration, as well as a commitment to protecting the distinct ecological factors inherent in traditional timber houses in Bangladesh. The findings will serve as

background study for the concerns and will assist professionals and policymakers in advancing architectural design recommendations for enhancing occupant wellbeing.

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References

Gustafson, P. (2001). Meanings of place: Everyday experience and theoretical conceptualizations. Journal of environmental psychology, 21(1), 5-16.

Islam, R. and Ahmed, K.S., (2021). Indoor Thermal Environment and Occupant's Living Pattern of Traditional Timber Houses in Tropics. Designs, 5(1): p.10.

Islam, R., (2022). Study on thermal performance of traditional timber houses in Bangladesh, Unpublished masters' thesis.

Mandal, R.B. (2001) Introduction to rural settlements. Concept Publishing Company.

Rapoport, A. (Ed.). (1976). The mutual interaction of people and their built environment: A cross-cultural perspective. De Gruyter Mouton.

Rapoport, A. (2004). Local Environment in a Global Context. 6th International Symposium for Environment-Behavior Study. Tianjin University: School of Architecture 22-25 October 2004.

Zukin, S. (1995). Cultures of Cities. Oxford: Blackwell.

Masaeli, S. (2009). Plan acquired as a religious belief in traditional housing Iranian desert. Journal of Fine Arts, 37, 27-38.

POLICY ANALYSIS AND WAY FORWARD FOR A SUSTAINABLE RURAL COMMUNITY

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Abstract: *Development both in urban as well as rural areas is still handled in a piecemeal manner. Even with a number of researches done in the field of urban and rural development, the ground reality is still farfetched. The most basic concept of the different dynamics of urban and rural areas is not addressed in policy documents. One such element of development which is the open space and semi-covered space that plays an important role in the functioning of rural households is not addressed. The National Sample Survey of India (NSS 69th Round, Schedule 1.2, 2012) highlights several conditions of rural household data and one of the data that can be highlighted is that 62.1% of rural households had a shade of some form or the other. None of the development policies takes into account this factor that plays an integral role in both the economic and as well as cultural functioning of the household. While various policies address and targets various issues of development, none of the policies address changing time, changing needs, or changing culture neither there is a policy that looks into finer details of development and a bridging policy that integrates all the disjointed policies. The paper attempts to highlights the findings of National Sample Survey of the rural household and analyses the PMAY-G implementation reality on ground through a case study done of a village named Chutiapara in Baksa District. The paper raises critical questions on the need to look at community system rather than focusing on dwelling unit as single entity. The paper concludes with a way forward and the need for policy makers and development agencies for a more holistic approach to development.*

Keywords: *Policy analysis, rural development, sustainable development, dwelling unit, community living.*

1. Introduction:

India has very clear rural and urban development policies. After India got its independence in 1947, a number of policies were drafted that aimed to put India on the development path. The five-year plans is one such example that focused on various facets of development that India needed to become an independent country including a clear focus on rural development too. Development focus over the last few decades in rural area is not limited to agriculture but has diversified to address various development needs. These policies and development plans have been continuously evolving to meet the needs and demands of a growing country. In the past decade, policies such as Mahatma Gandhi National Rural Employment Act (MNREGA), 2005 that focused on social development of rural area gives guarantee of "right to work", Pradhan Mantri Gram Sadak Yojana (PMGSY) that aims to bring farfetched corners of the country on the main grid also brought many unconnected areas of Himalaya, Northeast India and tribal belts of India into the connectivity road map.

Policies targeting various aspects of development such as housing, sanitation, social, economic, and physical infrastructure are continuously evolving and adapting for a more holistic development. One such policy is the Pradhan Mantri Awas Yojana – Gramin (the erstwhile Indira Awas Yojana) that provides grant to rural people below poverty line (BPL) to either build dwelling units or upgrade the existing houses. Pradhan Mantri Adarsh Gram Yojana (PMAGY) aims to empower Scheduled Cast (SC) and Other Backward Classes (OBC) through various programmes such as area-based development, hostels and residential schools and economic development by providing financial assistance and skill development. The Saansad Adarsh Gram Yojana (SAGY) is another village development programme under which a Member of the Parliament adopts three villages and hand holds in its physical and institutional infrastructure. Each of these policies has been instrumental in bringing a positive change in rural areas of India.

Rural area presents a unique character where the dwelling unit is still much interlaced with the economic activity. And this interlacing of various activities is what makes rural areas a unique sustainable model. While the above-mentioned development policies and programmes have been able to address specific issues, these development policies have not been able to address this unique character of rural areas. From a naturally sustainable model, rural areas are taking the character of urban fabric.

The paper highlights the findings of National Sample Survey of the rural household and analyses the PMAY-G implementation reality on ground through a case study done of a village named Chutiapara in Baksa District. The paper raises critical questions on the need to look at community system rather than focusing on dwelling unit as single entity. The paper concludes with a way forward and the need for policy makers and development agencies for a more holistic approach to development.

2. National Sample Survey Of Rural India:

The National Sample Survey (NSS) was set up in the year 1950 under the Ministry of Statistics and Programme Implementation, Government of India. The National Sample

Survey Office (NSSO) which is headed by a Director General implements various surveys on many diversified fields.

The NSSO conducts primary survey across the length and breadth of the country with data classified for both urban and rural areas. The NSSO has four divisions namely: (i) Survey Design and Research Division; (ii) Field Operations Division; (iii) Data Processing Division and; (iv) Survey Coordination Division.

Table 1: Average floor area (sq. m.) of the dwelling

State/Union territories	Rural	Urban	State/Union territories	Rural	Urban
Andhra Pradesh	29.85	32.75	Mizoram	60.5	58.14
Arunachal Pradesh	37.47	47.94	Nagaland	67.9	60.36
Assam	57.78	53.75	Odisha	31.27	34.04
Bihar	31.65	32.42	Punjab	58.19	40.47
Chhattisgarh	54.01	45.02	Rajasthan	42.71	41.4
Delhi	39.24	30.6	Sikkim	51.98	38.14
Goa	58.88	55.74	Tamil Nadu	32.58	35.76
Gujarat	48.4	44.46	Tripura	44.37	39.33
Haryana	54.34	51.15	Uttarakhand	39.13	43.29
Himachal Pradesh	60.14	36.17	Uttar Pradesh	40.87	41.86
Jammu & Kashmir	56.08	57.51	West Bengal	32.93	35.23
Jharkhand	40.25	37.36	A & Nicobar Is.	55.78	48.13
Karnataka	35.91	36.52	Chandigarh	24.99	29.66
Kerala	64.01	68.91	D & Nagar Haveli	48.69	39.11
Madhya Pradesh	42.26	45.73	Daman & Diu	35.7	15.93
Maharashtra	39.05	34.94	Lakshadweep	83.41	58.99
Manipur	69.58	68.77	Puducherry	36.79	37.94
Meghalaya	52.21	53.57	***All-India***	***40.03***	***39.2***

Source: NSS 69th Round, Schedule 1.2, 2012

The survey of Housing Condition conducted in the 69th round (2012) brings forth important facets of rural India. The focus of the survey was to understand the housing "micro-environment" and other important components that is necessary to maintain the quality of life. Under the housing condition component such as age of the house, condition of the house, type of dwelling unit, floor area of the dwelling unit, sources of financing were collected (NSSO, 2012). The broad household type that was surveyed in 69th round was self-employed (both agriculture and non-agriculture), regular wage/salary earning, casual labour and others.

The type of structures that were recorded in the survey was classified into pucca, semi-pucca and kutcha (serviceable kutcha and unserviceable kutcha). It was identified that 65.8 percent of households in rural India in pucca houses and 24.6 percent lived in semi-pucca houses. The survey further highlighted that the percentage of households living in pucca houses were relatively much lower in Northeast India. Majority of the population in Northeast India lived in semi-pucca houses. Another important aspect that the survey conducted was the floor area of the dwelling unit where it was indicated that the average floor area of dwelling unit in rural area was 40.03 sqm (NSS, 2012) as indicated in Table number 1. It was also observed 52.6 percent of rural households did not have a separate kitchen in their dwelling unit.

The survey included an important area that could play a crucial role in understanding the character and built fabric of settlement. This aspect was covered in the "Micro-environment" section. The working paper series on Rural Housing in India: Status and Policy Challenges by Lokashraya Foundation (2016) highlights that the need for additional space requirement

used mainly for animal shed or poultry farms. It was also highlighted that about 62.1 percent of rural households had some form of shed (either detached or attached to the dwelling unit) (Kumar, Deka, Sinha, 2016). This brings forth the unique character of rural households that needs to be addressed by development policy documents. The working paper also stresses upon the importance for addressing rural household with a different perspective and the need for policies to address rural housing that must take into account the need for additional spaces accommodating the economic activity associated with the household.

3. Pradhan Mantri Awas Yojana-Gramin (PMAY-G)

The Independence of India in 1947 and the partition of India into India and Pakistan led to a major influx of refugees into the country. The housing and rehabilitation of refugees was a major challenge for the then Government of India. Though the demand of housing was met through various programs, rural housing as an independent policy was first formulated as Indira Awas Yojana (IAY) in the year 1996. IAY was considered a successful programme; however certain gaps were identified during the performance audit by Controller and Auditor General of India in 2014. Lack of transparency in beneficiary selection, inappropriate assessment of housing shortage, low quality houses, no technical supervision, lack of financial assistance etc. were highlighted that limited the impact of IAY to reach its desired output. To bridge this gap, IAY was repurposed into Pradhan Mantri Awas Yojana-Gramin (PMAY-G) in 2016 aligning it to the “Housing for All 2022” mission. The core aim of PMAY-G was to provide Pucca house to households living either in kutcha or dilapidated houses, the immediate line of action being to provide one crore houses between 2016 to 2019.

A number of decisions were taken to improve the living condition of quality of life apart from providing the basic house such as increase in the minimum size of household from 20sqm to 22sqm, increase of financial assistance from INR 70 thousand to INR 1.2 lakhs and INR 75 thousand to INR 1.3 lakhs in hilly states, difficult areas and Integrated Action Plan (IAP) districts). For a more holistic approach, the beneficiaries were also entitled to 90/95 person days of employment under unskilled labour category from Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA). Provision of piped water, electricity connection, LPG gas connection was also proposed to be provided through streamlining different government schemes.

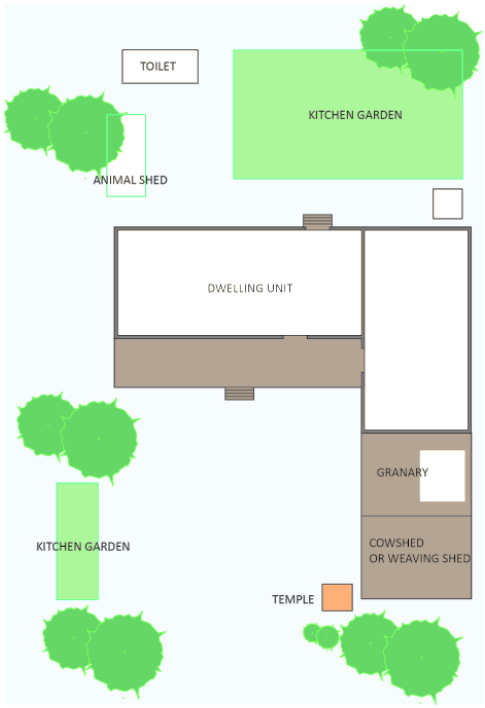
In terms of quality control, National Technical Support Agency (NTSA) was envisaged. To overcome the lack of skilled masons, a pan India training and certification programme was launched pan India. A ready reference of building typology with disaster resilient features considered to be appropriate to geo-climatic conditions were made available in a document called PAHAL were introduced. This exercise was also conducted to ensure that beneficiary does not over-construct the house in initial phases leading to incomplete house and need of borrowing money by the beneficiary to complete the house.

A study conducted by the Centre for Rural Infrastructure (National Institute for Rural Development & Panchayati Raj) in 2018 on the impact of PMAY-G in the states of Madhya Pradesh, Odisha and West Bengal highlighted some key findings. The study concluded that the PMAY-G had a positive effect on the physical facilities improvement of the households. However, the study also highlighted that the policy on the convergence of PMAY-G with

other programmes requires evaluation. The study also mentioned that both beneficiaries and PMAY-G local motivators were unaware of these convergence possibilities.

While PMAY-G provides an opportunity for households for a better quality of life and upliftment of the social well-being of the society, the alteration of the traditional built-form, the systems of settings of rural settlements and other social norms that is considered most sustainable is slowly disappearing slowly easing the rural set-up into urban ways.

Figure 1: Traditional dwelling unit and surrounding area of Baksa district, Assam



Source: Author

4. Sustainable Traditional Community

Sustainable development has many definitions the broad definition being one that defines sustainable development as that "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2013). Man shares a complex relationship with its environment. This environment is not limited to nature but to the built environment and to the social construct. Sustainable development is still understood by many as still having to do with protection of the environment while the other aspect of economic sustainability, social sustainability is still not being pursued actively by government and developmental agencies.

The uniqueness of traditional environment is in the existence of various layers of interlinkages. Households do not function as single community but a group of households that form a settlement are link through various activities. Almost all housing schemes look at providing a dwelling unit as a solution disregarding the importance and benefit of community living. Social values which are considered as the foundation of human behaviour (Filho, W., Levesque et.all, 2022) are still not a priority or a problem large enough that requires an intervention. Values are also considered an important aspect in sustainable development studies through individual as well as collective identities (Thome, 2015). Value system is also considered an important aspect in the assessment of vulnerable communities (Vallance, Perkins, Dixon, 2011). In the recent past, the theme of the role of culture and traditional values in sustainable is being explored by many researchers including international organizations.

Traditional communities in the state of Assam as in the case of most rural communities in India still lives in a very tightly system. A household which is mostly agrarian in nature have a self-sustaining system. The household is not limited to only the dwelling unit but has area earmarked for livestock, a cowshed, granary, a kitchen garden, a shed for weaving and an open space in front of the house used for functions and festivals as schematically shown in

Figure 1 and 2. A place for worship is located in a specific direction that is common to households. All the households within the community are known to each other and exchange of kitchen items, gardening tools, childcare etc. is an integral part of the community social fabric.

Figure 2:Built environment as observed in Chutiapara, Assam

(1.) Front yard with a typical dwelling unit (2.) Granary (3.) Weaving in the front verandah (4.) Namghar or temple. Source: Author.

A number of households have benefitted from PMAY-G scheme and has facilitated married sons to get a separate dwelling unit. The dwelling unit observed in a village called Chutiapara in Baksa district with 99% of the households is still rural (Census, 2011) are built in the same ancestral land. The traditional generic norms followed have taken a back step since the new PMAY-G houses have to be accommodated in land available or carved out from existing land parcel that belongs to the family. Almost all houses under PMAY-G Scheme were of the same plan built with brick and mortar with GI sheet roofing. The houses

did not follow traditional norm or direction or had an allocated space for temple. The beneficiaries were unaware of the PAHAL typology.

Baksa district comes under Zone A of the PAHAL document which is highlighted to be a highly vulnerable flood hazard zone with a likelihood of flood inundation lasting more than 24 hours in a year (PAHAL-II, PMAY-G). The area of the proposed typology is 560.27 sq.ft. with fly-ash brick suggested as the viable building material. Bamboo is being proposed to use extensively for verandah roof post, partition etc. The cost is estimated at INR 1,67,268/- (PAHAL-II, PMAY-G). Firstly, the knowledge of fly-ash brick was unknown by the beneficiaries. The PAHAL-II typology also used daub and wattle above sill level in certain parts of the house which did not match up to the aspirations of a pucca house by the beneficiaries.

Figure 3: Under construction dwelling unit under PMAY-G scheme

Source: Author.

On ground, none of the houses visited had followed the suggested typology or the building material. The local construction workers along with the beneficiary have come up with a dwelling unit and the primary material of almost all the PMAY-G houses were brick wall and not fly-ash brick as shown in Figure 3. To minimize the cost, the average area of most of these houses were ranging from 275 to 350 sq.ft. and the average cost of construction considering INR 1400 per sq.ft. (as stated by architects practicing in the state) still came to about INR4,90,000/-.

PMAY-G has been successful in providing homes to many rural populations of the country. Numerous schemes and policies have been drawn up to provide basic services and improve the quality of life. The question we need to ask then are: (i) Is piecemeal approach to development the right way to a sustainable future; (ii) Do we embrace this development and embrace the change.

5. Way Forward

The built-environment is a system of settings that goes through series of changes with time. While change is an important evolutionary process, many a times these changes are often controlled by external forces. As stated in the book, Crisis in the Built Environment, The Case of the Muslim City by Jamel Akbar, “there is a serious need for a theory which will make the future of the built-environment rationally predictable so that we professionals can better judge the results of the intervention” (Akbar, 1988).

Traditional communities had a self-sustaining model and a tightly knit-community. An open space network at various scales both at household level, neighborhood and community level were not only an important part of the society but a crucial element for the ecology. Community living also inculcates value system which is plays an important role in upkeep and preservation of systems. The need for human to, “make sense of their lives and to conduct themselves on the basis of that sense” results in the manifestation of a value system (Hawkes, 2001). The need for culture and traditional systems to be included in the development policy and strategy is to shape this value system.

While brick and mortar building and upgradation of kutcha houses to pucca houses is an attractive offer to many, handholding and planning for the future to ensure that the traditional fabric is studied and the evolution process be channelized should be prioritized. The involvement of experts should not end at paper and research level rather a more proactive role on the ground reality is the need of the hour. As discussed in the previous section, the budget prepared and the typology suggested or the material proposed in the PAHAL scheme remained only at document level. Dwelling unit is still considered in all such schemes as a single entity.

Dwelling units, its location, its interaction with the plot, street or other dwellings units, clustering and formation of these clusters to carve out open spaces needs a thorough examination. While it was apparent in the survey result of the NSS that covered or semi-covered shed or spaces for livestock are an integral part of dwelling units in rural areas, these facts were not considered at all. Recognition of public spaces, including streets, squares and other places as key resources for cultural interaction and participation must be looked at more deeply. A cultural and value system impact of government schemes needs a more thorough research and implementation.

References

Amos Rapoport, Theory, Culture and Housing, The School of Architecture and Urban Planning, University of Wisconsin-Milwaukee, Milwaukee, WI, USA, Taylor & Francis, 2001

Amos Rapoport, Some Further Thoughts on Culture and Environment, Archnet-IJAR, International Journal of Architectural Research (16-39), 2008

Coyle, D. J. and Ellis, R. J. (eds) (1994) Politics, Policy, and Culture, Boulder, CO: Westview Press

Department for International Development, (n.d.), Growth: Building Jobs and Prosperity in Developing Countries, The Organization for Economic Co-operation and Development (OECD), Retrieved on 15 September 2022, https://www.oecd.org/derec/unitedkingdom/40700982.pdf

European Alliance for Culture and the Arts (2017), 'No Sustainable Development without Culture', statement.

Gladwin, T., & Hofstede, G. (1981). Culture's Consequences: International Differences in Work-Related Values. The Academy Of Management Review, 6(4), 681. doi: 10.2307/257651

Global Taskforce of Local and Regional Governments, UN Habitat, and UNDP (c. 2016). Roadmap for Localizing the SDGs: Implementation and Monitoring at Subnational Level, GTF / UN Habitat / UNDP.

Hawkes, John. (2001). The Fourth Pillar of Sustainability: Culture's essential role in Public Planning. Cultural Development Network (Vic.), Australia.

Hosagrahar, J.; Soule, J.; Fusco Girard, L.; and Potts, A. (2016), 'Cultural Heritage, the UN Sustainable Development Goals, and the New Urban Agenda', concept note, ICOMOS.

Lumumba, T.M. (2010) Exploring Socio-Cultural Explanations for Residential Location Choices: The Case of an African City-Dar-es-Sallam. Unpublished Ph.D. Thesis.

Leal Filho, W., Levesque, V., Sivapalan, S. et al. Social values and sustainable development: community experiences. Environ Sci Eur 34, 67 (2022). https://doi.org/10.1186/s12302-022-00641-z

"Our Common Future: Report of the World Commission on Environment and Development". UN Documents. n.d. Web. Retrieved 27 June 2013. < http://www.un-documents. net/ocf-02.htm>

Segun, O. (2012). Behavioral outcomes of culture and socio-economic status on urban residential morphology: A case study of lagos. Procedia - Social and Behavioral Sciences, 50, 294–306. https://doi.org/10.1016/j.sbspro.2012.08.035

Senlier, Nihal, Yildiz, Reyhan, Salihoglu, Tayfun, Liveability on Different Housing Settlements, Gebze Institute of Technology, Faculty of Architecture, Cayirova, No.101, 41400, Turkey.

Shahed Kahn, NKA Dwijendra. Can we afford to neglect cultural appropriateness in providing affordable housing, A review of affordable housing provision in Bali, Indonesia, Conference Paper.

Soubbotina, T. Beyond Economic Growth an Introduction to Sustainable Development, 2nd ed.; World Bank: Washington, DC, USA, 2004; p. 13.

The Government of Assam, 2006. Cultural Policy, Government of Assam, Cultural Affairs Department.

Thome H (2015) Values, sociology of. In: Wright JD (ed) International encyclopedia of the social and behavioral sciences, vol 25, 2nd edn. Elsevier, Oxford, pp 47–53

UNEP (2016). Environment, Religion and Culture in the Context of the 2030 Agenda for Sustainable Development. United Nations Environment Programme, Nairobi.

World Urban Forum 6, Prosperity for Sustainable Cities: Balancing Ecology, Economy and Equity, Background Document. Retrieved from https://mirror.unhabitat.org/downloads/docs/9241_84198_Concept%20Paper%20for%20WUF%206.pdf on 21 August, 2020

United Nations General Assembly "48. Sustainable development: managing and protecting our common environment "2005 World Summit Outcome. 24 October 2005. Web. Retrieved 27 June 2013. < http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N05/487/60/PDF/N0548760.pdf?OpenElement>

ANALYSIS OF WILLINGNESS TO PAY FOR SEA TRANSPORTATION SERVICES IN INDONESIA

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Abstract: *Willingness to pay (WTP) is an important aspect in determining transportation service tariffs. In sea transportation services, regional conditions and service availability greatly influence the amount of WTP passengers. This paper aims to analyze how much the WTP value of sea transport service users is in the conditions of the services provided. Analysis will also be carried out on differences in WTP in various regional conditions.*

The WTP value is obtained based on a survey of prospective passengers and non-passengers regarding how much they are willing to pay for the services provided. These methods are widely known as contingent value methods (CVM).

The results of the study show that the average WTP is 16.80% above the existing rate. The western region of Indonesia has the highest WTP, which is 21.59% over the existing tariff, followed by the central region (16.67%) and the eastern region (15.15%). The results of the analysis show that the income level is most closely related to WTP.

Keywords: *Willingness to Pay, Contingent Value Methods, sea transportation, Indonesia*

1 Introduction

Sea transportation is one of the modes of transportation used to support the increasing mobility of the population, especially for areas that cannot be reached by land or air mode. The high use of sea transportation services is reflected in the large number of passengers who come or depart at a port. The number of passengers from all ports in Indonesia in 2020 was 25,285,284 people, while in 2021 it rose to 29,049,990 people (Central Statistics Agency, 2021). Passenger shipping is served by state-owned companies namely PT Pelayaran Nasional Indonesia (Pelni) and PT ASDP Indonesia Ferry as well as private companies, including PT Jemla Ferry, PT Jembatan Nusantara, and PT Dharma Lautan Utama.

In terms of fares, economy class passenger transportation has not increased since 2017 with the enactment of the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 109 of 2017 concerning the Upper Limit Tariff for Domestic Sea Passenger Transportation in Economy Class. The regulation sets fares on 3,830 routes in Indonesia. Over a period of 5 years until 2023, there have been changes in prices in Indonesia, mainly caused by inflation. For this reason, tariff adjustments are needed so that they can accommodate various changes that occur.

In general, there are two approaches to tariff setting, namely based on cost and based on user ability. Some factors that affect transportation costs are distance, weight and density (Zaroni, 2015). Tariff determination can also be done from the user side, by paying attention to the amount of willingness to pay owned by the user. *Willingness* to pay is how much the user is willing to pay for the quality of service provided (Tamin, 2000). The difference between willingness and the set tariff becomes the basis for the government to set policy. If the service is considered important and significant enough for the community, the government can provide subsidies or *public service obligations* (PSO), as currently applied to various transportation services in Indonesia.

This study will analyze how much willingness to pay for sea freight passenger services in various regions in Indonesia. Information about the amount of WTP can be considered by the government in determining the amount of sea transportation rates, especially in the economy class.

2 Methods

2.1. *Contigent Value Methods*

The method used is to ask passengers for a response if there is an increase in fares compared to existing fares or known as Contingent Value Methods (CVM). There are 3 tariff increase scenarios, namely 10%, 20%, and 30% against existing tariffs. The expected response varies between definitely want to use, want to use, hesitate, do not want to use and definitely do not want to use. In the analysis, 3 scenarios were arranged, based on interpretations of the hesitant answer, namely the optimistic scenario (the hesitant answer is assumed to be willing to pay) and the pessimistic scenario (the undecided answer is assumed not to pay). The moderate scenario is the middle value of the optimistic and pessimistic scenario.

The WTP value is calculated by averaging the tolerable rate of increase and the number of respondents who answer, or mathematically as follows:

$$WTP = \frac{\sum_i^n R_i * X_i}{n} \quad (1)$$

with:
Ri = tariff increase by i%
Xi = number of respondents willing to pay in an increase of i%
n = total respondents

2.2. Responden

The sampling method is carried out by *Purposive Sampling* by paying attention to the location, operator branch class and path characteristics. By location, the survey is divided into Western, Central, or Eastern Regions; based on branch class, operators are divided into class A/B/C/D; Meanwhile, based on the characteristics of the line, it is divided into main routes, other lines, and other modes of connected lines.

Based on these indicators, the survey was conducted at 12 locations that are expected to represent a variety of different characteristics, namely:

a. Western Region: Batam (S2) and Surabaya (S1),
b. Central Region: Balikpapan (S3), Bitung (S7), Baubau (S5), Bima (S4), and Kupang (S6),
c. Eastern Region: Ambon (S9), Dobo (S11), Jayapura (S8), Ternate (S10), and Sorong (S12).

The number of samples of each location is targeted at 60 respondents, with the criteria of being passengers and prospective passengers of sea transportation modes with a minimum age of 17 years and traveling between provinces.

3 Results

The survey results show the response to tariff increases in all regions is as follows:

Table 1: Respondents' Results on Tariff Increase at All Survey Locations

Optimistic			Pesimistic	
% Tariff increase	Number of accepted		% Tariff increase	Number of accepted
30%	347		30%	223
20%	91		20%	53
10%	116		10%	124
0%	112		0%	266

Based on the data above, the WTP calculation for each scenario is as follows:

$WTP_{optimistic}$ = (30%*347+20%*91+10%*116+0%*112)/(347+91+116+112) = 20,11%

$WTP_{pesimistic}$ = (30%*223+20%*53+10%*124+0%*266)/(223+52+124+266) = 13,50%

$WTP_{moderate}$ – (20,11 + 14,38)/2 = 16,80%

In addition to the whole, the analysis was also carried out per region category and per survey region.

Based on the data obtained, it can be calculated the average tariff increase received by respondents in various groups. The results of the WTP calculation in the moderate scenario are as follows:

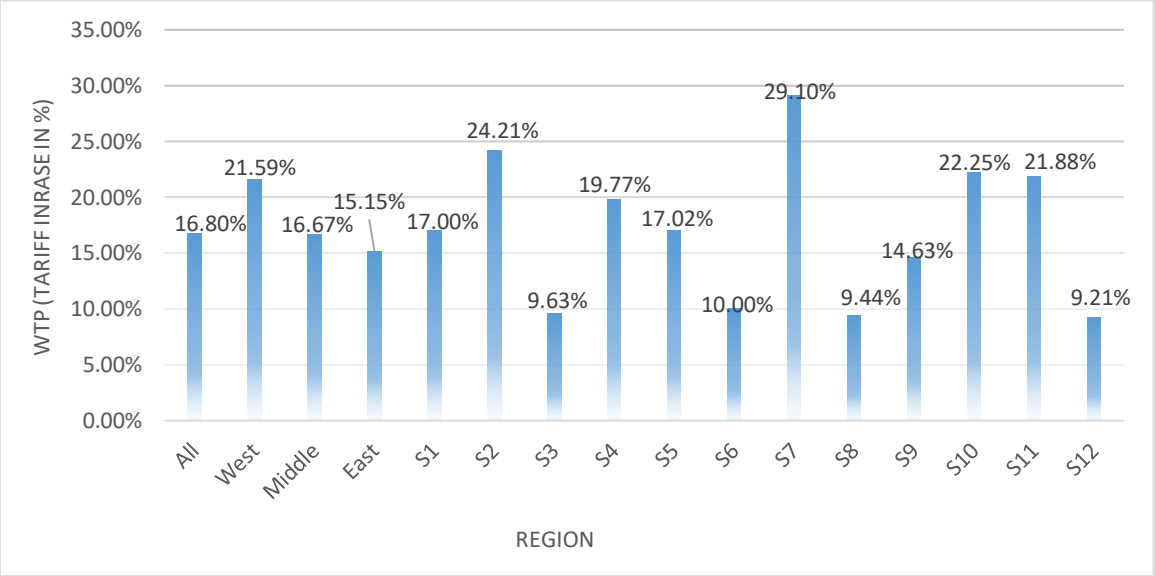

Figure 1: WTP of Ship Passengers

The table shows that overall respondents tolerated an increase of 16.80% compared to the existing tariff. When compared per region, the western region has the highest tolerance, which is 21.59%, followed by the central region at 16.67% and the eastern region at 15.15%. When viewed per survey location, the location with the highest WTP is S7 (Bitung) at 29.10%, followed by S2 (Batam) at 24.21%, S10 (Ternate) at 22.25% and S11 (Dobo) at 21.88%. The lowest WTP was found in S12 (Sorong) at 9.21%, followed by S8 (Jayapura) at 9.44%, S3 (Balikpapan) at 9.63% and S6 (Kupang) at 10%. Other regions, such as S4 (Bima), S5 (Baubau), S9 (Ambon) and S1 (Surabaya) have medium upgrade categories.

The results show that the WTP value for each survey location is different. Some indicators that are estimated to be influential include income level, frequency of travel and the number of family members who travel.

Data on the average number of family members who travel, frequency of trips per year and income per month respondents are as follows:

Table 2: The Average Number of Family Members, Frequency of Trips Per Year and Income Per Month

Survey Location		WTP	Number of Family Member	Trip frequency per year	Income per month
S1	Surabaya	17,00%	1,15	1,85	4.595.000
S2	Batam	24,21%	3,17	1,20	3.404.286
S3	Balikpapan	9,63%	3,43	1,05	2.510.000
S4	Bima	19,77%	2,68	3,82	1.534.091
S5	Bau-bau	17,02%	3,42	2,25	2.822.115
S6	Kupang	10,00%	1,51	1,65	2.198.611
S7	Bitung	29,10%	2,32	1,52	3.155.000
S8	Jayapura	9,44%	3,40	1,80	1.410.000
S9	Ambon	14,63%	3,33	2,13	1.376.250
S10	Ternate	22,25%	2,85	2,00	3.845.000
S11	Dobo	21,88%	2,19	2,29	2.407.639
S12	Sorong	9,21%	1,00	1,23	861.429

When compared between the amount of WTP and income per month per survey area, the results are as follows:

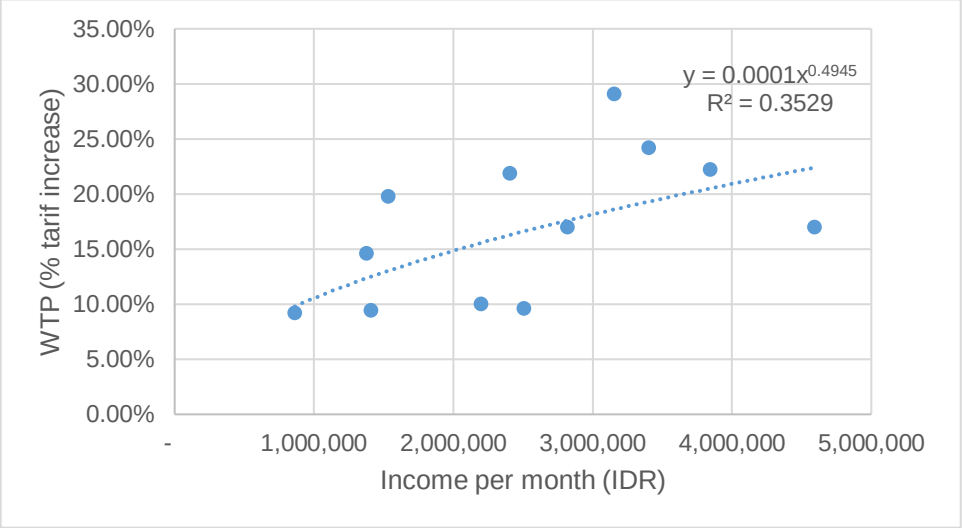

Figure 2: The Relationship Between Income and WTP

While the relationship between WTP and the number of family members who travel is as follows:

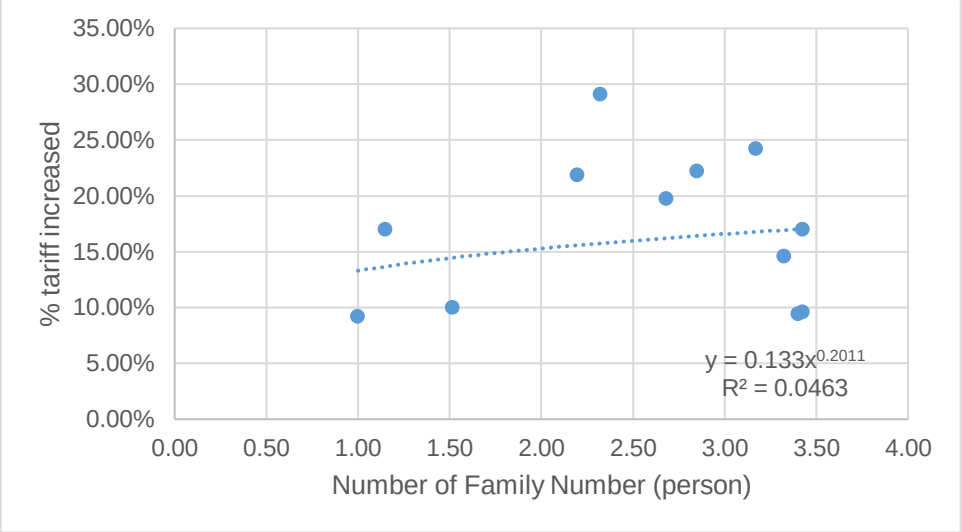

Figure 3: The Relationship Between Number of Family Member and WTP

The relationship of WTP with the frequency of travel per year is as follows:

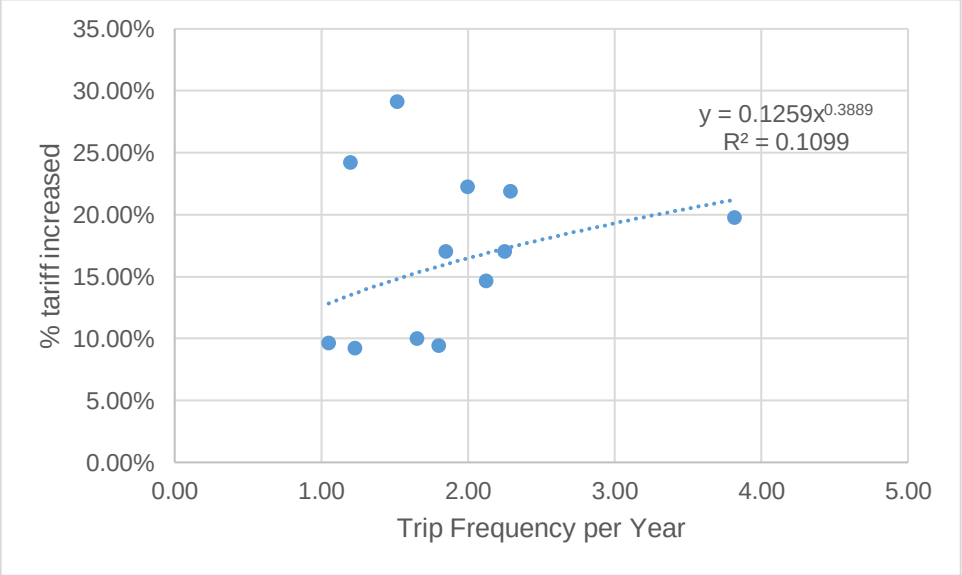

Figure 4: The Relationship Between Trip Frequency per Year and WTP

The figure shows that the relationship between WTP and income is the most closely compared to WTP with the number of family members and frequency of travel, indicated by the highest R^2 value.

4 Discussion

Various studies show that one of the important factors that determine the amount of WTP is the amount of income and frequency of use (Jiang et al, 2021; Yusuf et al, 2015). The

tariff increase is of course also expected to be accompanied by an increase in the quality of services provided by operators (Mathisen and Solvoll, 2010; Suparman et al, 2022; Pujiati et al, 2019).

The results of this study show similarities with the findings of Jiang's study. The income level factor is indicated to have the most close relationship compared to other factors to WTP.

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References

Central Statistics Beureu. (2021) Sea Transportation Statistics. Jakarta.

Jiang, X.; Yu, W.; Li, W.; Guo, J.; Chen, X.; Guo, H.; Wang, W.; Chen, T. (2021) Factors Affecting the Acceptance and Willingness-to-Pay of End-Users: A Survey Analysis on Automated Vehicles. Sustainability 2021, 13, 13272. https://doi.org/10.3390/su132313272

Kementerian Perhubungan. (2017) Peraturan Menteri Perhubungan Republik Indonesia Nomor PM 109 Tahun 2017 tentang Tarif Batas Atas Angkutan Penumpang Laut Dalam Negeri Kelas Ekonomi

Mathisen, T. A and Solvoll, G. (2010) Service Quality Aspects in Ferry Passenger Transport – Examples from Norway. EJTIR 10(2), June 2010, pp. 142-157

Pujiati, A., Nihayah, D. M., Bowo, P. A., Pratiwi, F. S. (2012) Willingness to Pay for Improving the Quality of Public Transportation. Jejak (Journal of Economics and Policy) Vol 12 (2) (2019): 365-381. DOI: https://doi.org/10.15294/jejak.v12i2.20302

Suparman, A., Fajardini, Z., Sugiharto, T. (2022). The Influence of Time Value, Price Perception, And Service Quality on The Intention to Repurchase Tickets on Passengerroro Ships. Media Bisnis P-ISSN: 2085 – 3106. Vol. 14, No. 2, September 2022, Hlm. 247-258 E-ISSN: 2774 – 4280

Tamin, O. Z., (2000) Perencanaan dan Pemodelan Transportasi. Penerbit ITB. Bandung

Yusuf, J.E., O'Connell, L., Anuar, K.A. (2014) For Whom the Tunnel Be Tolled: A Four-Factor Model for Explaining Willingness-to-Pay Tolls. School of Public Service Faculty Publications. 1. Old Dominion University.

Zaroni. (2015) Penetapan Tarif Transportasi. Supply Chain Indonesia

THE USE OF DIGITAL LAYERS IN POST-GROWTH COMMUNITIES - AN EXPLORATORY STUDY

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Abstract: *The pursuit of infinite growth on a planet with finite resources is leading to a failure in achieving global sustainable transition goals. The concept of Degrowth or 'post-growth' has emerged as a counter-movement advocating for alternative approaches focused on living within resource constraints. Within this context, small-scale communities with post-growth orientations are particularly interesting, as they actively explore their own alternative development models. These communities have potential to act as decentralised laboratories for radical change, translating Degrowth/post-growth theory into actionable practices.*

This paper examines how the operational tools have changed for post-growth communities since 2004 (Web 2.0). Through in-depth interviews with tech-savvy representatives in this field, the study explores the potential of "new" technologies to empower post-growth communities.

The findings indicate that using digital layers had potential to support community setup, organisation and evolution, in particular having impact on i) improving access to community; ii) facilitating internal communication and coordination; iii) enabling a common boundary and internal diversity; iv) encoding alternative development models into sharable and adaptable systems. However, despite the identified benefits, the main barrier was how to introduce technologies that community members were not already familiar with. People tended to only use tools they already knew - often particularly unsuited *for community coordination. While the study hints at potential solutions, the introduction of truly useful technologies to communities deserves further investigation since their power depends on learning how to use - and adapt - these tools for community purposes. This exploration provides insights into how digital layers can aid and abet communities developing their own paths towards sustainability. It represents a step towards identifying strategies and tools for implementing post-growth theories in practice, contributing to the discussion on how to transition towards a diverse and resilient society.*

Keywords: *Post-growth, Technology, Communities, Laboratories of Change, Interviews*

1. Introduction

The world needs alternative development models. More than 30 years after the sustainable development paradigm emerged, the intended harmonisation of economic growth, social welfare and environmental protection has proved elusive (Asara et al., 2015). Despite this, the dominant line in mainstream economics is to continue to pursue perpetual growth (Hickel, 2019) - although this goes counter to a well documented empirical record of the relationship between economic growth and ecological breakdown (Hickel, 2020; O'Neill et al., 2018).

A potential alternative path might be found in the concept of Degrowth, or 'post-growth' economics, a paradigm that calls for the abolishment of economic growth as a social objective and signifies a desired direction where societies will use less natural resources and "*organise to live very differently than today*" (Kallis et al., 2015, p. 1).

Implementing this paradigm in practice, however, might face difficulties depending on the context they are being developed within. As housing and jobs centralise (United Nations, 2023), cities continue to be the main drivers of the growth paradigm (Florentin, 2018; Molotch, 1976). Developing post-growth approaches might be shaped and limited by this context (Florentin, 2018) - the alternative solutions are trying to emerge within the very systems they are trying to change. Instead, we could look towards options of how to develop post-growth practices in decentralised forms and contexts, not from within the very centres of the 'engines of growth' (GTIPA, 2018).

One group that have been pointed out as decentralised 'laboratories of change' (Nogueira et al., 2019) is intentional sustainable communities working towards developing their own alternative development paths. Intentional communities have been described as groups that create a whole way of life for the attainment of a certain set of goals (Schenker, 1982). They encompass a wide variety of conglomerations, but the classic definition by Metcalf (2018) is *"five or more people, drawn from more than one family or kinship group, who have voluntarily come together for the purpose of ameliorating perceived social problems and inadequacies"* (Metcalf, 2012, p. 1). Traditionally, these communities often take the form of alternative habitation such as ecovillages, but with the rise of networked technologies not necessarily place based forms, such as associations and coops, are also emerging.

These communities are not a new occurrence, nor is their ability to be innovative catalysts or "seedbeds of society" (Morgan, 1942). However, the operative tools for coordinating groups have vastly changed in the last 20 years, and there is limited research on how post-growth oriented communities are using technologies in their day-to-day operations. Although the impact of the fourth and fifth technological revolutions on society have been extensively researched (Knell, 2021), the potential of digital layers to support in particular intentional sustainable communities as socio-technical innovators -i.e. 'agents of change' - is currently underexplored (Nogueira et al., 2019).

Therefore the primary aim of this paper is to explore which aspects of post-growth communities can be aided by a digital layer, in order to support them as decentralised laboratories of change. Through purposive interviews with tech adept representatives that have both professional and personal knowledge of community, this explorative study aims to provide a better understanding of *how post-2004 technologies can support decentralised communities in developing their own alternative development models.*

2. Background: key concepts

The below sections expand on the key concepts: intentional 'post-growth' communities, the definition and role of 'technology', and the concept 'laboratories of change' .

2.1 Identifying 'post-growth' communities

Modern self-organised communities often emerge as a response towards the inadequacy of conventional governmental structures (Edelenbos et al., 2018; Nederhand et al., 2016) and the sustainability challenges that the neoliberal and capitalistic economic system has not been able to tackle (Nederhand et al., 2016). In this sense they can be associated with the Degrowth and post-growth movements (Asara et al., 2015; Pansera and Fressoli, 2021). Some organisations are more *"informal and loosely structured"* (Edelenbos et al., 2018: 52), while others are more defined (Comfort, 1994) and explicitly pursue self-governance (Nederhand et al., 2019) by embracing *"an internal point of view on the world and deliberative standpoint, supporting the literal applicability of intentional description"* (Ismael, 2011, p. 23). For the purposes of this paper a broad definition is applied, modified from Metcalf (2018): Five or more people, drawn from more than one family or kinship group, who have voluntarily come together for the purpose of ameliorating perceived unsustainable social, environmental and economic patterns through self-organising around their own alternative development model.

2.2 Definition and potential role of technology

'Technologies' in the context of this paper refers to network enabled innovations developed post 2004, when the emergence of Web 2.0 (Hesse et al. 2011) introduced the ability to contribute with content and interact with others on the Web. The unprecedented progress networked enabled innovations (Roldán Bravo et al., 2016) have made over the last decades expresses a potential for supporting the sustainment of self-organised communities (Morrow, 2019). ICT (Information and Communication Technology) can support *"a better use of knowledge and data (...) across a wide range of groups that share one or more characteristics that define them communities"* (Hesse et al., 2011, p. 15), as well as organisational forms not previously seen - from open source platforms such as GitHub (Padhye et al., 2014) to blockchain technology that displays *"potential for facilitating redistributive and regenerative post-capitalist economies."* (Howson, 2021, p. 1). The potential role of technology in this paper chimes with the view of Kostakis et al. (2023) as *"a vital component of modern society cutting across all its other aspects, required to achieve social and environmental sustainability"* (Kostakis et al., 2023, p. 1).

2.3 On post-growth communities as laboratories of change

Nogueira et al. (2019) explores small scale communities such as intentional communities from their *"potential as laboratories for the emergence of innovative practices and their possible capacities for the introduction of change in the sociotechnical regimes and, later, for their transition"* (Nogueira et al., 2019, p. 17). By incorporating technologies to co-create knowledge and solutions for a wide range of social needs *"at a scale and speed that was unimaginable before the rise of the internet"* (Bria, 2016, p. 9) these communities might be strengthened, and *"provide a glimpse into what 'innovation without growth'* could mean in terms of technology and social organisation (Pansera and Fressoli, 2021, p. 380) Still, these authors recognize that existing studies are incipient and further research is needed to disentangle such a potential from the romanticisation of such communities and better understand how they have been using technologies in their day-to-day operations.

3. Research approach and methodology

This paper adopts an exploratory research approach, which is useful when the object of study is relatively underexplored (Stebbins, 2001). The data was gathered through semi-structured interviews, focusing on insights from tech-savvy participants with in-depth experience of community. *Figure 1* outlines the three major steps and associated methodologies of the process.

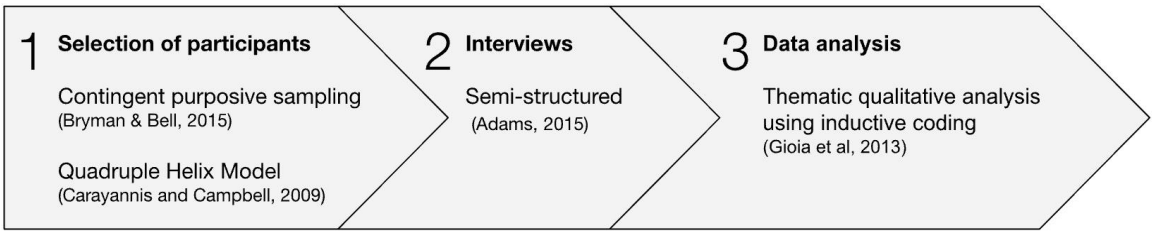

Figure 1: Research design

3.1 Selection process

The participants were selected using contingent purposive sampling (Bryman & Bell, 2015) and the Quadruple Helix Model (Carayannis and Campbell, 2009; Schütz et al., 2019). Slight adaptations of the model helices were made for the context of this paper, find their specifications in Table 1.

Selection criteria were a) professional or practical experience of technology in relation to community b) relation to one or more communities with a post-growth approach c) representing multiple aspects of the Quadruple Helix Model ('Affiliation', Table 1). For example, being both an active member of a community and a software engineer indicated an affiliation with both 'Community' and 'Industry' aspects.

The final selection resulted in seven participants. As the purpose of this paper was to make an explorative study to identify patterns of interest in relation to the topic this smaller focus group was deemed sufficient. The group represented six countries and three continents. The community the representatives related to varied between being at the forefront of using technologies to using very little technologies at all, approximately half representing tech-proficient communities and half non-tech proficient.

3.2 Conducting the interviews

The data was collected primarily in the form of semi-structured interviews (Adams, 2015), conducted conversationally with one respondent at a time through open-ended questions. This allowed for focusing on the topic while still being able to explore relevant ideas that came up in the interview, talking through participants' thoughts and beliefs. The questions covered their general relationship to community and perspectives on technology use in this context (Table 2).
The interviews were conducted in September and October 2023. One of the interviews was conducted in Swedish, and the remainder in English. All interviews took place through video call and were between 1-1.5h in length.

Table 1: Participant profiles

	Quadruple helix*						
Participant	A	G	I	C	Country	Affiliation**	Rationale for involvement
#1			●	●	United States	Weaving Water (C) Software Engineer (I)	Resident in an intentional community, Software engineer, setting up the tech stack for their community
#2	●		●		Puerto Rico	Holochain (I) Political Theorist/ Applied Philosopher (A)	Director of Business Development for Holochain - a free and open source framework for building peer to peer applications. Member board of directors for 'Toward Warm Data'. Founded co-housing spaces, helped run a makerspace.
#3		●		●	Portugal	OASA (G) Traditional Dream Factory (C)	Founder of OASA: a nonprofit which has as its purpose to acquire, conserve and regenerate land, and Traditional Dream Factory: A regenerative village run through a Decentralised Automated Organisation (DAO).
#4			●	●	Spain	Can Mas Deu (C) Software Engineer (I)	Long term resident in an intentional community, group and tech knowable, Software Engineer student.
#5			●	●	Sweden	Uddebo/ Borderlands (C) Technologist (I)	Builds collaboration tools for networks and communities. Co-founded Cobudget and Blivande, works with Edgeryders and Open Collective. Worked with Uddebo, Borderlands.
#6		●	●		United States	Timebank (G) Holochain (I)	Former Executive Director of a Timebank, Holochain advocate, previously involved with a range of companies relevant within the field, currently independently researching technologies used by communities
#7	●			●		University of Edinburgh (A) Village resident (C)	Chair of Design Informatics, explores how design provides methods to adapt, and create products and services within a networked society

* Quadruple Helices and their adaptations for the context of this paper:
Academia - Academic research, both independent and institutionalised
Government - Institutions involved with governance mechanisms
Industry - Entrepreneurs and developers
Communities - Small scale communities with post-growth intentions

** In most cases participants represented more than two affiliations.
This table lists only the primary roles through which they relate their experiences in the interviews.

Table 2: Interview questions

General	Tell me about yourself - what is your relationship to community?
Community focus	From your perspective, for what do communities use technology? From your perspective, why would communities use technology?
Technology focus	Progression of tech in community - what have you seen? Which specific technologies have you heard about or used in relation to community, and what are your experiences with these? What is the future of technology in communities?

3.3 Data analysis

The analysis used the approach of (Maguire and Delahunt, 2017; Vaismoradi et al., 2016) for thematic content analysis with inductive coding in qualitative semi-structured interviews. To enhance the qualitative rigour, the analysis was based on methodology developed by Gioia et al (2013). An example of the process can be seen in Table 3.

Table 3: Coding scheme, extract

Example sentence	First-order codes	Second-order theme	Aggregate dimension
"*...these kinds of digital tribes that are globally connected and that can identify around certain values and purposes rather than just by where they're born.*"	Connecting with like minded people Non place based engagement	Finding community	Setup

Fireflies.ai was used for automatic transcription of the interviews. All subsequent analysis was manual, using the productivity software Notion to organise the data.
The initial analysis focused on informant-centric terms, and aimed for a wide initial scope. This resulted in a total of 192 first-order codes. Next, the relationships between these codes were analysed in order to merge and cluster the result into eight themes. Finally, the themes were aggregated into dimensions.
The final coding scheme is seen in Figure 3.

4. Findings

The interviews ranged from the practical to the theoretical, spanning extremes of technology use - from communities setting up their own decentralised governance to communities barely using email. An encompassing trend was the importance to understand the nature of the discussed communities, and the need to respect where technologies may be of use - and where they may not. *'…none of us are joining community so that we can make more spreadsheets [...] we're joining it for the heart work. We're joining it for the connections and what it brings in happiness and joy. Those things are not tangible, but when you're bringing 50 some people together there's work that goes into those logistics.'#1*

Three dimensions emerged where technologies were seen by the participants as having potential to constructively support community operations: their setup, organisation and evolution. The findings section is structured according to these aggregated dimensions, their second-order themes and first-order codes – seen outlined in Fig.3. The impacts and barriers involved in the findings are summarised in the discussion.

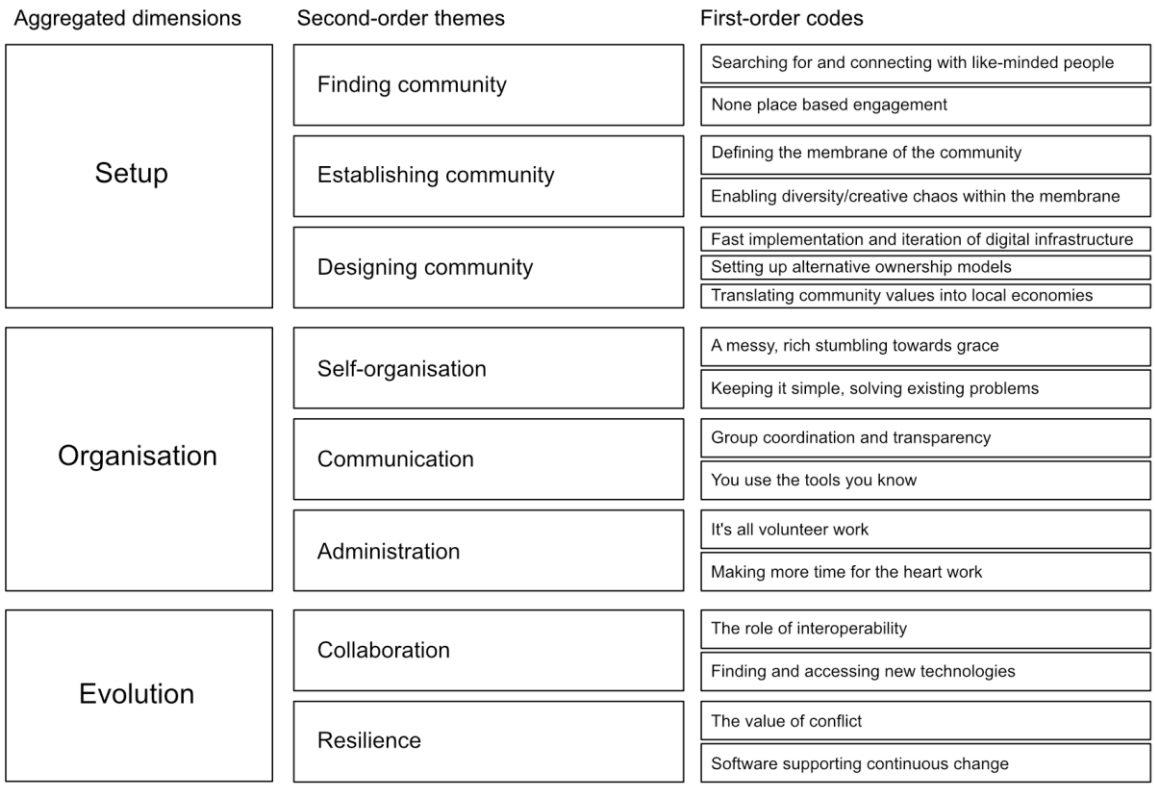

Figure 3: Coding scheme/summary of findings

4.1 Setup

4.1.1 Finding community

From the interviews it was apparent that the ways to find and connect with like-minded people had changed drastically in the last 20 years: *"I mean, 20 years ago, if I was starting a community, it would be like I'm going fully offline. I'm going to create my little bubble with my friends. We're not really going to communicate with the outside world and that's it. We're just going to be living together on this plot of land. Whereas today in this space, for example, we get people visiting from all over the world. We are digitally connected."/#3*

The participants shared various experiences of using post-2004 technologies in relation to finding like-minded others. Specifically, sites which gather information on existing initiatives (such as cohousing.org) and apps that enable distance communication with others in conglomerative contexts (such as Discord) were mentioned. These platforms were seen as giving individuals an increased awareness of, increased access to, and increased agency in relation to searching for and finding people and contexts they wished to engage with. *"Most of those who use these [technologies] do it to get access to a community [...]/participant* #5

Network technologies were seen as enabling groups of people to be *"…globally connected and identify around certain values and purposes rather than just by where they're born."/#3* and as an opportunity for distance communication and engagement *"...it can turn into movements that allow community to be non place based as well as place*

based."/#7. This non place based engagement was seen as an inclusive way to connect on your own terms: the participants did not have to be physically present in order to build or affect a community, and they could remain an individual and be part of the collective simultaneously.

4.1.2 Establishing community

The code 'defining a membrane' summarises statements on what keeps the community together, setting *"... our membrane, our container"/#6*. The importance of this container not being too restrictive was stressed. Technologies such as the decision making platform Loomio were mentioned as examples that let communities make their own choices on how to collaborate. A main lesson the Traditional Dream Factory (TDF) - a regenerative village that operates as a Decentralised Automated Organization (DAO) - learnt since their start was not to use the DAO for managing everything, instead be *"...the holder of what the community actually wants"/#3.* Although setting up a general boundary for the community was deemed important, it was crucial to not *"...make people feel like they're just clocking in for a second shift."/#1*. Despite most of the communities involved could be prefixed 'intentional' there was an aversion to defining the actual intentions of the community too strongly. Scepticism towards defining too rigid/strong structures were expressed, best summarised in the quote *"if you claim that any community is very strong you'll be leaning toward a cult."/#7.*

The opposition to this dangerous rigidity was seen as enabling a rich diversity within the community membrane, a form of creative chaos. "*It's just that's how community actually works. It's actually a whole ecology of relationship.*"/#2. The charm of being in community was seen as precisely the lack of too formal organisation and the richness and diversity of internal interactions. A repeatedly stressed point was that community is not conducive to the same organisational structures as companies. Communities are *"...not a system or a design that lends itself to control."/#2.* Where corporations will always try to have *"...a standardised experience in order to reduce the complexity they have to deal with to serve the larger customer base"/#2,* the community aim was instead to support complexity, in order to have *"...a rich ecology of interaction and communication and relationship"/#3*.

4.1.3 Designing community

A potential for how technologies can *"disrupt different economies and cultures"/#7* was identified, but this was dependent on translating alternative development approaches into systems *"If we actually want to be sustainable [...] we have to create systems that can last and persevere [...] otherwise they're just going to disappear."/#3*. Digital infrastructure can be easier to implement than physical infrastructure *"... software can build, measure, learn much faster than perhaps laying cable, laying networks. Having said that, you do need the two."/*#7. Some of the communities attempted through such infrastructure to design different economies and cultures into the very foundations of their operations, relating to the statement *"...there's a possibility that software can rewire some of those old things that we can't change."/#7*

In relation to setting up alternative ownership models technology was seen as *"…tools to kind of hack the legal system a little bit"/*#3. An example is OASA - a nonprofit land trust emulating wrapper for Web3 villages that tries to acquire, conserve and regenerate land through blockchain technology. Holochain - a free and open source framework for building peer to peer applications - also involves ideas along the same lines, having: *"...a*

vision for what they call land weaving society"/#6 that lets communities put land that they already own or collectively pull together, as well as purchase land to create common spaces.

Some participants talked of how technologies were helping define alternative economies - and what 'value' or 'wealth' meant in relation to their own communities. Technologies were seen supporting how individuals could share in and add to this value, for example in the case of how Timebanks can help visualise how to share competencies with each other, or in the case of TDF - using blockchain to set up own currencies that embody their value system and ties it to governance. Their alternative economic model includes the 'TDF', an access token that can be thought of as a timeshare, the 'Proof of Presence', indicating the time you've spent physically on site, and 'Proof of Sweat', indicating how much work you actually contributed to the community projects. These currencies combine to give you voting rights within the community.

4.2 Organisation

4.2.1 Self-organisation

Technology was here seen as a way to support coherence without top-down hierarchy being a dominant part of the equation, enabling "...*very different patterns of organisation and coordination"/#2*. Self-organisation was standard in almost all the communities and described as - *"…a messy, rich stumbling towards grace"/#2* - being compared to the dynamics of dancing, where despite *"A lot of stepping on toes"* eventually you collectively (hopefully) figure out how to make it work. The Holochain ecosystem represents an approach that attempts to develop online tools inspired by how natural living biological systems are organising themselves. Here organisational technologies operating on interoperability principles allow for users to continuously test, combine and change their online toolbox, in order to pick up on "...*that individual creativity, and provide the mechanisms for seeing what actually worked or not."/#2*

Most of the participants expressed that they as the 'tech literate' members of their communities had identified needs for using specific technologies to make day to day interactions and logistics easier, making these smoother and less frustrating *"...so that we can enjoy the shared meal together and not have to say, oh, well, we bought so many leftovers that we have 20 more meals."/#1.* This translated in practice to preferring simple technologies that help solve the many small logistical problems of self-organisation: who wants food tonight, who takes out the trash, organising a party, pooling funds… and then picking and choosing to use these technologies as they're needed.

4.2.2 Administration

The phrase 'It's all volunteer work' kept appearing in relation to daily operations. Simply the person who had time did what was needed. This was tied to frustrations relating to lack of time and issues with the right skills in the right place.

Here technologies were seen as able to ease the burden of administration by using systems that could easily connect, organise and share information, such as cloud services and project management software. These technologies were seen as useful in supporting administration by making it easier to break down and distribute responsibilities and decision-making as well as help with accounting and expenses.

Overall *"In the best of worlds, [using technologies] just opens up so much more time and opportunity for the heart work. "*/#1

4.2.3 Communication

All communities used asynchronous communication tools "*...the way people travel nowadays, how do you [otherwise] go away for a month and get your voice heard?"/#1,* alongside their use to "*capture the notes from what you decided"/#1*. Communication platforms were beside their use for coordination seen as ways to increase transparency into interactions and actions of community, although some mentions were made of how this transparency might not be welcomed by all.

In terms of which platforms were used this was again and again expressed as the sentiment 'you use the tools you know'. For example, *"They start using Slack at work - and then they think 'we can have Slack for our coop [bostadsrättsförening] as well'. It's convenient."#5*. This translated to most communities using WhatsApp, Messenger and Facebook groups for their communication - sometimes, frustratingly, even several of these platforms at the same time, depending on each individual's familiarity. 'Single thread' technologies from the interviews appear particularly unsuited for community communication, as illustrated through the quote*"...there's suddenly 80 people in the [WhatsApp] group and you can't even friggin follow the conversation because people are talking so fast, there's so many conversations going on that it just becomes a friggin waste of time [...] you send a message and it's gone forever".*/#4.
In contrast, the conversations involving channelled communication tools - such as Discord or Slack - did not mention such frustrations. Dynamic organisation and search are key design features in these tools (see Figure 4). This seems to indicate they are more suitable for communities than a single, 'black hole' approach.

Several participants mentioned that this tendency to only use tools that are already known - despite their drawbacks - often resulted in them giving up attempts to introduce better suited technology, since it was like *'pulling teeth just to get people to friggin make an account'/#1* and overall compared the experience to *'herding cats'/#1*. It does not appear to be resistance to technology per se, though, rather *"...they just didn't get around to it."/#1*. In terms of successful attempts to introduce new technologies two major approaches were mentioned: to increase familiarity with the tool using a loose guiding hand, and to be consistent: *'…it was the way you contacted the board'*.#4

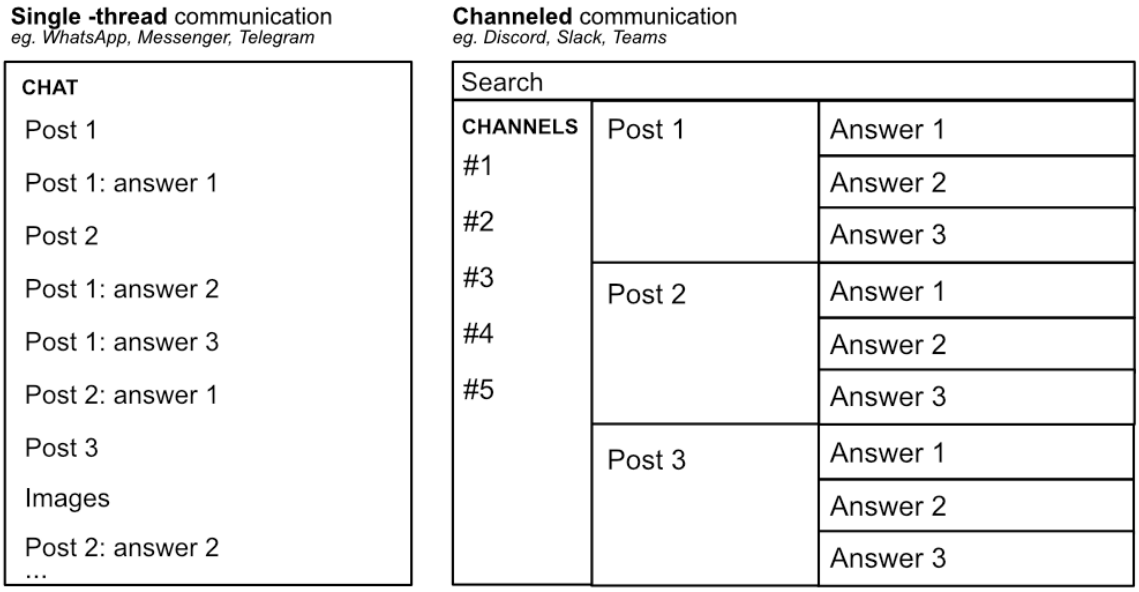

Figure 4: Simplified difference between single vs channelled communication tools

4.3 Evolution

4.3.1 Collaboration

The more technically inclined communities were actively collaborating on developing software. TDF is, for example, via the platform Closer building an operating system for land stewardship communities. Here interoperability emerges as a crucial concept, indicating systems that can function and communicate with each other. This principle allows for the users to change the apps as they wish: " [about Holochain apps] *if it's not working well enough, you can take it and tweak it and try again."/#2.* Parallels were drawn between interoperable digital layers and the aims of post-growth communities in general, *"there's a really interesting overlap between the decentralised web and the idea of autonomous communities"/#1*

Participants use the same technologies for the purposes of building community as they do in their other lives, which meant they used search engines for finding information on other communities, and forums to connect and learn from each other (in particular Discord). However, how to find exciting new projects, and which groups were able to access them was questioned. Needs were identified for better overviews of what's available as well as ways to access new tools for non tech savvy people.

4.3.2 Resilience

Building community was described as complex, often involving conflict. Perhaps a bit surprisingly, this was not expressed as a problem per se. Instead conflicts were seen as crucial to enable necessary changes *"I'm very skeptical of utopias. Anything that has perfect harmony is dead, or at least not going to be very resilient."/#2*. To have *"enough diversity, tension, maybe even disagreement, fighting"/#2* was seen as a natural process to enable the community to handle new challenges "*And if it doesn't work out well, the whole community doesn't just go away. Right? There's not a catastrophic failure"/#2.*

The role of post-growth communities as laboratories of change was seen as tied to their ability to continue to evolve and, importantly, never getting there entirely *"because if we get there entirely, then there's no more movement and change happening in the world"/#2*. The lifecycle of developing software was compared to that of developing community. *"There's a cycle of build, measure, learn."/#7*, and this cycle was seen as having potential for supporting community evolution. The goal being to foster vibrant ways of being responsive to the circumstance we face "*individually, collectively, subgroup collectively."*/#2 In practice, the evolution of the community was seen as being supported by adopting a changing suite of technologies *"…rather than trying to build your own or building something centralised."*/#7. *"Everytime I've launched something it has been a* simple *idea."*/#5. In general, technologies focused on *"...empowering that community to augment very slightly its ways of operating."/#2* were seen to be of most use, because these focused on solving particular problems, not setting up encompassing structures, and so did not hinder the evolution of the community by locking it into one form.

5. Discussion

The aim of this study was to explore how post-growth communities can be supported through digital layers, specifically by leveraging technologies developed in the past 20 years. This exploration gathered data from seven interviews with tech adept representatives having in-depth professional and personal experience of community, and attempts to synthesise their insights. The next section summarises the contributions of this study in relation to specifying the potential impact technology can have in the setup, organisation and evolution of post-growth communities, while the second section expands on identified barriers. Following this, we discuss limitations of the study and finally summarise conclusions and directions for further research.

5.1 Impact

Digital layers were found to support the communities in the interviews with:

- *Setup* - Finding, establishing and designing community
- *Organisation* - Self-organisation, administration and communication in community
- *Evolution* - Collaboration and resilience of communities

The impact can be summarised as: i) *improving access to community*; ii) *facilitating internal communication and coordination*; iii) *enabling a common boundary and internal diversity*; iv) *encoding alternative development models into sharable and adaptable systems.*

Improving access to community

Traditionally, communities form around place based attachments (Manzo and Perkins, 2006). The findings of this study indicate that using online platforms and forums for the particular purpose of finding and engaging in community might be able to mitigate the divide between what Appleyard (1979) in a now classic study calls "insiders" and "outsiders", relating to the "ingroup/outgroup" concepts in social identity theory (Tajfel, 1970), meaning we tend to discriminate against people not from our ingroup (Hewstone et al., 2002). Here we can identify a risk that awareness of and access to community might be limited to only spread within those who have the privilege to have heard of it within their own networks, for example, within an ingroup of a well-educated, white middle-class.

It is apparent from the interviews that the landscape for finding and defining your ingroup has changed drastically in the last 20 years. The participants describe how they through online platforms could search and engage with like-minded people from a distance - whereas prior to networked computers engaging in community was largely dependent on location, physical connections and frankly, luck. Technologies that are described as allowing for non place based visibility, initial engagement and in-group formation independent of an individual's original location or group attachment show promise of democratising access to community, radically changing who gets to be involved in the innovation of alternative futures.

Enabling a common boundary and internal diversity

Organisation design has a significant impact on how people work together (Burton and Obel, 2018). In community, organisation was not seen as having the role of reducing, but supporting complexity, enabling diversity within the defining membrane of the community that lets it dynamically evolve. This tendency of communities to organise around a common boundary has been previously identified (Georgiou and Arenas, 2023) and chimes with anthropological research that has found a common ideology keeps communities together for longer (Abramitzky, 2011; Dunbar and Sosis, 2018). Enabling self-organisation in practice, however, was from the interviews described as difficult to do offline. The ability of the web to self-organise millions of individuals operating independently and having a variety of backgrounds, knowledge, goals and cultures without a central authority has been documented since the beginning of the 2000's (Flake et al., 2002), perhaps the most classic example being Wikipedia. This study identified that communication and coordination platforms were seen of particular use for self-organising communities. The participants rejected encompassing systems that attempted to structure the whole community, instead preferring simple tools that were already anchored in a context that helped self-organise around practical issues - such as deciding on ideas, financing a project or dinner logistics.

Facilitating internal communication and coordination

The results of this study specifies which form of communication tools appear to be least suitable for community organisation and suggests which designs might be a better match. Specifically, the results indicate that 'single-thread' communication tools such as WhatsApp are particularly unsuited to communities, since they do not allow for organising and searching inputs. Channelled tools (such as Discord or Slack) were ideally preferred due to the ability to sort the community discussions into channels, posts and threads - essential dynamics for enabling self-organisation of the preferred approach described in the interviews: a form of constructive creative chaos.

Encoding alternative development models into shareable and adaptable systems

The interviews identified a hope of 'rewiring the old things we can't change' by translating alternative development models into code. Since software is cheaper and faster to implement than physical infrastructure it was seen as a way to test out and tweak new models, providing tools for the members of a community to themselves design how they want their community to operate. TDF, OASA and Holochain are implementing this in practice by encoding cultural and organisational practices into systems - setting up their own local currencies and alternative ownership models, bypassing central institutions. CityDAO is another example of how to use digital layers for alternative purposes, a DAO was there used to organise around collectively buying land and collaboratively planning a new city (*Could a DAO Build the Next Great City?*,

2022). Such digital layers can allow the community to set up a governance structure that both translates its ideas into governance mechanisms, as well as lets this governance structure quickly adjust and be updated according to bottom-up inputs, allowing the community to respond quickly when there is need to change. As such, these technologies could be impactful in providing supplementary digital layers that make community easier while still allowing for continuous evolution of the community, opening up for implementing own decentralised versions of how they want the future to look, and therein experiment with what works for them and doesn't.

5.2 Barriers

There are challenges involved with fulfilling the potential described in the above sections, even if we disregard the technologies requiring significant technical knowhow - DAO's, local currencies and alternative ownership models. These barrier fall under: i) *You only use the technologies you know* ii) T*hresholds to introducing new technologies* iii) *Communities are not companies* vi) *Finding and developing interoperable technologies*

You only use the technologies you know

Although there exists technologies showing a lot of promise to support communities, they might not be used. Channelled communication tools such as Slack or Discord were frequently mentioned by the participants in the interviews as tools they considered superior for communication, but they also repeatedly pointed out difficulties with actually getting the members to use them. The reason for this boils down to 'You use the tools you know' - a main takeaway from this study. This results in communities attempting to coordinate hundreds of people in WhatsApp or Messenger groups - technologies designed for simple interactions - which results in frustrations and overwhelm. These technologies appear particularly unsuited for the forms of complex interactions involved in the vibrant, active webs of relationships that define these communities.

Thresholds to introducing new technologies

This strong tendency of only using technologies you already know - regardless how unsuitable they are for the purpose - unfortunately could mean some of the communities discussed in the interviews do not benefit from changes in the technology field these last 20 years. This threshold to learning new technologies is understandable, and not an issue isolated to these communities, for example teachers have difficulty adopting and persevering with new technologies (Pelton and Pelton, 2008). However, since technologies are used to boost for example startups, an organisational form aiming *"to grow company value by driving sales of new products (goods or services) through the creation and application of innovative technologies leading to a growth in productivity and increase in domestic and global market share"* (Skawińska and Zalewski, 2020, p. 5), communities wishing to propose an alternative future to growth - and develop and spread their own alternative development approaches - *not* using appropriate technology for their own purposes could mean shifting the playing field towards those who tailor their supporting software to their operational, technical, schedule, political, legal and economic needs (Sakthivel, 2023).

Using technologies to assert control - communities are not companies

Organisation focused around conformity is a classic trope in science fiction in relation to dystopias (Seeger and Davison-Vecchione, 2019), where attempting to assert social control tends to result in fragility and the eventual fall of the system. Perhaps counterintuitively, a 'strong' community was described as the most fragile. For the

communities in this study a ‘strong’ community could also be negatively associated with ‘cults’, in this context indicating top-down organisational structures that limit personal freedom and development. Interestingly, this aversion to association with cults emphasises the differences between communities and companies, which in some cases develop into extremes called ‘secular business cults’, characterised by an ultrastrong culture, formalised manipulation, manipulative hierarchical relationships, competition, and operations efficiency tools (Kulik and Alarcon, 2016).
Despite this being an extreme example, the interviews point out that companies in general strive for order and simplicity where in contrast, the values of communities was to enable complexity, rich and diverse evolving webs of relationships, and to embrace internal conflict as a natural part of community - a way to enable change and develop a flexible approach to challenges. Attempting to create conflict-free, ‘strong’ communities would kill dynamics that lead to resilience.
This crucial difference might hint as to why some of the participants talked of how the ecovillage movement in general is ‘technophobic’. Perhaps this could be due to an association between the tools used by such companies and technology in general.

Finding and developing interoperable technologies

When discussing particular technologies, it is important to be aware that these forms of communities are not all the same, and that they do not lend themselves to control. Technologies used should reflect this, and focus on enhancing the community, not restrict it. A need was identified for technologies that match the particular makeup of communities and doesn't lock them into one form. This appears to represent an emerging tendency to translate alternative development models into software that can be shared and continuously improved upon by any community wishing to do so. Here, interoperability emerged as a term of importance, as it allows for communities to share, edit and continuously update their digital layers. Parallels between the decentralised web and autonomous communities came up in the interviews, relating to the discussion on how to demonopolise the internet: Alphabet owns search; Amazon runs e-commerce; Apple has the hardware; Meta controls social networking; and Microsoft dominates business software” (Arnao, 2022), but interoperability can empower communities and individuals to escape monopoly platforms (Doctorow, 2021). There are promising projects on the horizon, exemplified by Holochain, OASA and TDF present in this study, but such projects accessibility, spread, and most of all - introduction - to communities deserve further attention.

5.3 Limitations

This paper focused on identifying links between how post-growth oriented communities wish to operate and areas where technologies could be used to support them in their approach. Although mentioning the technologies discussed, it did not dig further into the specifics of each technology. Further study is needed on the current landscape of existing technologies and their characteristics - eg, whether the design fits the purposes of the community, the intention matches with the community ideology, and whether they are truly ‘sustainable’ - in order to outline a map of available choices to communities.

The participants in this study were chosen particularly because they were both community and tech proficient, in order to identify the *potential* of using tech in community. They do not represent all communities, and some of the interviews indicated other communities may be either uninterested in technology or actively technophobic.

6. Conclusion

Using a supporting digital layer was seen as having potential to support community setup, organisation, evolution and, ultimately, spread the impact of the community's alternative development model. Specifically:

- Using open forums and online platforms can *democratise access to community*, drastically changing who gets to be involved with and develop alternative futures;
- *Bottom-up self-organisation* in communities can be supported by adaptable technologies that channel creative chaos into constructive avenues;
- *Communication* can be simplified by channelled communication tools that promote transparency and overview, and finally;
- Alternative culture, value, land and ownership *models can be encoded into interoperable systems, and shared with other communities*.

The potential of using digital layers was seen as making it easier to self-organise around, test and share alternative approaches to the growth paradigm, and radically change how communities form, learn from each other and spread - supporting their impact as laboratories of change.

Despite the use of digital layers appearing game changing, far from developing their own digital infrastructure, most of the communities were just starting to use even the simplest of communication tools. The main barriers found were:

- *People tend to only use technologies they already know*, often resulting in working with particularly *un*suited technologies, and subsequent frustration and rejection of technology.
- *There are thresholds to using new technology.* Introducing new technology requires analysis of what the community actually needs - usually problem-solving tools, not encompassing systems - combined with that tech adept community members attempting to introduce new, better suited, tools often gave up due to the first barrier.
- *Communities are not to be confused with companies* - technology would need to enhance the community, not impose unwanted control. Some technophobia may be due to technology being associated with the growth paradigm, specifically its use in companies.
- Lastly, s*oftware of particular use to communities are still in their infancy*, and appear to depend on incorporating interoperability principles that do not lock the community into one form - instead allowing for free adaptation. Such technologies can at present be hard to find and use for non tech-savvy community members.

Although some of the reasons as to why these barriers exist and potential approaches to counter them are hinted at in this explorative study, they deserve further research. In particular, the criteria for how to introduce specific technologies useful to post-growth communities.

This study finds that using digital infrastructure has the potential - if overcoming the barriers - to empower communities to better compete with entities that advocate for continuous growth by making it easier to explore and disseminate their own alternative models of development. In essence, supporting such communities in developing, implementing, and sharing paths towards a diverse future where our way of life has hope of differing significantly from the present.

References

Appleyard, Donald. 1979. *Inside vs. outside: The distortions of distance. Working Paper 307*, Institute of Urban and Regional Development, University of California.

Abramitzky, R., 2011. On the (Lack of) Stability of Communes: An Economic Perspective, in: McCleary, R.M. (Ed.), The Oxford Handbook of the Economics of Religion. Oxford University Press, p. 0. https://doi.org/10.1093/oxfordhb/9780195390049.013.0009

Adams, W., 2015. Conducting Semi-Structured Interviews. https://doi.org/10.1002/9781119171386.ch19

Arnao, Z., 2022. Why Monopolies Rule the Internet and How We Can Stop Them [WWW Document]. URL http://uchicagogate.com/articles/2022/1/4/why-monopolies-rule-internet-and-how-we-can-stop-them/ (accessed 11.27.23).

Asara, V., Otero, I., Demaria, F., Corbera, E., 2015. Socially sustainable degrowth as a social–ecological transformation: repoliticizing sustainability. Sustain. Sci. 10, 375–384. https://doi.org/10.1007/s11625-015-0321-9

Bria, F., 2016. Growing a Digital Social Innovation Ecosystem for Europe - DSI Final report [WWW Document]. Futur. - Eur. Comm. URL https://ec.europa.eu/futurium/en/content/growing-digital-social-innovation-ecosystem-europe-dsi-final-report (accessed 11.15.23).

Burton, R.M., Obel, B., 2018. The science of organizational design: fit between structure and coordination. J. Organ. Des. 7, 5. https://doi.org/10.1186/s41469-018-0029-2

Carayannis, E.G., Campbell, D.F.J., 2009. "Mode 3" and "Quadruple Helix": toward a 21st century fractal innovation ecosystem. Int J Technol. Manag. 46. https://doi.org/10.1504/IJTM.2009.023374

Comfort, L.K., 1994. Self-Organization in Complex Systems. J. Public Adm. Res. Theory J-PART 4, 393–410.

Could a DAO Build the Next Great City? | Scott Fitsimones | TED, 2022.

Doctorow, C., 2021. Demonopolizing the Internet with Interoperability. OneZero. URL https://onezero.medium.com/demonopolizing-the-internet-with-interoperability-b9be6b851238 (accessed 11.21.23).

Dunbar, R.I.M., Sosis, R., 2018. Optimising human community sizes. Evol. Hum. Behav. 39, 106–111. https://doi.org/10.1016/j.evolhumbehav.2017.11.001

Edelenbos, J., van Meerkerk, I., Schenk, T., 2018. The Evolution of Community Self-Organization in Interaction With Government Institutions: Cross-Case Insights From Three Countries. Am. Rev. Public Adm. 48, 52–66. https://doi.org/10.1177/0275074016651142

Flake, G.W., Lawrence, S., Giles, C.L., Coetzee, F.M., 2002. Self-organization and identification of Web communities. Computer 35, 66–70. https://doi.org/10.1109/2.989932

Florentin, D., 2018. The challenges of degrowth in cities. Field Actions Sci. Rep. J. Field Actions 16–19.

Georgiou, A., Arenas, D., 2023. Community in Organizational Research: A Review and an Institutional Logics Perspective. Organ. Theory 4, 26317877231153189. https://doi.org/10.1177/26317877231153189

GTIPA, 2018. Cities as drivers of growth | Global Trade and Innovation Policy Alliance [WWW Document]. URL https://www.gtipa.org/publications/2018/09/20/cities-drivers-growth (accessed 9.29.23).

Hesse, B.W., O'Connell, M., Augustson, E.M., Chou, W.-Y.S., Shaikh, A.R., Rutten, L.J.F., 2011. Realizing the promise of Web 2.0: engaging community intelligence. J. Health Commun. 16 Suppl 1, 10–31. https://doi.org/10.1080/10810730.2011.589882

Hewstone, M., Rubin, M., Willis, H., 2002. Intergroup bias. Annu. Rev. Psychol. 53, 575–604. https://doi.org/10.1146/annurev.psych.53.100901.135109

Hickel, J., 2020. What does degrowth mean? A few points of clarification. Globalizations 18, 1–7. https://doi.org/10.1080/14747731.2020.1812222

Hickel, J., 2019. Is it possible to achieve a good life for all within planetary boundaries? Third World Q. 40, 18–35. https://doi.org/10.1080/01436597.2018.1535895

Howson, P., 2021. Distributed degrowth technology: Challenges for blockchain beyond the green economy. Ecol. Econ. 184. https://doi.org/10.1016/j.ecolecon.2021.107020

Ismael, J.T., 2011. Self-Organization and Self-Governance. Philos. Soc. Sci. 41, 327–351. https://doi.org/10.1177/0048393110363435
Kallis, G., Demaria, F., D'Alisa, G., 2015. Degrowth, in: Wright, J.D. (Ed.), International Encyclopedia of the Social & Behavioral Sciences (Second Edition). Elsevier, Oxford, pp. 24–30. https://doi.org/10.1016/B978-0-08-097086-8.91041-9
Knell, M., 2021. The digital revolution and digitalized network society. Rev. Evol. Polit. Econ. 2, 9–25. https://doi.org/10.1007/s43253-021-00037-4
Kostakis, V., Niaros, V., Giotitsas, C., 2023. Beyond global versus local: illuminating a cosmolocal framework for convivial technology development. Sustain. Sci. 18, 2309–2322. https://doi.org/10.1007/s11625-023-01378-1
Kulik, B.W., Alarcon, M., 2016. Manipulative Businesses: Secular Business Cults. Bus. Soc. Rev. 121, 247–270. https://doi.org/10.1111/basr.12087
Maguire, M., Delahunt, B., 2017. Doing a Thematic Analysis: A Practical, Step-by-Step Guide. 9.
Manzo, L.C., Perkins, D.D., 2006. Finding Common Ground: The Importance of Place Attachment to Community Participation and Planning. J. Plan. Lit. 20, 335–350. https://doi.org/10.1177/0885412205286160
Metcalf, B., 2012. Utopian Struggle: Preconceptions and Realities of Intentional Communities. RCC Perspect. 21–30.
Molotch, H., 1976. The City as a Growth Machine: Toward a Political Economy of Place | American Journal of Sociology: Vol 82, No 2 [WWW Document]. URL https://www.journals.uchicago.edu/doi/abs/10.1086/226311 (accessed 11.28.23).
Morgan, A.E., 1942. The Small Community: Foundation of Democratic Life, 1st edition. ed. Routledge.
Morrow, O., 2019. Community Self-Organizing and the Urban Food Commons in Berlin and New York. Sustainability 11, 3641. https://doi.org/10.3390/su11133641
Nederhand, J., Bekkers, V., Voorberg, W., 2016. Self-Organization and the Role of Government: How and why does self-organization evolve in the shadow of hierarchy? Public Manag. Rev. 18, 1063–1084. https://doi.org/10.1080/14719037.2015.1066417
Nederhand, J., Klijn, E.-H., van der Steen, M., van Twist, M., 2019. The governance of self-organization: Which governance strategy do policy officials and citizens prefer? Policy Sci. 52, 233–253. https://doi.org/10.1007/s11077-018-9342-4
Nogueira, C., Pinto, H., Marques, J.F., 2019. Innovative and transition potential of intentional sustainable communities. Cid. Comunidades E Territ.
O'Neill, D.W., Fanning, A.L., Lamb, W.F., Steinberger, J.K., 2018. A good life for all within planetary boundaries. Nat. Sustain. 1, 88–95. https://doi.org/10.1038/s41893-018-0021-4
Padhye, R., Kumarasamy Mani, S.K., Sinha, V., 2014. A study of external community contribution to open-source projects on GitHub. https://doi.org/10.1145/2597073.2597113
Pansera, M., Fressoli, M., 2021. Innovation without growth: Frameworks for understanding technological change in a post-growth era. Organization 28, 380–404. https://doi.org/10.1177/1350508420973631
Pelton, T., Pelton, L.F., 2008. Technology Outreach Workshops: Helping Teachers to Climb Over the Technology Threshold by Engaging Their Classes. Presented at the Society for Information Technology & Teacher Education International Conference, Association for the Advancement of Computing in Education (AACE), pp. 4273–4278.
Roldán Bravo, M.I., Ruiz Moreno, A., Llorens-Montes, F.J., 2016. Supply network-enabled innovations. An analysis based on dependence and complementarity of capabilities. Supply Chain Manag. Int. J. 21, 642–660. https://doi.org/10.1108/SCM-02-2016-0062
Sakthivel, S., 2023. A critical review of cost-benefit analysis for business software investments. Am. J. Bus. 38, 229–247. https://doi.org/10.1108/AJB-09-2022-0145
Schütz, F., Heidingsfelder, M.L., Schraudner, M., 2019. Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation. She Ji J. Des. Econ. Innov. 5, 128–146. https://doi.org/10.1016/j.sheji.2019.04.002
Seeger, S., Davison-Vecchione, D., 2019. Dystopian literature and the sociological imagination. Thesis Elev. 155, 45–63. https://doi.org/10.1177/0725513619888664

Skawińska, E., Zalewski, R.I., 2020. Success Factors of Startups in the EU—A Comparative Study. Sustainability 12, 8200. https://doi.org/10.3390/su12198200
Stebbins, R., 2001. Exploratory Research in the Social Sciences. SAGE Publications, Inc. https://doi.org/10.4135/9781412984249
Tajfel, H., 1970. Experiments in Intergroup Discrimination. Sci. Am. 223, 96–103.
United Nations, 2023. World Urbanization Prospects - Population Division - United Nations [WWW Document]. URL https://population.un.org/wup/DataQuery/ (accessed 11.23.23).
Vaismoradi, M., Jones, J., Turunen, H., Snelgrove, S., 2016. Theme development in qualitative content analysis and thematic analysis. J. Nurs. Educ. Pract. 6, 100–110. https://doi.org/10.5430/jnep.v6n5p100

INNER RURAL AREAS ENTREPRENEURSHIP

ITALIAN COMMUNITY COOPERATIVES & SMART PROPOSAL FOR THE SICILIAN MOUNTAIN MADONIE DISTRICT

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Abstract: *In the Mediterranean Basin, in Sicily, there is the "Madonie District" in the UNESCO Geopark with 21 municipalities, the largest inner rural area in Italy. It is suffering from depopulation and lack of work despite its natural and architectural potential. Now is the time to bring to light its cultural importance, as it is full of culture and history, fundamental for our country. Villages organized into communities deeply rooted in the territory with old traditions, arts and crafts, religious and popular festivals, in which there is a strong sense of active citizenship, community, cooperation, and collaboration. A better quality of life can be guaranteed through the process of creating smart villages, small collaborating urban centers through innovation and CCs - Community Cooperatives. This research work aims to analyze Italian CCs examples, a method of aggregation capable of promoting important job opportunities in inner areas and enhancing them. Models of social innovation in which citizens organize themselves to be producers and users of goods or services, fostering synergy, opportunities due to an Italian regulation built in recent years. A focus is dedicated to the analysis of Italian CCs, their benefits, competitiveness, and goals scattered throughout the rich rural territory. These areas, by creating new job opportunities, can truly be called smart villages; if this activity is extended to the entire Madonie district, then they could be competitive at the Italian, European, and global level. If extended all over the world, they can bring them back into vogue and stop the existing gap with smart cities: it means above all active citizenship, which constitutes the success of a resilient community. A smart village makes the most of itself with innovation, preserving and promoting the value of tradition: new inner rural areas that we must encourage.*

Keywords: *Sicilian inner rural areas, Smart Villages, Community Cooperatives, Madonie District, Collaboration for development*

1 The great district of 21 inner rural areas in Sicily: Madonie

In the middle of the Mediterranean Basin and at the centre of Sicily, just a few kilometres from the regional capital, the city of Palermo, lies the large Madonie Park: a recognized UNESCO Geopark[1] since 2004. It is an inner rural area with a rich geological and geomorphological heritage that is significant for its rarity, scientific interest, aesthetic appeal, and educational value. Its identity is linked first to geology, and it is enriched by its natural and cultural heritage. Spread over more than 40,000 hectares, this large park also includes 21 small municipalities, linked by an indissoluble union of artifice and nature. It encompasses geosites of geological, archaeological, ecological, historical, and cultural interest; all of these are the subject of enhancement actions to be undertaken. It is a territory that also enhances its geological and geomorphological heritage by promoting sustainable development, environmental education, training, increased scientific research in the various disciplines of the Earth Sciences, and sustainable tourism or geotourism, but that is still not so widespread today. Its protection takes place through a coordinated strategy of protection, thanks to many EU projects led by the University of Palermo and the Faculty of Agriculture, but also the geological and geomorphological heritage through innovative conservation strategies that do not exclude man from enjoying the environment and that embrace the sustainability goals outlined in the so-called "Agenda 2030" document. Managed by a coherent and structured administration that has adopted a strategy of sustainable and lasting economic development, the park involves inhabitants, authorities, public organizations, and businesses in the management and enhancement of geological sites through a strategy of protection, education, and sustainable development, aimed at local economic progress. The aim of this area is to improve the natural environment and the lives of the people who populate it.

This marvelous area gathers not only naturalistic but also architectural assets, such as innumerable isolated properties that enrich the territory, such as haystacks, drinking troughs, farmhouses, mountain refuges, thermal complexes, sanctuaries, abbeys, and panoramic viewpoints of great scientific value. However, the real protagonists of the great park are all the small villages, perched in the great mountain range of the Madonie Park, custodians of an architectural heritage well preserved over time, still close to the cultural, religious, peasant, and artisanal traditions of the past, and where the old local inhabitants still live. Small villages that arose in the past and that gather historical and non-historical architectural examples of great value and uniqueness in the world.

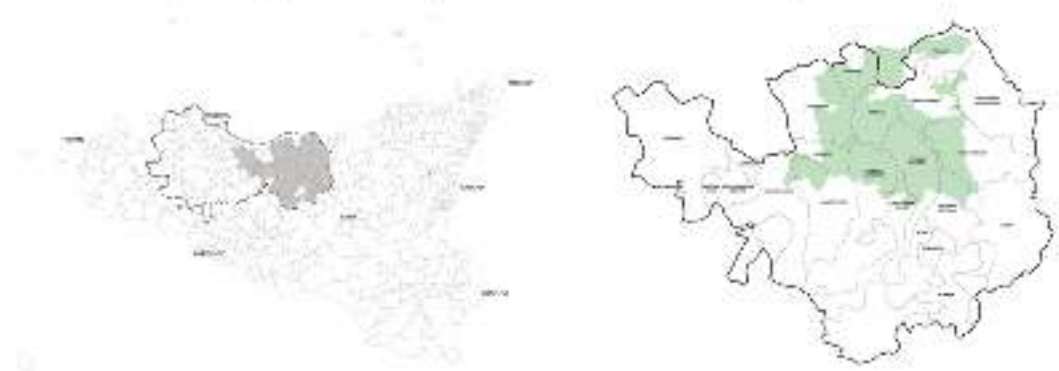

Figure 1 - Madonie inner rural area in Sicily; © Luisa Lombardo, 2023

[1] Madonie UNESCO Geopark, https://www.parcodellemadonie.it/

Places full of history, but today lacking job opportunities and effective restoration strategies. A great opportunity could be the joining of forces in the area: technicians, businesses, administrations, freelancers, and associations to reactivate the economy and provide new development opportunities (Arminio, 2011). Places that have always had a strong sense of collaboration and cooperation, but have been lacking effective and efficient strategies to bring them back to a state of contemporary living (Anselmi, 2014).

Figure 2 – An inner rural area in the Madonie Park, Blufi Municipality. © Luisa Lombardo, 2022

Recently, the Italian government has issued several directives, regulations, and calls for proposals to help inner areas achieve economic rehabilitation through the "National Strategy for Inner Areas" (SNAI). SNAI is an innovative national development and territorial cohesion policy that aims to counter the phenomena of marginalization and demographic decline specific to inner rural areas in Italy.

SNAI is an ambitious place-based policy project that has developed new methods of multi-level local governance to address demographic challenges and meet the needs of territories with significant geographic or demographic disadvantages. This is done through the adoption of an integrated approach that promotes local development.

Fragile territories, such as rural areas, are often distant from the main centers of essential services and are too often left to their own devices. However, they cover 60% of the national territory, 52% of the municipalities, and 22% of the Italian population. These areas are the "truest" and most authentic Italy, and their primary need is to be able to attract residents or retain those who already live there.

SNAI aims to intervene in these areas by investing in the promotion and protection of the wealth of the territory and local communities (Bianchi, 2020). This includes enhancing natural and cultural resources, creating new employment opportunities, and counteracting "demographic hemorrhage."

The Italian areas selected by SNAI are 72, and they include a total of 1,077 municipalities with approximately 2,072,718 inhabitants. From this strategy, the "Piano Nazionale di Ripresa e Resilienza" (PNRR) and the "Bando Borghi" were created. These are programs funded by the European Union's Next Generation funds, which can create new opportunities and possibilities for rural areas. In addition to these programs, SNAI also plans to promote local aggregation initiatives. These are considered a winning way to bridge the gap between large cities and small municipalities. They are possible because

of the great sense of belonging and aggregative spirit that differentiates these small municipalities from large metropolitan cities.
One example of a local aggregation initiative is Community Cooperatives (Spinicci, 2011). These are new, effective, and innovative tools that are regulated by the various Italian regions. They can generate new and innovative job opportunities in areas where everything has stood still and immobile in recent years (Borzaga et al., 2001).

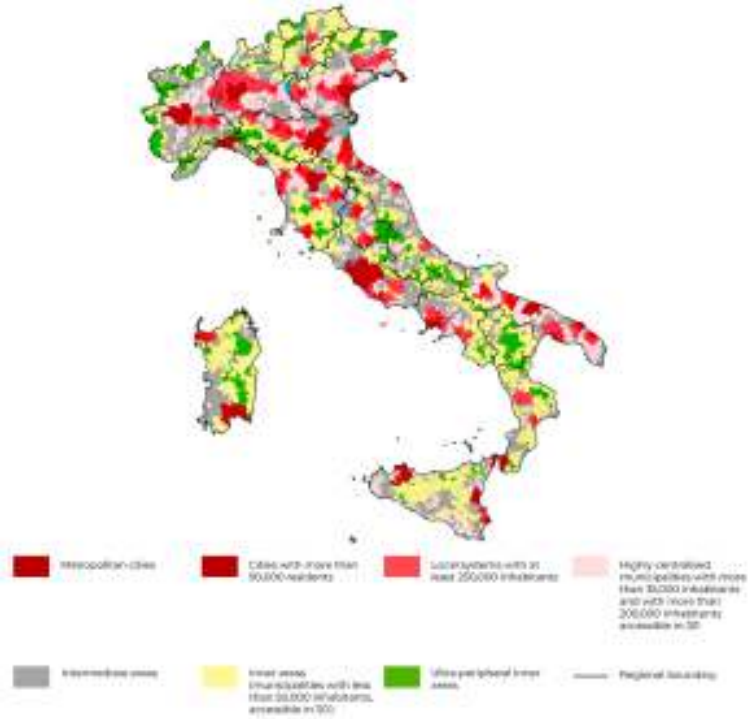

Figure 3 - Italian urban network and rural and peripheral areas; © Luisa Lombardo, 2023

2 Italy and regulations for the revitalization and enhancement of rural areas: an analysis and comparison of community cooperatives

The Community Cooperatives project was established in Italy in 2010 with the aim of promoting the growth of a widespread network of cooperatives that enhance local communities by stimulating the autonomy and organization of citizens (ISTAT, 2008). The project supports existing experiences in different parts of the country and promotes the birth and spread of this entrepreneurial model. In recent years, several factors have contributed to the emergence of community cooperatives, including the crisis of trust in politics and representative institutions, the economic crisis, the lack of essential services by the public sector, technological innovation, and a new civic protagonist (Leonardi A., 1996). These factors have led to a significant change in the socio-economic paradigm, and community cooperatives are one of the tools that the cooperative model offers citizens to address this change. They represent a fundamental shift in the mentality that is all too common in Italy, which sees "public goods" or "common goods" as "no one's goods."
Community cooperatives reclaim these "no one's goods" by giving them back to the community, enhancing them, and making them available for common use (Mannia, 2020). In Italy, there is still no single legal framework for community cooperatives, but many Italian

regions have passed laws and articles integrated into building regulations to promote their legal recognition. In fact, regional registers exist to promote their access to regional subsidies. Members of community cooperatives (Mastronardi et al., 2020) are residents, holders of property rights or real rights over real estate in the community, and those who carry out activities on a continuous or occasional basis. They can also be legal persons, third sector organizations, and public bodies. Each community must submit an annual report at the end of the year of activity to identify the benefits obtained and the utility of the activities carried out for the community.

It is a competitive model of social innovation in which citizens are producers and users of goods and services. It is a model that creates synergy and cohesion in a community by bringing together the activities of individual citizens, businesses, associations, and institutions, thus responding to multiple needs for mutuality. Community cooperatives are mainly born in inner rural areas at risk of progressive abandonment and urban areas where social cohesion is undermined by a modernity that impoverishes the context of relationships. They must have the explicit objective of producing benefits for the community to which the promoting members belong or which they elect as their own. This objective must be pursued through the production of goods and services that have a stable and lasting impact on the quality of the community's social and economic life. It is not the type of cooperative (labor, user, social, mixed, etc.) or the type of activity carried out that matters, but the objective of enhancing the community of reference. Community cooperatives usually involve several sectors, primarily tourism (60%), environmental conservation and protection (47%), and agriculture (38%), often related to natural and cultural heritage. Community cooperatives emphasize the centrality of human capital, which means setting up organizational and management models that favor participation and involvement. They are experiences that combine the themes and values of active citizenship, subsidiarity, management of common goods, and solidarity. Activities that generate a set of impacts on several spheres linked to common goods and the territory, for example through the creation and development of supply chains and economies of place not strictly linked to tourism (reported by 80% of realities) or to the regeneration of heritage (77%), but also to the wellbeing of territorial communities, especially in terms of sociality and community life. Cooperatives must be born in places of vulnerability and specific need and must have as their objective collective well-being and not profit maximization (Birchall, 2011). They are resilient communities where an economic and cultural fabric needs to be rebuilt. An organization at the service of an entire community whose priorities are linked to the territory, the local population, and the spirit of service to the community, that is why the purpose involves also the Madonie district.

When integrated into areas such as inner areas, it enhances the competitiveness of the area, brings the most disadvantaged areas back into vogue, constitutes virtuous examples of rural areas that have managed to withstand extreme conditions, and above all, eliminates the existing gap between urban and rural areas. At the same time, they constitute new forms of entrepreneurship, bringing together technicians, companies, associations, individuals, and even the public administration. Moreover, with their bottom-up approach, they encourage bottom-up input by fostering participatory processes and promoting a virtuous society with collaborating and cooperating citizens. They also stimulate the redevelopment of the built heritage by bringing it back to a contemporary condition, if they include technicians and businesses (Di Gesù, 2017).

Each community cooperative is unique and inimitable in its kind, in terms of size, objectives, and activities. This is because the peculiarities of each community are different and unique, as are the needs and ways of responding to those needs, which are rooted in the history and way of life of that specific community. There is no specific type of "community cooperative," and as such, it is not yet legally recognized (Borzaga, 2006). A national regulatory framework is lacking, while some regions have already regulated community cooperation. A community cooperative is a shared project conceived by all, or at least by many, that enhances and strengthens social capital by facilitating the coordinated action of individuals and establishing new relationships of trust and reciprocity. These relationships are not only established among members, but also between them and the citizens who are the recipients of the services and projects elaborated in the "community laboratory." In this laboratory, citizens/members together identify needs, elaborate ideas, and build a response path that is consistent with the available resources in human, financial, organizational, and institutional terms. In this context, the municipal administration must play a role of promotion and dissemination. It must provide, in compliance with current regulations, opportunities and resources, and thus foster an open and transparent horizontal subsidiarity governance process in which local social capital can unfold and contribute to change and improvement (Fici, 2013).
Setting up a community cooperative helps to create a stable coordination of the various possible activities of supportive citizenship. It can create new jobs over time, strengthen or reintroduce community services that are no longer sustainable today, especially in small municipalities. It can also enhance the role of volunteerism and time banks, and welcome the instances and creativity of women and young people and the experience of the elderly. In essence, it creates a community social enterprise. Above all, the cooperative has a social mission. This is to bring society into action with positive social outcomes aimed at change and the provision of goods and services, but also new employment opportunities at better conditions than the market.

There are 188 community cooperatives surveyed by Aiccon (Italian Association for the Promotion of Cooperative and Non-Profit Culture) on behalf of the School of Community Cooperatives, Legacoop Emilia-Romagna and Confcooperative Emilia-Romagna. Almost 2 out of 3 community cooperatives are located in an inner rural area, but there is also a significant share in peri-urban areas. In the three-year period 2018-2020, there has been a strong increase in the phenomenon, driven above all by specific territorial areas: Tuscany (45), Abruzzo (33), and Emilia-Romagna (20). Over the same period, more than half of the mapped cooperatives (57%) were born. The most widespread legal form is that of the production and work cooperative, and the presence of social cooperation is also significant. However, the community cooperative usually involves a plurality of sectors of intervention, first and foremost tourism, environmental conservation and protection, and agriculture, often connected with natural and cultural assets. These activities generate a set of impacts on multiple spheres linked to common goods and the territory. For example, they can create and develop supply chains and economies of place that are not strictly tourism-related (reported by 80% of realities), or regenerate heritage (77%). They can also contribute to the well-being of territorial communities, especially in terms of sociality and community life (Keillor, 2000). Thanks to the survey developed by the associations, it was possible to delve into some qualitative and quantitative aspects. The most widespread generative mechanisms are linked to the difficult conditions of the territories in terms of community needs and the vulnerabilities of the territorial context. The action of these organizations is characterized by the important involvement of a plurality of stakeholders: almost all the responding cooperatives involve the direct beneficiaries of the activities, as

well as members of the territorial community and public institutions. On average, each cooperative in 2019 managed to involve 14 stakeholders and more than 2,500 people belonging to the territorial community and beyond.

Many community cooperatives have sprung up in Italy in recent years. A feasibility study by Legacoop reports that many of them are spread across the country: "Valle dei Cavalieri" and "Briganti del Cerreto", in the Appennino Tosco Emiliano National Park (Emilia-Romagna), "L'innesto", in Cavallina Valley (Lombardy), and the "CC of Melpignano" (Puglia). These are some pilot examples and examples that are geographically "less accessible" as they are in internal territorial contexts. Over time, two experiences have been added in urban and metropolitan areas: the Cooperativa Anonima in Perugia (Umbria) and the Cooperativa sociale "La Paranza Onlus" in Naples (Campania). The constitutive procedure of these cooperatives took into consideration two main phases: The analysis of testimonies to identify the characteristics of the territories and The development of analyses for the construction of the feasibility study, considering variables, contingencies, and projections in the short, medium, and long term.
This was followed by a SWOT analysis: a business plan on par with a company to be set up from scratch.

2.1 Community Cooperative in Brigì, Mendatica (IM), Liguria

Figure 4 - Coop Brigì in Mendatica & Mendatica Municipality ©Legaliguria Coop, 2022

Founded in 2015 by two young men, driven by their love for their magnificent mountain territory and with the support of the municipality, the Community Cooperative (CC) was created for the inhabitants: sustainable tourism as a reactivator of local cycles, both economic and social, in a village of 150 inhabitants. Micro-entrepreneurship activities were created to create a real enterprise and bring out the full potential of projects from volunteering to work. The double catchment area present, tourists and the community, benefits from having a young and active entrepreneurial reality in the area, which bases its activity on the link with the territory. The cooperative's mission is to create an opportunity and a bet for the territory, exploiting sustainable tourism as a reactivator of local economic cycles and social relations. The objective: to enhance tourism with new jobs for local youth to promote outdoor activities, trips, adventure parks, and local products. The attempt is to bring together restaurateurs, hoteliers, private bus lines, municipalities, and local authorities. The main promotion strategy is to exploit the knowledge networks of members and their families and the use of social media. The CC also works on publicly funded local development projects such as: the construction of a small refuge in a

strategic area with respect to the main soft mobility routes; the creation of a coworking area, Internet access and a corner of local food and craft products; silvicultural interventions in the area and the restoration of forestation and trails for tourists and hikers. In addition, there are also projects for the recovery and cultivation of some local fruit trees, with an educational component on local crops that could involve schools and visitors. The creation of a station, an infrastructural centre for open-air tourism without ski lifts and therefore entirely sustainable, with hiking circuits, services, and various activities (guide office, snowshoe trails, freeride skiing with electric snowmobile ascent, e-bike trails, etc.), within which the operators involved, both public and private, would work together to manage a reception centre. The completion of the renovation of the "Ca' da Cardella" refuge. As regards the Park, its maintenance and the creation of adventure park routes and a play area with accessibility for the disabled, thematic routes and experiences related to disability, and a route for the blind. Educational and creative workshops in the mill, play activities with donkeys. Herd activities, seasonal adjustment, services for hikers.
These projects involve a total of 13 members, 14 employees, 6 collaborators, and around 5,000 visits per year between the various activities.

2.2 Community Cooperative Valle dei Cavalieri, Succiso, Reggio Emilia

Figure 5 - Valle dei Cavalieri CC; ©Valle dei Cavalieri, 2022

The Valle dei Cavalieri Cooperative was founded in 1991 after the last bar in the village of Succiso closed. In Italy, when a town loses its bar or shop, it is doomed to die, because it loses its sense of community. The pro loco association decided to set up the cooperative, which is named after the geographical area in which Succiso is located.
The initial project was the "Ventasso fishing experience", a regulated tourist fishing initiative that was entrusted to external associations in the area. The goal was to develop a close synergy between fishing and the tourism industry in the area. Fishing permits could be purchased at bars and tourist facilities in the reserve, and the proceeds would be used exclusively for environmental protection and upgrading actions, the repopulation of waterways, surveillance activities, and organizational expenses.
Succiso is located at the gateway to the Tuscan-Emilian Apennines. In 1950, the town had around 1,200 inhabitants, but after a series of landslides and the industrialization process that led people to emigrate to the cities, the population began to decline. In 1985, the school closed, and three years later, the last shop closed. By 1991, only a small bar run by two pensioners remained.

The Valle dei Cavalieri Cooperative was founded to revitalize the town. It opened a grocery store, a bar, a conference room, a farmhouse with 20 beds, and a restaurant, some of which were located in the old disused school. The cooperative also built a wellness center with changing rooms for outdoor activities and a multi-purpose synthetic sports field.
Over the years, the Valle dei Cavalieri Cooperative has promoted various agritourism and catering activities, and it has developed new tourist offerings in collaboration with the National Park of the Tuscan-Emilian Apennines. The cooperative offers environmental education projects and activities for children and young people, and it also offers projects to schools and families during the summer period.
The cooperative's farm produces PDO pecorino cheese, and the restaurant enhances the agri-food products of the territory within the National Park of the Tuscan-Emilian Apennines. The cooperative also promotes forms of tourism linked to the excellence of the territory. The cooperative has grown over the years, and it has purchased a minibus for transporting pupils, a new photovoltaic system, and a turnover of approximately €700,000. The cooperative has also invested €1.5 million, and it has 33 volunteer members, 7 permanent employees (over 10% of the population), and other seasonal employees.
The Valle dei Cavalieri Cooperative is a social enterprise that acts as a meeting and aggregation place for the community. It has also made it possible to set up a grocery store, providing a service for the elderly who would otherwise have to go shopping and face long and difficult journeys. The cooperative is a replicable and exportable model that has been analyzed by the United States, Canada, Japan, and Korea.

2.3 Community Cooperative in Melpignano, Lecce, Puglia

Figure 6 – Meeting of Melpignano CC; © Melpignano Community Cooperative, 2022

In the municipality of Melpignano, in the province of Lecce, a small town in the Griko region with less than 2,500 inhabitants, the CC “Cooperativa di Comunità” was born. It is the first experiment in Italy of a limited liability cooperative society, established by citizens-users-members to create a capillary network of photovoltaic systems on the roofs of houses, companies, and public buildings. The cooperative has installed 179.67 kW of photovoltaic systems on 33 solar plants, 29 of which are owned by the cooperative. This has met almost all the electricity needs of as many families and has avoided 118,892 kg of CO2 emissions and 336 kg of NOx emissions per year. The investment of around €400,000, made possible by a loan from Etica bank, has resulted in significant financial savings for families

and the development of a virtuous local economy thanks to the use of the community's human and professional resources, including engineers, electricians, and blacksmiths. First, a feasibility study showed that families in the small Salento municipality had a terrace suitable for the installation of a photovoltaic system. The CC then started working on other projects, again aimed at social and environmental sustainability. One of the most important projects is the installation of 54 drinking water supply systems, called Water Houses “Live the Water”, in 42 municipalities in the province of Lecce. These systems aim to enhance public water and reduce the consumption and impact of water distributed in plastic bottles. This activity provides permanent employment to two citizen-members, who take care of maintenance activities.

2.4 School of Community Cooperatives, Puglia

Figure 7 - Meeting of the Community Cooperative School in Italy; © CC School, 2021

In inner areas affected by population abandonment and the scarcity of services, and in cities where social cohesion is being tested by social, economic, and demographic phenomena, the need to create networks in which people are the protagonists of a rebirth of sociality and good living is becoming increasingly widespread. In many of these situations, these networks take the form of community cooperatives. To give strength and tools to these realities, the School of Community Cooperatives has been active for years. It is a real training school that focuses on the paradigm and practices of community cooperation as a tool to nurture new forms of mutualism and economies of place promoted by inhabitants. The conversations at the school focus on the experiences, learnings, and skills acquired over the years, with the intention of nurturing a circular reflection with the participants, who have always been co-protagonists and co-producers of this common training experience. Thanks to the multidisciplinary team that coordinates it and the numerous scientific and experiential testimonies it hosts, the school has become an eagerly awaited appointment for all those - cooperators, active members of small communities in inner and urban areas, social innovators, administrators, students, and researchers - who are committed to the construction, animation, and planning of community experiences on both the regional and national territory. The success of this experience, launched in 2014 on the initiative of Emilia-Romagna Confcooperative and

Legacoop, led the school to form a Network Contract in 2018, at national and international level, to promote community cooperation.

The School of Community Cooperatives, now in its fifth edition, is relaunching its social function in the face of the territory's and people's need to be responsive and enterprising at the same time. The aim of the project is to stimulate the promotion of cooperative start-ups, raise awareness in the territories and refine support tools, and to transmit experiences, acquire knowledge, identify, and confront new communities.

2.5 Community Cooperative "I Briganti di Cerreto", Benevento, Campania

Figure 8 – Men at work at Briganti del Cerreto CC; © I Briganti del Cerreto, 2022

The Cooperative "I Briganti di Cerreto" is based in Cerreto Alpi, in the municipality of Collagna, and was established in June 2003 by a group of young residents with the aim of redeveloping and implementing local activities for the benefit of the environment and the local community. The main objective was not to abandon the place where they were born and raised to find work, but to exploit all the potential of the mountain to continue to make it live and progress, in full respect of nature. The cooperative's initiatives, both those already implemented and those to be implemented, are strictly local in character and touch on a wide variety of sectors. These include: Care of greenery and the territory, Community tourism and school tourism, Marketing of products from the local area, Educational paths for schools and the general public on issues related to the territory, such as agriculture, forestry, nature, environment, history, and culture, Environmental services for monitoring and controlling the territory, Coordination and management of initiatives aimed at the management of accommodation, rooms, or other forms of tourist reception, Management of various services related to the territory, on behalf of entities or private individuals.
The cooperative is committed to promoting sustainable tourism and the development of the local economy, while also protecting the environment. It is a valuable asset for the community of Cerreto Alpi and the surrounding area.

2.6 Community Cooperative in Sciacca, Agrigento, Sicily

Figure 9 - Sician Community Cooperative in Sciacca WebPage; ©Community Cooperative Identity and Beauty, 2022

Recently, the Sicilian government passed a law that allows for the creation of community cooperatives. These cooperatives are a unique aggregation model that increases collaboration between citizens, creates new job opportunities, and promotes the rebirth of inner villages. The regulation defines community cooperatives as organizations that are not defined by a particular type of work, their specific users, or individual activities carried out. Instead, they are defined by the enhancement of the society to which the members belong, the skills of the resident population, cultural traditions, and territorial resources.
The goal of community cooperatives is to meet the needs of the local community by improving its social and economic quality of life. They do this by performing economic activities for sustainable development, such as the production of goods and services, the recovery of environmental and monumental assets, and the creation of job opportunities for the community itself. The new cooperation instrument is easily implemented in particularly disadvantaged contexts and can also avail itself of the support of many European funds. The Region of Sicily has already established a regional register of Community Cooperatives and their Consortia. These entities will be able to avail themselves of special support measures for the start-up of revitalization, redevelopment, and aggregation activities for the enhancement of local contexts. By bringing together the activities of individual citizens, enterprises, associations, and institutions, community cooperatives can respond to multiple local needs and at the same time promote the repopulation of inner areas. The Community Cooperative in Sciacca is a good example of this. It was established immediately after the Sicilian government's enactment and has been working to revitalize the town. The cooperative has created a cultural welfare experience called the "Sciacca 5 senses diffuse museum". This project has transformed the town into an open-air museum, with squares becoming exhibition halls, buildings becoming showcases, and streets becoming corridors connecting the rooms of the great museum. The Sciacca 5 senses diffuse museum offers more than 40 experiences of doing, such as creating one's own plate in the ceramics shop or one's own carnival mask in the small business that works with papier-mâché. These experiences guarantee visitors the discovery of the real archaic and rural Sicily.

Community cooperatives are a concrete realization of resilient communities that have managed to adapt to their precarious condition due to their remoteness from essential services. They are some virtuous examples that help the rest of Italy's inner areas to find effective strategies to activate the country's economy.

3 Approach to the methodology: analysis and comparison of Italian community cooperatives

This section presents the methodology adopted for the analysis and comparison of the community cooperatives. The analysis is based on a qualitative approach, using a case study design. The following steps were taken to carry out the analysis:

Selection of the cases: A total of four community cooperatives were selected for the analysis. The cooperatives were selected based on the following criteria:

- They are located in different rural areas in Italy.
- They operate in different sectors, such as agriculture, tourism, and culture.
- They have different levels of maturity and development.

Data collection: Data were collected through a variety of sources, including:

- Interviews with key stakeholders, such as members, managers, and local authorities.
- Document analysis, including statutes, financial statements, and project documents.
- Observation of the cooperatives' activities.

Data analysis: Data were analyzed using a thematic analysis approach. Thematic analysis is a qualitative data analysis method that involves the identification of themes or patterns in the data.

The analysis focused on the following dimensions:

The purpose and goals of the cooperatives: What are the cooperatives' objectives and how do they contribute to the revitalization and enhancement of rural areas?
The governance structure of the cooperatives: How are the cooperatives organized and managed?
The activities and services of the cooperatives: What activities do the cooperatives carry out and what are the benefits they provide to the community?
The challenges and opportunities facing the cooperatives: What are the challenges and opportunities that the cooperatives face in their efforts to achieve their objectives?

The analysis of the four cases revealed a number of similarities and differences. In terms of similarities, the cooperatives were all found to be committed to the revitalization and enhancement of their respective rural communities. They also all had a participatory and inclusive governance structure, with members playing a key role in decision-making.
In terms of differences, the cooperatives were found to have different objectives, activities, and challenges. For example, some cooperatives focused on the development of productive activities, while others focused on the promotion of tourism or culture. Some cooperatives faced challenges related to funding and resources, while others faced

challenges related to coordination and collaboration. The findings of the analysis suggest that community cooperatives can be a valuable tool for the revitalization and enhancement of rural areas. However, it is important to note that cooperatives are not a panacea. They face a number of challenges, and they need to be carefully designed and managed in order to be successful.

The following are some of the key recommendations that emerged from the analysis:

- Community cooperatives should be supported by public policies and programs;
- Community cooperatives should be provided with training and technical assistance;
- Community cooperatives should build strong partnerships with local stakeholders.

These recommendations are intended to help community cooperatives overcome the challenges they face and to achieve their full potential in revitalizing and enhancing rural areas.

4 Smart strategies for mountain villages & community Cooperatives for the rebirth of the Madonie Park

Sicily, together with the Madonie, needs to regain possession of its most authentic territorial portions, such as the small villages, and transform them, through a shared path, into social, cultural, environmental, economic, and human value, capable of making everyone grow, in a responsible and sustainable manner. From this moment on, we have one more concrete tool to do so. The experience of Sciacca and the existence of an all-Sicilian regional register of Community Cooperatives represents, today, a very important step forward towards not only innovation, but also the recognition of bottom-up forms of cooperation, whose centrality is the human being, social relations, and the skills of individuals recognized and reorganised so as to respond to needs in relation to welfare, sustainable development, and the improvement of the quality of life and the environmental, social and local context. This is a social innovation model that creates synergy and cohesion in a community, transforming citizens from residents to inhabitants, and systematizing the activities and skills of individuals to build shared responses to collective needs. It is a truly effective tool that, if applied in other contexts, such as that of the twenty-one villages of the Madonie inner area, enhances and strengthens social capital, facilitating coordinated action through which individuals, enterprises, associations, and local authorities can build effective and efficient responses to the needs of the community. These are shared and participatory paths that combine the most pressing issues and values of active citizenship, subsidiarity, management of common goods and solidarity. With the explicit objective of producing benefits for a community to which the promoting members belong or which they elect as their own, goods and services must have a stable and lasting impact on the quality of the community's social and economic life. It is therefore not the type of cooperative that matters, which may be labor, social, or mixed, or the type of activities carried out, but rather the purpose of enhancing the community of reference. The villages under study are all different from each other with unique and specific characteristics, and this important step could give an economic, and not only, breathing space to the area. Enhancing the centrality of human capital, encouraging participation and involvement: these are experiences that combine the issues and values of active citizenship, subsidiarity, and management of common goods. Each cooperative that could

be set up is unique and inimitable in its kind, in terms of size, objectives and activities, because different and unique are the peculiarities of the community, of the municipalities, different are the needs and the ways of responding, rooted in the history and ways of being of that specific community. This is a decidedly smart, innovative strategy, capable of transforming an entire area, creating new job opportunities, strengthening the concept of community, promoting the collaboration of people and professionalism in support of the territory, but above all in its own area. The Madonie, taking a cue from what has been done by Sciacca and other Italian villages, but above all by collaborating and networking with all twenty-one of them, could absolutely benefit and be competitive by implementing a plurality of community cooperatives scattered throughout the territory in which there is art, culture, tradition, history, food, ancient knowledge and trades, nature, native products, architecture and much more to be spent and re-proposed in an innovative way by exploiting this new aggregative characteristic.

It is well known that for several years countless young people have abandoned their land in search of work elsewhere, if not even in Northern Italy; this strategy, on the contrary, could slow down the exodus trend by promoting the possibility of returning to “Live in the South” by cultivating territorial values and mobilising the return to home, repopulating the inner areas of Sicily, of the South for an advantageous transition. An intelligent minor centre is one that makes the best of itself and makes use of innovation but preserves and promotes the authentic value of tradition. This is the new objective we must set ourselves and it is precisely these new villages of tomorrow, in transition, that we must encourage.

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References

Anselmi, F.A. (2014). Banks and Territory: Investigation in Knowledge and Building New Relationships between Territorial Banks and Local Actors. In Uscire della crisi. Città, Comunità e Specializzazioni Intelligenti (pp. 1-20).

Arminio F., (2011), Terracarne. Viaggio nei paesi invisibili e nei paesi giganti del Sud Italia. Mondadori, Milano, ISBN: 9788804613138.

Bianchi M. (2020), A Critical Analysis of Italian Community Cooperatives: a Qualitative Research through Social Capital Theories for Investigating Territorial Connections and Community Development Processes, Università degli Studi di Urbino.

Beecher J. (1986), Charles Fourier: The Visionary and his World, University of California Press, Berkeley.

Birchall J. (2011), People-Centred Businesses - Co-operatives, Mutuals and the Idea of Membership, Palgrave Macmil-lan, Basingstoke.

Borzaga C., Defourny J. (a cura di) (2001), The Emergence of Social Enterprise, Routledge, London-New York.

Borzaga C., Ianes A. (2006), L’economia della solidarietà, Donzelli Editore, Roma.

Chaddad R.F., Cook M.L. (2004), “Understanding New Cooperative Models: An Ownership-Control Rights”, Review of Agricultural Economics, 26, pp. 348-360.

Cole G.D.H. (1944), A Century of Co-operation, George Allen & Unwin, Londra.

Cooperatives UK (2009), Simply Legal - All you Need to Know about Legal Forms and Organisational Types for Com- munity Enterprises, Manchester.
Corrigan P., Parston G., Steele J. (2001), The Case for the Public Interest Company - A New Form of Enterprise for Public Service Delivery, Public Management Foundation (PMF), Londra.
Di Gesù (2017), Studio di ricerca sulla sostenibilitá economica della cooperativa di comunitá: Inquadramento ed analisi empirica delle principali realtá italiane, Universitá degli Studi di Trento, Dipartimento di economia e management, Corso di laurea magistrale in management.
Fici A. (2013), "Cooperative Identity and the Law", European Business Law Review, 24, pp. 37-64.
Gide C. (1922), Consumers' Co-Operative Societies, Alfred Knopf, New York (trad. Les sociétés coopératives de con- summation, L. Tenin, Paris, 1917).
Hoffman S.M., High-Pippert A. (2010), "From Private Lives to Collective Action: Recruitment and Participation Incentives for a Community Energy Program", Energy Policy, 38, pp. 7567-7574.
Holyoake G.J. (1893), The History of the Rochdale Pioneers, Swan Sonnenschein & Co, Londra (1st ed. 1857).
ISTAT (2008), Le cooperative sociali in Italia - Anno 2005, Roma.
Keillor S.J. (2000), Cooperative Commonwealth: Co-Ops in Rural Minnesota 1859-1939, Minnesota Historical Society Press, St. Paul.
Leonardi A. (1996), "L'area trentino-tirolese, la regione a più forte sviluppo cooperativo d'Europa", in Zaninelli S. (a cura di), Mezzo secolo di ricerca storica sulla cooperazione bianca: risultati e prospettive, Società Cattolica di Assicurazione, Verona.
Mannia (2020). Identità e territori, abbandoni e ritorni. In M. Pinna (a cura di), L'Europa delle particolarità. L'identità del territorio come principio di autodeterminazione (pp. 63-86). Sassari: EDES.
Mastronardi L., Romagnoli L. (2020) Metodologie, percorsi operativi e strumenti per lo sviluppo delle cooperative di comunità nelle aree interne italiane. Firenze UniversityPress, EAN: 9788855181679.
Matthies A.-L. (a cura di) (2006), Nordic Civic Society Organizations and the Future of Welfare Services. A Model for Europe?, Nordic Council of Ministers, Copenhagen, TemaNord 517.
Mori P. A. (2013), "Customer Ownership of Public Utilities: New Wine in Old Bottles", Journal of Entrepreneurial and Organizational Diversity, 2, pp. 54-74.
Pestoff V. (2009), "Towards a Paradigm of Democratic Participation: Citizen Participation and Co-production of Personal Social Services in Sweden", Annals of Public and Cooperative Economics, 80, pp. 197-224.
Spinicci F. (2011a), Le cooperative di utenza in Italia e in Europa, Euricse, Trento. http://euricse.eu/it/node/1615.
Spinicci F. (2011b), La cooperazione di utenza in Italia: casi studio, Euricse, Trento. http://www.euricse.eu/it/ node/1894.
Van Gyes G., Vael V., Vandekerckhove S. (2009), "Liberalising Services of General Economic Interest: The Citi- zen-user Perspective in Six EU Countries", Pique Policy Report no. 5, Leuven.
Wales Co-operative Centre (2012), Community Co-operatives in Wales, Cardiff.
Woeste V. S. (2003), "Cooperative Agriculture and Farmer Cooperatives", in Mokyr J. (a cura di), Oxford Encyclopedia of Economic History, Oxford University Press, Oxford.
ISTAT (2016), bes 2016. IL BENESSERE EQUO E SOSTENIBILE IN ITALIA. Istituto nazionale di statistica Via Cesare Balbo, 16 – Roma, ISBN: 978-88-458-1917-9.
Web, EURICSE - Libro bianco. La cooperazione di comunità. Azioni e politiche per consolidare le pratiche e sbloccare il potenziale di imprenditoria comunitaria (2016), https://euricse.eu/wp-content/uploads/2016/05/Libro-Bianco.pdf (accessed 11 June 2023).
Web, EURICSE - Research Report (2015), "ECONOMIA COOPERATIVA. Rilevanza, evoluzione e nuove frontiere della cooperazione italiana" www.euricse.eu (accessed 12 June 2023).
Web, EURICSE - Research Report (2020), "IMPRESE DI COMUNITÀ E BENI COMUNI. Un fenomeno in evoluzione" https://euricse.eu/wp-content/uploads/2020/05/Rapporto_Imprese-Comunita%CC%80-e-beni-comuni.-Un-fenomeno-in-evoluzione_def.pdf (accessed 11 June 2023)
Web, Legacoop, https://www.legacoop.coop/cooperativedicomunita/cosa-sono/ (accessed 11 June 2023)

SUSTAINABLE ENERGY MANAGEMENT AND MICROGRIDS IN SMART VILLAGES

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Abstract: *This conference paper explores the concept of smart villages as a transformative solution to bridge the rural-urban gap, improve living conditions, and foster sustainable development in peripheral areas. Smart villages, inspired by smart cities, aim to leverage digitalization and Information and Communication Technologies (ICTs) to address challenges in accessing essential services like healthcare, education, and transportation. By integrating renewable energy sources and microgrids, smart villages can ensure reliable, affordable, and clean energy access, reducing carbon emissions and promoting energy independence. This contributes to environmental sustainability, economic growth, and social well-being. Successful smart village initiatives from countries like Germany, India, and Alaska demonstrate the transformative power of renewable energy and technology-driven solutions in empowering rural communities. The paper emphasizes the need for a holistic approach to smart village development, encompassing strategic planning, information systems, social services, and economic activities. The United Nations' Sustainable Development Goals (SDGs) provide a framework for guiding smart village initiatives, aligning with global efforts to achieve balanced economic growth, social inclusivity, and environmental protection. Supportive policies, adequate financing, technical expertise, and community engagement are crucial for fully embracing smart village models. By embracing smart villages, rural communities can thrive, fostering sustainable development and bridging the gap with urban areas.*

Keywords: *Smart Village, ICT, Smart Microgrids, SDG's, Sustainable Energy.*

1 Introduction

Many people still live in rural areas all over the world in addition to the general trend of migration to metropolitan areas. This percentage represents 29% of the total population of the European Union (EU), according to EUROSTAT and data from 2020 (Eurostat, 2020). However, these regions lag behind or don't offer as many services of broad interest as urban areas do, including those related to health, education, and transportation (Prinsloo, G., Dobson, R., & Mammoli, A. 2017). A smart city is an urban living environment that has been constructed, rebuilt, or refurbished (Glasmeier, A., & Christopherson, S. 2015) to provide the best coordination for otherwise disjointed urban sub-systems, to simplify daily life for residents, and to make cities more sustainable and livable (European Comission) .The idea of "smart" development's use in rural areas has gradually drawn more attention. People have high hopes for the sustainable development of rural areas through the smart village project and practice, even if smart villages and their methods have gotten less attention than smart cities (Adamowicz, M., & Zwolińska-Ligaj, M. 2020) Today's rural-urban divide is more apparent than ever, and people still find country living unappealing, particularly the younger generations. The goal of research on "smart villages" is to identify the issues and problems that rural residents face on a daily basis, address these issues, and come up with a solution by utilizing the benefits of digitization and information and communication technologies (ICTs) (Visvizi, A., & Lytras, M. D. 2018) ICT is a generic term that encompasses a wide spectrum of technology, from the very basic—like phone text messaging services—to the highly sophisticated, like cutting-edge software solutions (George, T. 2011). According to Cohen's extremely broad definition, "smart villages use information and communication technologies (ICT) to be more intelligent and efficient in the use of resources, resulting in cost and energy savings, improved service delivery and quality of life, and reduced environmental footprint—all supporting innovation and the low-carbon economy" (Hayat, P. 2016) (p. 178). The notion of the smart village dates back to the middle of the previous decade, when T. van Gevelt and J. Holmes (Van Gevelt, T., & Holmes, J. 2015) offered a vision of smart rural communities on the basis of initiatives already taken in this field in Africa and Asia. The two polarized frames of rural and urban are scarcely strictly separated in the so-called smart development of infrastructure. In the case of Indian smart growth, as Srivatsa (Srivatsa, P. 2015) brilliantly describes, it is vital to take into account both areas at once, their mutual interconnections, and take into account that significant changes in one will affect the other and vice versa. More than 70% of the population in India lives in villages, which significantly contributes to development. With the support of contemporary energy services, the Indian government has introduced the Smart Village concept to improve village living. This initiative aims to elevate people out of rural poverty from the ground up. On the other hand, the Indian government is supporting solar energy to meet current and future power demand. The controlling pillar for the nation's development is the electrification of rural areas (Singh, K, 2017).

2 Elements and Subsystems of Smart Village Systems: A Framework for Sustainable Development

In general, the three subsystems are: the resource and environment subsystem, the economy subsystem, and the social subsystem make up the rural system from an element-structure-function perspective (Fang, F., 2014). First off, the strategic subsystem is a crucial component for the development of "smart" village systems as well as a crucial

component of the long-term sustainability of smart villages. Some writers have claimed that in the study of smart cities, a holistic and all-encompassing framework is required in order to comprehend the various elements of a smart city and to outline the strategic actions to be taken. For a city to become a smart city, a comprehensive plan is required (Soumaya, B.L. 2015). Secondly, in the smart village system, the information subsystem is equally crucial. The ability of ICT solutions to completely support the sustainable development of the villages is what distinguishes smart villages from non-smart villages. The strategic subsystem is a group of connected planning, including the strategic vision, objectives, tasks, and execution strategies for the planning and construction of smart villages. The strategic planning for the construction of smart villages primarily reflects it. The social subsystem is made up of a variety of digital and intelligent operations that are displayed by various village government and ICT-influenced activities. It is mostly manifested in rural smart service applications such e-government, smart security, smart healthcare, smart finance, smart elder services, and smart education. The economic subsystem is made up of diverse rural production activities influenced by ICT that present a collection of digital and intelligent operations. It mostly manifests in smart rural tourism, smart rural e-commerce, and smart rural agriculture. The operation and growth of smart villages are supported by a variety of natural resources, including land, water, plants, etc., as well as the ecological environment that is created as a result of these resources' interactions. Information technology, information infrastructure, and public information platforms are the primary components of the information subsystem. Information technology comprises areas including perception, communication, networking, application, and information security, among others (Zhang, X., & Zhang, Z. 2020).

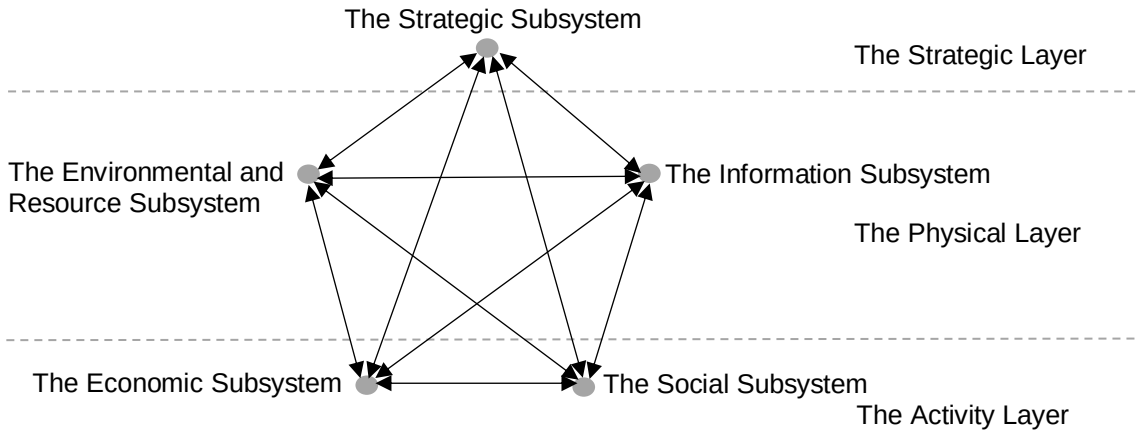

Figure 1: The Conceptual framework of smart village systems (Zhang, X., & Zhang, Z. 2020).

The employment of a series of measures aimed at meeting the fundamental requirements of a given population or society while protecting natural resources for future generations can be characterized as sustainable development (Czudec, A., Miś, T., & Zając, D. 2018).The term "sustainability" originally meant the necessity to conserve environmental resources, but over time it came to represent unending, neo-liberal, durable development based on economic expansion with few restrictions on the exploitation of natural resources (Lisocka-Jaegermann, B. 2015). The idea of sustainable development specifically relates to rural areas, which unquestionably make up the majority of Poland's land area, as well as to natural economic sectors like agriculture, forestry, fishing, and mining that are

situated in those areas. Rural development was once thought of as almost exclusively referring to agricultural development because rural regions were long thought to be centers of agro-food production. During the post-war era, the idea of rural development in Europe evolved. The agro-industrial model, the post-productivist model, and the emerging, sustainable rural development model, in which rural sustainability is gaining in importance, are the three models of rural development dynamics that T. Marsden examines (Marsden, T. 2003). Renewable and non-renewable resources can both be used to generate energy. Solar, wind, biomass, hydropower, geothermal, and hydrogen are examples of renewable energy sources, whereas coal, diesel, nuclear power, natural gas, and oil are examples of non-renewable energy sources (Longe, O. M., Oluwajobi, F. I., & Omowole, F. 2013). As a result of worries about environmental changes brought on by global warming, there is a rising demand for energy produced by renewable resources including solar, wind, and biomass (Buchana, P., & Ustun, T. S. 2015). The proportion of renewable energy in the mix used to generate power needs to be steadily increased in order to ensure universal access to electricity and minimize emissions of CO2 and other greenhouse gases (Longe, O. M., Oluwajobi, F. I., & Omowole, F. 2013). Increased energy demand and a growing proportion of RS in the generation mix have led to problems that power engineers were previously unaware of (Ustun, T. S., Ozansoy, C., & Zayegh, A. 2011). Because of its ambiguity, the fundamental idea behind sustainable development and sustainability is sometimes criticized as being chaotic, meaning both everything and nothing, and being used to justify virtually anything (Shucksmith, M., & Ronningen, K. 2011). The idea of sustainability has been more easily accepted across ideological, national, and cultural divisions and in a variety of scientific fields, economic sectors, and societal settings due to the vagueness of its definitions, their integrative nature, and its holistic nature (Bowler, I. R., Bryant, C. R., & Coclin, C. (Eds.). 2002).

3 Sustainable Development Goals and Strategies for Rural Sustainability

The necessity of sustainable development is mentioned in documents and strategies of the United Nations (Agenda 21) and its specialized organizations, such as the Food and Agriculture Organization (FAO), the Organization for Economic Cooperation and Development, the Council of Europe, treaties governing the functioning of the European Union (The Maastricht Treaty, The Treaty of Amsterdam), and strategies formulated on their basis, such as the Lisbon Strategy, Europe 2020, and other documents and strategies (Adamowicz, M., & Zwolińska-Ligaj, M. 2020). In order to secure global economic and social progress, protect the environment, and solidify peace, more than 190 nations acting within the framework of the United Nations committed to achieving 17 sustainable development goals (SDGs) in 2015 (Adamowicz, M., & Zwolińska-Ligaj, M. 2020)(United Nations General Assembly. 2015). This activity, which aims to serve the aforementioned objectives, invariably includes a significant portion focused on rural sustainability and smart rural development. The 17 SDGs listed in Table 1 are intended to address the complex social, political, economic, and environmental issues that face individuals, organizations, and governments today (Garcia-Feijoo, M., Eizaguirre, A., & Rica-Aspiunza, A. 2020). The European Union's 2001 and 2006 strategies for sustainable development placed a strong emphasis on tackling climate change while also highlighting the importance of protecting the environment, promoting sustainable production, preventing social exclusion, and addressing a number of demographic issues (European Commission. 2010).

Table 1. Seventeen sustainable development goals of the UN (United Nations General Assembly. 2015).

1. No poverty	2.Zero hunger	3.Good health and well-being	4.Quality Education	5. Gender Equality	6. Clean water and Sanitation
7. Affordable and clean energy	8. Decent work and economic growth	9. Industry innovation, and infrastructure	10. Reduce inequalities	11. Sustainable cities and communities	12. Responsible consumption and production
13. Climate action	14. Life below water	15. Life on land	16. Peace, justice and strong institutions	17. Partnerships for goals	

By supplying clean, dependable, and inexpensive energy, renewable energy sources are essential to the development of smart villages. They support energy independence, sustainable development, and the reduction of carbon emissions.

- Using renewable energy sources like solar, wind, hydro, and biomass results in a large reduction in carbon emissions because they don't produce any greenhouse gases while they're in use. The International Renewable Energy Agency (IRENA) estimates that increasing the proportion of renewable energy sources in the world's energy mix to 36% by 2030 could cut carbon emissions by as much as 8.6 gigatonnes annually (International Renewable Energy Agency (IRENA). 2016).
- Promoting Energy Independence: The availability of renewable energy sources locally lessens reliance on imported fossil fuels. This improves energy security and keeps money spent on energy in the community's economy. For instance, the Smart Village initiative in India was started by the government with the goal of achieving energy independence by using solar energy to meet all of the rural areas' energy needs.
- Fostering Sustainable Development: By supplying energy for lighting, heating, cooking, and other needs in rural regions, renewable energy sources can also promote sustainable development. In addition to raising living standards, this can lower health risks, produce employment, and advance social and economic growth. In response to the considerable energy issues that developing countries confront, renewable energy technology can offer a cheap and dependable answer (Walton, T., et al. 2017).
- Enhancing Grid Stability: By enabling decentralized power generation, renewable energy sources can potentially improve grid stability. This can lower transmission losses, boost energy effectiveness, and increase the energy system's shock resistance. As an illustration, the German community of Wildpoldsried generates more than 500% of its energy from renewable sources, making it both energy independent and a net energy exporter (Deutsche Welle (DW). 2015).

4 Microgrids: Empowering Rural Areas with Reliable and Resilient Energy Solutions

Post-development economics are the origin of centralized grid-based rural electrification worldwide. A precondition for an industrial revolution is the accessibility of uninterrupted and affordable power as part of the import substitution industrialization development plan (IBRD, 1962). This viewpoint claims that the failure to provide power to rural areas jeopardizes prospective development initiatives. The creation of employment prospects in developing nations depends on significant investments in developing rural infrastructure (Mellor, J 1962). Renewable energy-powered microgrids are regarded as the best technology option for supplying electricity to isolated rural locations (Stevens, L. 2016)(PwC 2016). Localized grids known as microgrid systems can run separately from or in cooperation with the main grid. Particularly in rural locations where access to the main grid may be constrained or unreliable, they are intended to deliver electricity with stability and resilience. A microgrid system typically consists of a mix of loads (the structures or machinery that use the energy), energy sources (often renewable), and energy storage technologies like batteries. The system is controlled by a central management system that balances the supply and demand of energy, ensuring that the microgrid can function efficiently and reliably. The design of a microgrid system depends on various factors, including the available energy resources, community energy needs, and existing infrastructure (National Renewable Energy Laboratory NREL). Microgrids can be operated in offgrid, on-grid or dual-mode depending on factors such as energy sources and the required local load to be met. A microgrid sketch is shown in Fig. 2 with a generation mix of both renewable sources (solar, wind, hydropower and biomass) and a non-renewable source (diesel generator plant) with energy storage (Longe, O. M., Oluwajobi, F. I., & Omowole, F. 2013).

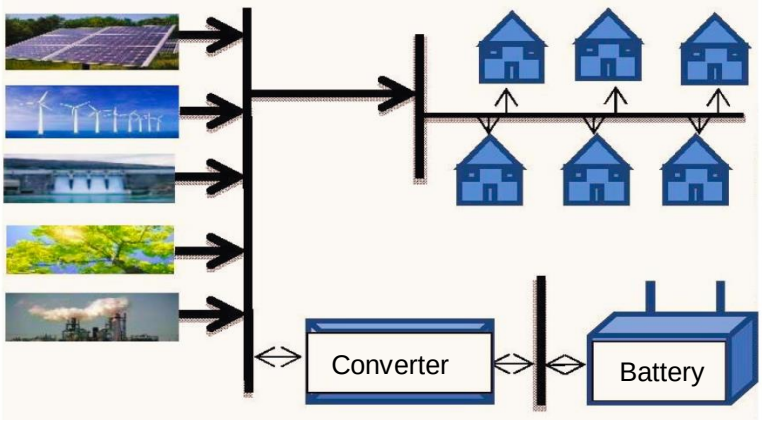

Figure 2: A Layout of Microgrid (Longe, O. M., Oluwajobi, F. I., & Omowole, F. 2013).

The microgrid is gaining prominence as a substitute for the existing energy supply system, harnessing distributed energy resources (DER) it offers a localized energy solution.. The distributed energy resources (DERs) encompass energy generation systems, energy storage, load management choices, and energy generation units that are typically situated in close proximity to the end users. (Mallikarjun, S., & Lewis, H. F. 2014). Designers of distributed energy microgrids (DEMs) encounter a significant hurdle in dealing with the intermittent and unpredictable nature of renewable sources (Lund, H 2015)(Jung, J., & Villaran, M. 2017). This challenge is further complicated by variations in domestic energy consumption patterns, such as daily, weekly, and seasonal fluctuations, which make it

difficult to balance local supply and demand (Amini, M.H. 2017). Microgrid systems offer the potential to enhance energy dependability and resilience in rural areas by ensuring a steady and uninterrupted energy provision, even in the face of disruptions to the main power grid. They possess the ability to adapt to changes in energy demand and supply, swiftly recover from power failures, and are capable of maintaining a reliable power supply. For example, in Alaska, microgrids have been successfully implemented in remote communities, utilizing a combination of renewable energy sources and energy storage systems, thereby ensuring a reliable and resilient power source (Holdmann, G., Wies, R., & Vandermeer, J. 2019). This innovative concept revolves around harnessing energy from diverse non-traditional sources and establishing a localized power generation system tailored to meet the specific energy requirements of a village, resulting in the creation of a compact power grid known as a microgrid, as illustrated in Figure 3. The microgrid is poised to play a pivotal role in meeting future power demands in India and represents a transformative solution for addressing the country's growing energy needs, acting as a catalyst for rural development. The Photo-Voltaic (PV) microgrid is particularly noteworthy, as it combines loads and distributed generators within the same cluster, functioning as a unified and controllable system. By enhancing the reliability and efficiency of the power system, the microgrid brings about both environmental and economic benefits. However, certain challenges persist, including the need for improved Power Management, Power Quality, active and reactive power flow control, and fault ride-through capabilities (Singh, K., Mishra, S., & Kumar, M. N. 2017).

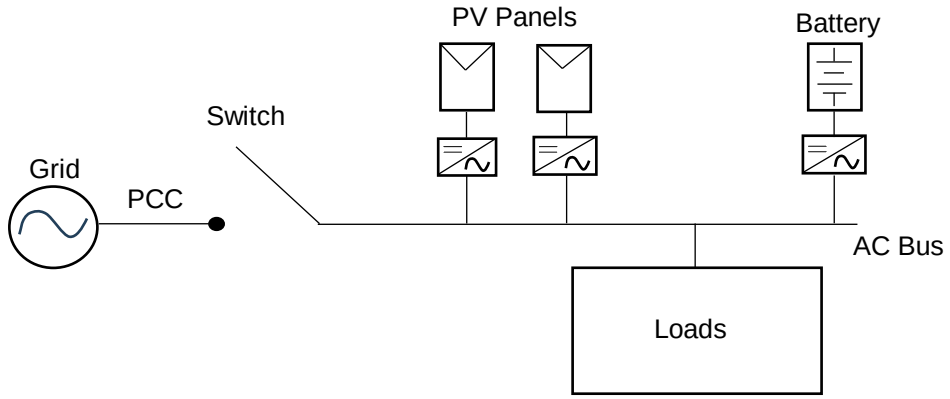

Figure 3. PV Microgrid integration in rural smart villages(Singh, K., Mishra, S., & Kumar, M. N. 2017).

5 Smart Grid Technologies for Efficient Energy Management and Renewable Integration

As microgrids serve as vital contributors to localized, dependable, and resilient energy solutions, their integration into a larger, interconnected, and intelligent energy infrastructure, commonly known as a smart grid, has become increasingly imperative for various reasons. Smart grid systems utilize digital technology to optimize the production and distribution of electricity, minimizing energy waste and improving the overall efficiency of the system. This advancement has the potential to generate significant cost savings for both utilities and consumers (The Smart Grid: An Introduction). The implementation of smart grid technologies plays a crucial role in optimizing energy management and

distribution within smart villages, leading to notable improvements in the efficiency, reliability, and sustainability of the energy system. Advanced Metering Infrastructure (AMI) incorporates smart meters that accurately record real-time energy consumption and communicate this data to the utility for monitoring and billing purposes. This enables more precise energy usage information, facilitating better demand forecasting and more efficient energy distribution. Additionally, consumers can monitor their own energy usage and make informed decisions regarding energy conservation (Overview and Benefits of Advanced Metering Infrastructure). Smart grid technologies also facilitate the integration of renewable energy sources by effectively managing the variability of renewable energy generation, supporting the operation of microgrids, and facilitating the participation of distributed energy resources in the energy market (Community Energy: Challenges and Opportunities).

Significant progress has been made in the implementation of the Smart Villages concept across Europe, with countries actively translating this concept into practical applications. Noteworthy examples can be observed in various countries, including Slovenia, the Czech Republic, Germany, France, Finland, Italy, as well as globally in places like Indonesia, Korea, Ghana, India, and East Africa (Stojanova, S., et al. 2021). Communities worldwide have effectively implemented smart village initiatives with remarkable success. For instance, the village of Wildpoldsried in Germany has achieved energy self-sufficiency by generating over 500% of its energy requirements from renewable sources like wind, solar, and biomass (Deutsche Welle (DW). 2015). In India, the government's Smart Village initiative has leveraged solar power to fulfill the energy needs of rural areas, fostering energy independence (Government of India. 2016). Similarly, in Alaska, microgrids have been employed to provide reliable and resilient power to remote communities by combining renewable energy sources and energy storage systems. These microgrids can operate in both grid-connected and islanded modes, bolstering energy security. They have significantly reduced diesel consumption for power generation, leading to environmental and economic advantages, with some villages achieving up to a 90% decrease (Alaska Energy Authority. 2018). The Smart Village Program in India aims to establish model villages that integrate sustainable energy solutions and infrastructure, ultimately enhancing the quality of life in rural areas. Through this program, villages receive access to solar-powered lighting, clean cooking facilities, digital connectivity, and essential infrastructure, leading to positive impacts. Currently, the program has reached more than 100 villages, benefiting over 50,000 households (Government of India. 2016). These instances highlight the immense potential of smart villages in fostering sustainable, low-carbon, and energy-independent communities. However, realizing this potential necessitates supportive policies, adequate funding, technical expertise, and active community participation. With the increasing affordability of renewable energy technologies and energy storage solutions, smart villages can gain reliable and cost-effective access to clean energy, consequently improving living standards and driving sustainable development.

6 Conclusion

The global shift towards urbanization has resulted in an evident disparity between rural and urban development, leaving individuals in peripheral regions facing difficulties in accessing essential services such as healthcare, education, and transportation. While smart cities have gained significant attention, the concept of smart villages has received comparatively less focus. Smart villages strive to enhance the quality of life in rural areas through the integration of digitalization and Information and Communication Technologies

(ICTs). By leveraging the capabilities of ICTs, smart villages can accomplish intelligent resource management, cost and energy savings, enhanced service delivery, and minimized environmental impact. Through the adoption of renewable energy sources and microgrid systems, smart villages can reinforce energy reliability, promote energy self-sufficiency, and contribute to sustainable development. The Sustainable Development Goals (SDGs) outlined by the United Nations emphasize the significance of balanced economic growth, social inclusivity, and environmental preservation, all of which align with the objectives of smart villages. The shift towards a smart village model corresponds to these objectives by enabling the delivery of vital services, renewable energy generation, and economic progress in rural regions. Across the globe, successful implementation of smart village initiatives has been evident, with notable illustrations from countries like Germany, India, and Alaska, demonstrating accomplishments such as energy independence, diminished carbon emissions, and enhanced living standards. However, the realization of the complete potential of smart villages necessitates supportive policies, sufficient funding, technical proficiency, and active community engagement.

References

Amini, M. H., Moghaddam, M. P., & Karabasoglu, O. (2017). Simultaneous allocation of electric vehicles parking lots and distributed renewable resources in smart power distribution networks. Sustainable Cities and Society, 28, 332-342.
Buchana, P., & Ustun, T. S. (2015). The Role of Microgrids & Renewable Energy in Addressing Sub-Saharan Africa's Current and Future Energy Needs. In IEEE International Renewable Energy Congress (IREC).
Fang, F., Liu, Y., Li, Y., & Liang, H. (2014). Impact of land conversion on rural systems in typical agricultural counties of eastern plain area in China. Progress in Geography, 33, 1405-1413.
George, T., Bagazonzya, H., Ballantyne, P., Belden, C., Birner, R., Castello, R. D., & Edge, P. (2011). ICT in agriculture: Connecting smallholders to knowledge, networks, and institutions. World Bank, 64605, 1-428.
Jung, J., & Villaran, M. (2017). Optimal planning and design of hybrid renewable energy systems for microgrids. Renewable and Sustainable Energy Reviews, 75, 180-191.
Longe, O. M., Oluwajobi, F. I., & Omowole, F. (2013). Electricity access in Sub-Saharan Africa—Case for renewable energy sources microgrid. In IEEE International Conference on Emerging & Sustainable Technologies for Power & ICT in a Developing Society (NIGERCON).
Mellor, J. (1976). The New Economics: A Strategy for India and the Developing World.
Prinsloo, G., Dobson, R., & Mammoli, A. (2017). Smart village load planning simulations in support of digital energy management for off-grid rural community microgrids. Current Alternative Energy, 12, 1-22.
Shucksmith, M., & Ronningen, K. (2011). The uplands after neoliberalism? The role of small farms in rural sustainability. Journal of Rural Studies, 27, 275-287.
Singh, K., Mishra, S., & Kumar, M. N. (2017). A Review on Power Management and Power Quality for Islanded PV Microgrid in Smart Village. Indian Journal of Science and Technology, 10(2), 1-4.
Stevens, L., Wilcox, M., Leopold, A., Taylor, C., & Waters, L. (2016). Poor People's Energy Outlook 2016. Practical Action Publishing Ltd.
Ustun, T. S., Ozansoy, C., & Zayegh, A. (2011). Recent developments in microgrids and example cases around the world-A review. Renewable and Sustainable Energy Reviews, 15(8), 4030-4041.
van Gevelt, T., & Holmes, J. (2015). A Vision for Smart Villages. Retrieved from https://e4sv.org/wp-content/uploads/2015/08/05-Brief.pdf

Visvizi, A., & Lytras, M. D. (2018). It's not a fad: Smart cities and smart villages research in European and global contexts. Sustainability, 10, 2727.
Zhang, X., & Zhang, Z. (2020). How do smart villages become a way to achieve sustainable development in rural areas? Smart village planning and practices in China. Sustainability, 12(24), 10510.
“Germany’s Renewable Village – DW – 05/28/2015.” dw.com, www.dw.com/en/feldheim-germanys-renewable-village/a-18466800.
“Overview and Benefits of Advanced Metering Infrastructure.” Overview and Benefits of Advanced Metering Infrastructure - Los Alamos County, www.losalamosnm.us/government/departments/utilities/meters___billing/overview_benefits_of_AMI.
“Renewable Energy Benefits Measuring the Economics,.” Renewable Energy Benefits Measuring the Economics, 1 Jan. 2016, www.irena.org/publications/2016/Jan/Renewable-Energy-Benefits-Measuring-the-Economics.
European Commission. (n.d.). About the Smart Cities Information System. Retrieved from https://smartcities-infosystem.eu/content/about-smart-cities-information-system-scis
European Commission. (2010). Europa 2020: A Strategy for Smart, Sustainable and Inclusive Growth. Communication from the Commission.
Eurostat. (2020). Urban and Rural Living in the EU. Retrieved from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-2020-0207-1
Government of India. (2016). Smart Village: Transforming Rural India.
Hayat, P. (2016). Smart Cities: A Global Perspective. India Quarterly, 72, 177-191.
IBRD. (1962). The Economic Development of Uganda.
International Renewable Energy Agency (IRENA). (2016). Renewable Energy Benefits Measuring the Economics.
PwC. (2016). Electricity beyond the grid: Accelerating access to sustainable power for all. PriceWaterhouse Coopers Global Power and Utilities Report.
Soumaya, B. L. (2015). How to strategize smart cities: Revealing the SMART model. Journal of Business Research, 68, 1414-1419.
United Nations General Assembly. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld
Walton, T., et al. (2017). Private Provision of Education: Opportunities for Emerging Markets.
“Germany’s Renewable Village – DW – 05/28/2015.” dw.com, www.dw.com/en/feldheim-germanys-renewable-village/a-18466800.
“Overview and Benefits of Advanced Metering Infrastructure.” Overview and Benefits of Advanced Metering Infrastructure - Los Alamos County, www.losalamosnm.us/government/departments/utilities/meters___billing/overview_benefits_of_AMI.
“Renewable Energy Benefits Measuring the Economics,.” Renewable Energy Benefits Measuring the Economics, 1 Jan. 2016, www.irena.org/publications/2016/Jan/Renewable-Energy-Benefits-Measuring-the-Economics.
“Germany’s Renewable Village – DW – 05/28/2015.” dw.com, www.dw.com/en/feldheim-germanys-renewable-village/a-18466800.
“Overview and Benefits of Advanced Metering Infrastructure.” Overview and Benefits of Advanced Metering Infrastructure - Los Alamos County, www.losalamosnm.us/government/departments/utilities/meters___billing/overview_benefits_of_AMI.
“Renewable Energy Benefits Measuring the Economics,.” Renewable Energy Benefits Measuring the Economics, 1 Jan. 2016, www.irena.org/publications/2016/Jan/Renewable-Energy-Benefits-Measuring-the-Economics.
“Germany’s Renewable Village – DW – 05/28/2015.” dw.com, www.dw.com/en/feldheim-germanys-renewable-village/a-18466800.

“Overview and Benefits of Advanced Metering Infrastructure.” Overview and Benefits of Advanced Metering Infrastructure - Los Alamos County, www.losalamosnm.us/government/departments/utilities/meters___billing/overview_benefits_of_AMI.
“Renewable Energy Benefits Measuring the Economics,.” Renewable Energy Benefits Measuring the Economics, 1 Jan. 2016, www.irena.org/publications/2016/Jan/Renewable-Energy-Benefits-Measuring-the-Economics.
"The Smart Grid: An Introduction" by U.S. Department of Energy:
U.S. Department of Energy. (n.d.). The Smart Grid: An Introduction. Accessed on 15th November 2021.
Community Energy Scotland. (n.d.). Community Energy: Challenges and Opportunities. Accessed on 15th November 2021.
EU Smarti Cities Information System. (n.d.). About the Smarti Cities Information System. Accessed on 9 May 2018.
Government of India. (2016). Smart Village: Transforming Rural India. Government of India.
Holdmann, G., Wies, R., & Vandermeer, J. (2019). Renewable Energy Integration in Alaska's Remote Islanded Microgrids: Economic Drivers, Technical Strategies, Technological Niche Development, and Policy Implications. Proceedings of the IEEE.
Stojanova, S., et al. (2021). Smart villages policies: Past, present and future. Sustainability, 13(4), 1663.
Deutsche Welle (DW). (2015). Wildpoldsried: Germany's renewable village.

SALINITY'S SHADOW: SUSTAINABLE MODULAR RESILIENCE FOR THE MUNDA COMMUNITY, SATKHIRA

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Abstract: *Bangladesh is gifted with abundant natural beauty, with rivers, woods, seas, plains, hills, haors, and canals. However, due to its tropical climate, it is prone to several natural calamities, including excessive salinity in coastal areas. Sundarban is one of these coastal areas where reside the Munda community which is one of the 33 ethnic groups of Bangladesh. Originating from India, Mundas are variously dependent on the Sundarbans for both livelihood and religious aspect and consider the Sundarbans as their mother nature. But poverty and calamities limit their participation in social activities and access to necessities like food, education, and healthcare. This paper aimed to evaluate the difficulties the Munda community faces due to salinity and create a modular structural system that was sympathetic to local culture and more cost-effective local resources that would be more resilient to natural disasters. This paper studied the lifestyle and livelihood of the affected munda community of Burigoalini, Satkhira. This paper finds the available construction materials' quality and resilience in connection to saline impacts and local housing characteristics and also focuses on the historical, cultural, and existential aspects of an ethnic group that is facing the risk of extinction.*

Keywords: *Salinity, Ethnic Munda Community, Cultural preservation, Modular housing, Sustainability.*

1 Introduction

Bangladesh is a naturally enriched country. She is ornamented with rivers, various types of forest, sea, plain lands, hills, haors, canals etc. The natural elements and tropical climate consistently invite various natural disasters such as tornado, flood, cyclone, excessive salinity, landslides, earthquakes etc. Naturally the elements, the tropical climate and the disasters of the country influences certain types of livelihoods, lifestyles and settlements. So basically, these disasters and the lifestyle of people of this small country are attached in the same string. These disasters act on all the basic needs of human, undoubtedly on housing. Housing does not only mean a durable physical structure but also a place that creates a sense of security, ensures a healthy environment for the residents, helps to fulfill daily human activities, and should be surrounded by community-based utility and services. All these can fall apart when hit by a disaster. Amidst all these disasters one of the most spreading and expansive is the problem of salinity. Bangladesh has been working on this certain issue for a while now. Excessive salinity happens when the salt in soil and water increment than the safety level resulting into hostile condition for human and their lifestyle. Coastal lines of Bangladesh are affected by this problem severely. Lands of Coxs Bazar, Teknaf, Satkhira, Patuakhali, Borguna, Barisal, Jhalakathi, Pirojpur, Jessore, Narail, Gopalganj and Madaripur districts are affected by different degrees of salinity. (Dasgupta et al., 2014) Our survey was conducted in Shyamnagar Upazila, Satkhira, an area with critical condition of salinity. This coastal area is also bordered by the largest mangrove forest Sundarbans. As our survey intended to find out the effect of salinity in human life and their settlements, we pinned down an indigenous community named “Munda”. Within the Sundarbans mangrove biological zone, this ethnic group can be found. They can be found in Khulna, Jessore, Joypurhat, and primarily in the Shyamnagar Upazila.(Roy, S.2022: 31-41). They rely on the ecology for their survival and way of life and live nearby to the Sundarbans mangrove forest. This led us to observe the impacts of salinity in their health, living condition, building materials and durability, eating habits, drinking water availability and many more.

The paper aimed to evaluate the difficulties the Munda community faces due to salinity and create a modular structural system that was sympathetic to local culture and more cost-effective local resources that would be more resilient to natural disasters. This paper studied the lifestyle and livelihood of the affected Munda community of Burigoalini, Satkhira. This paper finds the available construction materials' quality and resilience in connection to saline impacts and local housing characteristics and also focuses on the historical, cultural, and existential aspects of an ethnic group that is facing the risk of extinction.

2 Literature Review

There are about 33 ethnic communities in Bangladesh among which Munda is one of them (Knowledge World, 2005). They are sometimes referred to as the socially disadvantaged lower caste individuals. They are also referred to locally as "Buno," "Kooli," "Santal," and "Sardar."

They may be found in Khulna, Jessore, and primarily in the Shyamnagor upazila and Joypurhat, which are both close to the Sundarbans. They rely on the ecology for their

survival and way of life and live close to the Sundarbans mangrove forest.(Md. Kamrul 2012)

2.1 Salinity Situation in Bangladesh

Bangladesh Agricultural Development Corporation (BADC) has successfully identified the present state of underground salinity. According to their study, the southern-west portion (Satkhira, Khulna, Bagerhat, Potuakhali) has the most amount of salinity in groundwater. In these locations, there is compelling evidence linking high salt consumption to a number of chronic conditions. (WHO, 2006)

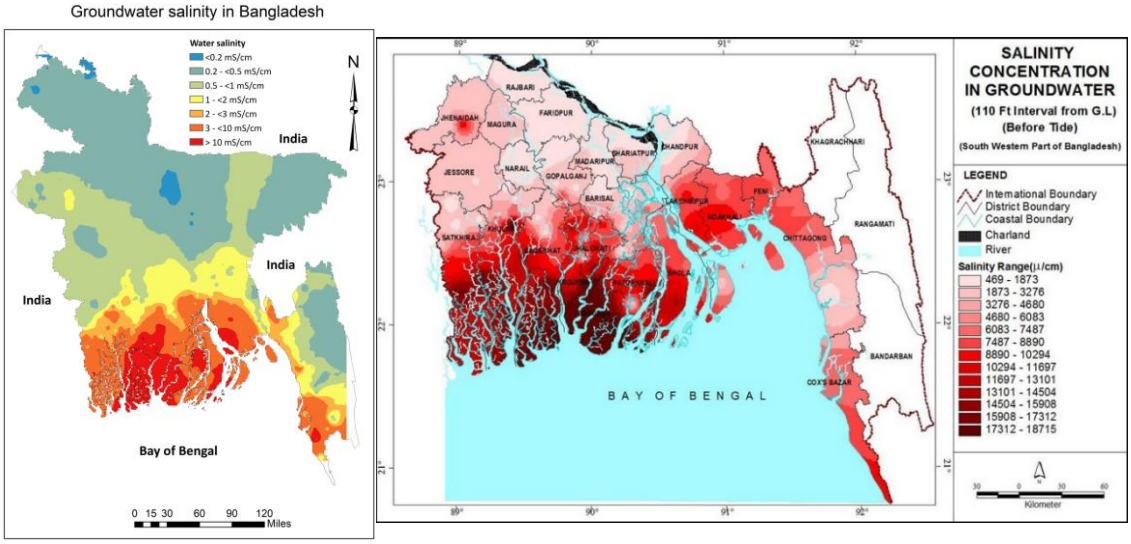


Figure 1: locations where the mean sea level has dropped below the groundwater level (BADC, 2011)

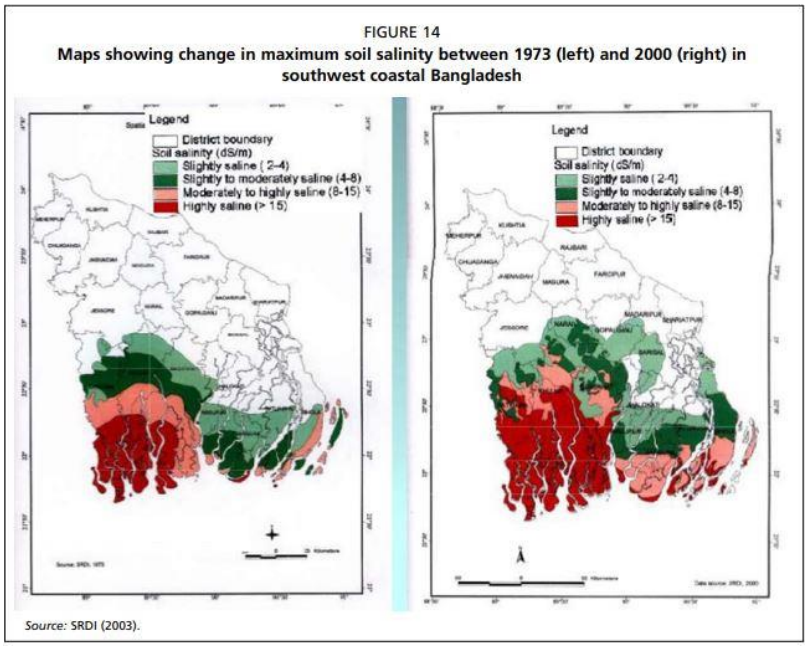


Figure 2: Maximum salinity of southwest coastal Bangladesh of 1973 and 2000.(Hossain,M . Hasan,M)

2.1.1 Sufferings from Salinity

Human suffering can be categorized into physical, mental, economic, and social (Anderson 2013). The increasing salinity intrusion in the coastal belt is increasing people's hardship day by day.

1. **Physical Sufferings:** Salinity causes major physical problems Kidney and skin diseases, Hair loss, Diarrhea, and Gastroenteritis. Etc.
2. **Mental sufferings:** A strange amount of fear, hopelessness, and distress is seen among the salinity-affected people.
3. **Economic sufferings:** Containing fresh drinkable water from a long distance and collecting them in containers, causes great economic suffering for the people of coastal areas
4. **Social sufferings:** The ultimate and direct sufferings caused by salinity in unemployment. The prevalence of salinity is behind it. There are other social sufferings directly causes by salinity like discrimination by normal people against the salinity affected people.

2.2 Munda Community in Satkhira

From this discussion of salinity, we can understand the adverse effects that salinity has on nature and the people living in it. As Satkhira is the most salinity affected area of Bangladesh, we elected an indigenous community of that area named Munda which suffered from the salinity issue for our study.

2.2.1 History of Mundas

According to HRCBM study, the Mundas were transported from Ranchi of Jarkandh and Bakura, Nagpur, Birbhum, Purulia, Saotal Pargona, and Medinipur districts of the west Bengal of India to the erstwhile East Bengal and present-day Bangladesh. First, the Mundas were introduced to what is now Bangladesh by the kings of Naldanga, a district in Jhinaidah (formerly Jessore), in Kaliganj. They served as clubmen, sometimes called 'lathial' locally, in the kings' homes. Secondly, the British rulers moved them to erstwhile East Bengal to produce the indigo plants following the collapse of the Santal uprising in 1850. Thirdly, to create human habitation in the areas close to the Sundarbans, the landowners of the south-western region sent them to Bangladesh to cut the Sundarbans and build embankments to prevent saline water from entering the cultivable land. Most knowledgeable people support the third idea strongly about their coming to Bangladesh. Despite the zamindar system being abolished, the Munda people stayed put in Ranchi. (Das M 2002) (Fr. Luigi Paggi S.X 2003) (Munda K 2018)

2.2.2 Social Status of Mundas

There are no opportunities to take part in gatherings, processions, meetings, arbitrations, trials, or other social activities because of landlines and ongoing poverty. There are no chances for accessing food, nutrition, education, healthcare, learning new skills, or other necessities. (Das M 2002) (Huda S.,2022) (Munda K 2018)

Table 1: Social problems faced by Munda peoples (Huda, Shaiful 2021: 484)

Types of problem	Frequency	Percentage
Education	210	63.64
Water	330	100
Housing	305	92.42

Health care	310	93.94
Social Discrimination	320	96.97
Writing own method	330	100
Entertainment	325	98.48
Religious Institute	330	100
Knowledge about digital Bangladesh	315	95.45

Table 2: Social situation of Munda people (Huda, Shaiful 2021: 484)

Social Layer	Frequency	Percentage
Low	330	100
Middle	0	0
High	0	0
Total	330	100

2.2.3 Demographic Data: Population

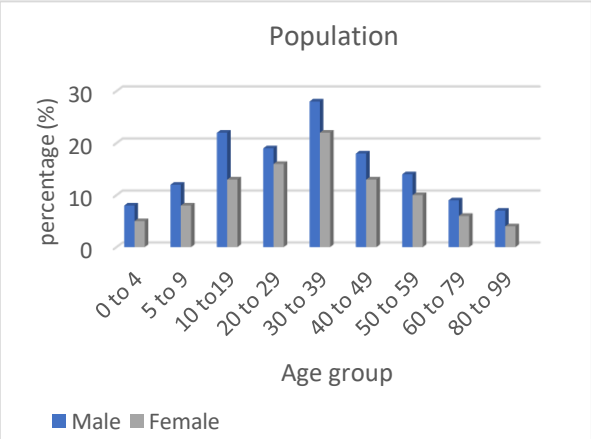


Figure 3: Population rate of Munda people in Satkhira

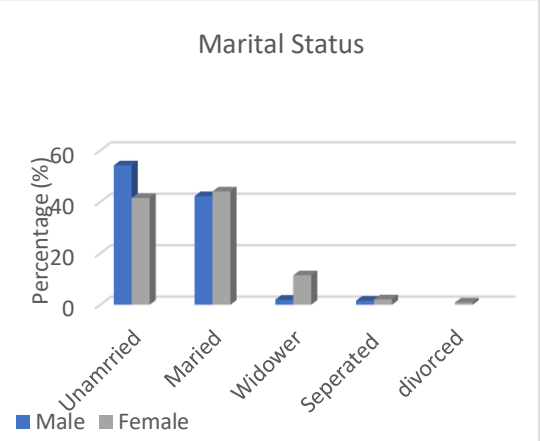


Figure 4: Marital status Of Munda in Satkhira

From the graph, we can see the age group of 30 to 39 dominates the population. Although the aged group of the community varies widely from 0 to 98 which was one of our considerations.

In the case of marital situation of the community, the cast is an important catalyst. So, to maintain cast they marry within their community or from another community which creates mobility in the population.

2.2.4 Literacy Rate

Almost all of the member aged up to 30-35 is literate, at least receiving education up to primary level. All the children of the area go to school, despite lack of transport availability. There is also a free primary school funded by UKAID and with the help of the Manusher Jonno Foundation under SAMSThe Mundas speak an unwritten language known as "Mundary/ Nagri/ Sadri" that they developed independently. It appears that this language is a mash-up of Bengali, Urdu, Hindi, and Persian. (Fr. Luigi Paggi S.X 2003) But unfortunately, they do not have any curriculum in their language which might be a reason for education backwardness among the previous generations.

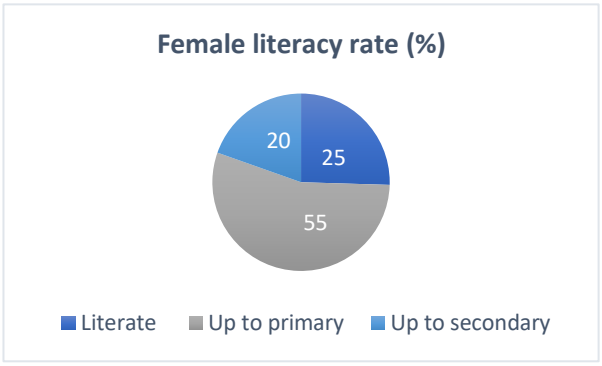


Figure 5: Female literacy rate of Munda in Satkhira

Figure 6: Free primary school by UKAID

2.2.5 Occupation

Cutting the Sundarbans to make cultivable land were Munda's primary livelihood in the past. Also, they had to build embankments to shield the cultivated land from salt water. (Das M 2002) (Md.Kamrul 2012) Their current jobs involve fishing, earthmoving, and farming on other people's properties. These tribes' men and women perform day labor on other people's property. They do difficult tasks like earth cutting. In rivers and ponds close to the Sundarbans, they both capture fish. They use spars to hunt birds. In order to seek tortoises, they uproot vegetation from the ground. Snails and shells are collected by some of them. Some of them also cultivate by renting out other people's land. (Das M 2002, Munda K 2018, Md.Kamrul 2012).

Table 3: Occupation of Munda people

Occupation	Frequency	Percentage
Farmer	45	13.64
Day Labor38	128	38.79
Seasonal Labor	108	32.73
Carpenter	18	5.45
Other	31	9.39
Total	N-330	100

(Huda, Shaiful 2021: 484)

2.2.6. Family Type

Most nuclear families are created when the mid-age male is capable enough to build his own house adjacent to his parental home. So most of the nuclear families originated from a single family living around a shared courtyard. Though of financial situation and to support their parents, they tend to live in a joint family more, so, they extend or moderate the existing house to accommodate extended family.

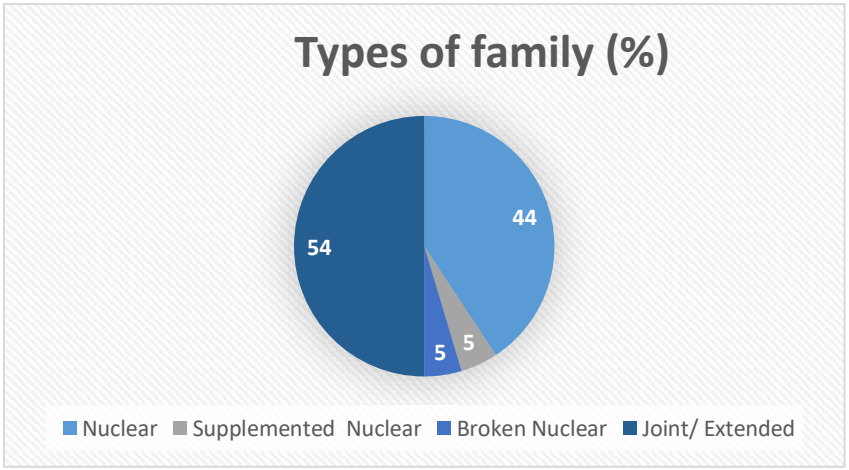


Figure 7: Types of Munda family in Satkhira

2.2.7 Housing Pattern of the Munda People

Only extremely poor people now live in the soil-walled huts with a rice-straw roof in the Munda region in South-West Bangladesh. A rice straw roof only requires labor costs (Das M 2002) (Fr. Luigi Paggi S.X 2003) (Sarkar S 2018) (Kamal, M 2010). However, such a roof does not last more than a rainy. The majority of Munda people can only afford to have this roof on their homes. Every one of their homes has a unique name for

1. Kitchen, which they refer to as "Haisal Ghar." They contend that it is preferable to have it face west.
2. The chamber is known as "Sutek Ghar." Ideally, it should face south.
3. The 'Bam Ghar' is the name of the residence where the cows are housed.
4. The residence known as the "house of worship" is the one in which the idol or image of "Thakur" is maintained. It would be great if this home faced south. (Munda K 2018, Kamal, M 2010)

2.2.8 Traditional Housing Type

After talking with them about their housing types, we created three prototypes of typical traditional houses that were previously built by them. Built materials were mainly local materials, mud, soil, gol pata, bamboo, and other woods from Sundarbans. Some of the common features of those houses were a Dawa (veranda) in front of the house, a kitchen and a toilet outside the main house (attached or separated).

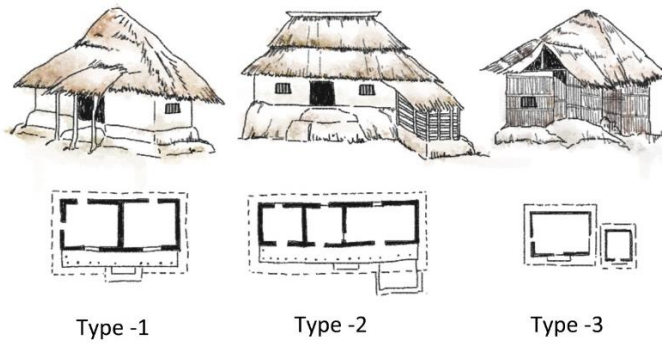


Figure 8: Traditional Housing type with plan

2.2.9 Building Materials

Sundarban is the primary supplier of building materials to the Munda people.They obtain local building materials from the Sundarban, such as golpata, bamboo, and wood. They also construct with goran, gorjon, and keura wood which are common trees of the mangrove. So, Sundarban is where the building materials come from because they can be found easily, affordable, and sustainable to the existing climatic condition.

2.2.10 Vegetation

Because of salinity in soil and groundwater, many trees and crops which require fresh water cannot grow here. Cattle grass is very rare in this area. The only source of vegetables is that grows on the loft (macha) and roof.

Figure 9: Types of plants in study area Burigoalini

2.2.11 Cultures of Munda People

Indigenous Munda people assert that their religious practices are distinct from those of other ethnic groups. The Sun-Spirit, the moon, and the stars—translated as "Sing Bonga"—are believed to be living witnesses of their cult. Special reverence is paid to the "Karam tree," which shielded and hid their ancestors while they fled the enemy. (Huda, Shaiful 2021: 484).

As the whole Sundarbans region, they also revere several Hindu gods and also pray to "Bon Bibi," the forest's patron god. (Das M 2002)(Fr. Luigi Paggi S.X 2003). They frequently perform a variety of additional rituals (Puja), including the following: Mage Puja, Karam Puja, Shoshi Puja, Sharul Puja, Gohil Puja, Gram Sara Puja, Pahari Puja, Bura Buri Puja, Valua Puja, Kali Puja (they arrange the traditional Hindu Kali Puja), Hari Puja, Durga Puja, and Tusu (Lakshmi) Puja (symbol of perfection). (Das M 2002)(Munda K 2018). In the many festivals and rituals, the Munda only practice a few festivals and rituals such as Pahari/Dangri Kharam Puja, Karam Puja, Sarul Puja, Natun Khaoa Puja, Valua/Velva Puja, and Sohrai Puja. The pujas are performed in full Mova style (Munda K 2018)(Sarkar S 2018) (Kamal, M 2010)(Munda K 2012)(Munda RD, Manki RS 2009).

The Munda people's cultural practices are distinct from those of other ethnic groups. There are still many different traditional dances and tunes. In the Munda community, Jhumur, Khemta, and Tusu songs and dances are well-known. The Mundas also have a belief in ghosts (Bhut) and spirits, both good and malevolent, and they invoke them to heal the sick or harm others. They said that Ojhara was haunted by spirits. When he is unable to feed the ghost personally, he places it on another person's neck. (Munda K 2018)(Kamal M, Barman V 2010)

2.2.12 Sundarban Adibasi Munda Sangathan, (Sams)

The organization SAMS was established in 2003 and the beginning of establishment SAMS always works for the betterment of Munda people. SAMS is not only an organization but it also works in different socio-economical aspects like education, health, sanitation, awareness of Munda people to their rights and so many works. Every month of our organization SAMS published a magazine named “Masik Munda Barta”. SAMS always uplift all type of Munda people activities and in this process SAMS impress Munda people’s livelihood patterns.

2.3 Case Study

Disaster Resilient Habitat: An Alternative to Cyclone Shelters, UNDP Bangladesh

- Location: **Adarshagram, Padmapukur, Shyamnagar, Shatkhira**
- Architect: **architects from BRAC University, Bangladesh**
- Client: **Cyclone Affected local people of Adarshagram**
- Design: 2009
- Completed: 2010
- Area of a single unit: **130 sq feet**
- Number of units: **43**

Figure 10: Adarshagram, Padmapukur, Shyamnagar, Satkhira

Cyclone Aila in 2009 affected the coastal region of Shaymnagar, Satkhira and destroyed a huge number of houses along with livestock and human lives as well. UNDP along with the help of DoA, BRAC took the non-profit project to help the lives affected by Aila. Local People were involved in the construction of the houses. The main objective was to create a single-unit house by the locals at first so that they learn and create the nest houses themselves. In Adarshagram, a total of 43 homes as well as a new school to replace the one that was destroyed will be constructed. The sturdy wood frame structure was built using the talents of boat builders or homeowners, but the concrete construction was overseen by engineers and completed by skilled workers, student volunteers, and local men and women.

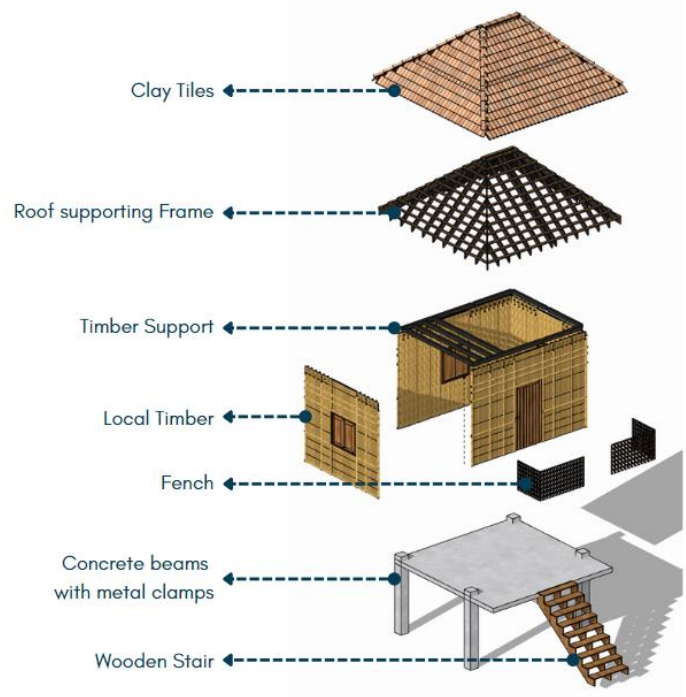


Figure 11: Exploded view of the structure

The homes, which were 10 feet by 13 feet and stood 8 feet tall, were supported by four concrete columns and reinforced concrete beams that were placed high above flood level. The beneficiaries preferred an above-ground building with room underneath for future alterations and additions. To make the concrete saline-resistant, stones were utilized in place of bricks together with a particular chemical. Additionally, additional spaces were provided to stop steel bars from rusting and swelling because of saline.

3 METHODOLOGY

The majority of the study's data and information were qualitative. Data have been gathered from primary and secondary sources to meet the study's goals. Fieldwork has been used to gather primary data, most of which is qualitative. The sources of secondary data are books, journals, research papers, and reports. Websites on the internet are used to gather data about pertinent subjects. In-depth key informant interviews, as well as group discussions with locals, were used to gather pertinent information on the topic at hand. For the study, primary data and information gathered by questionnaire have been compiled and analyzed.
By addressing the following three study issues, this article helps to comprehend the social dynamics caused by salt in Bangladeshi coastal areas:

a) How is salinity affecting the Munda Community of Shyamnagar, Satkhira?

b) What is the present scenario of their lifestyle, culture and housing condition?

c) How can we provide a disaster resilient and adaptable housing module preserving the Munda culture?

Following are the key steps that were taken considering these three research questions-

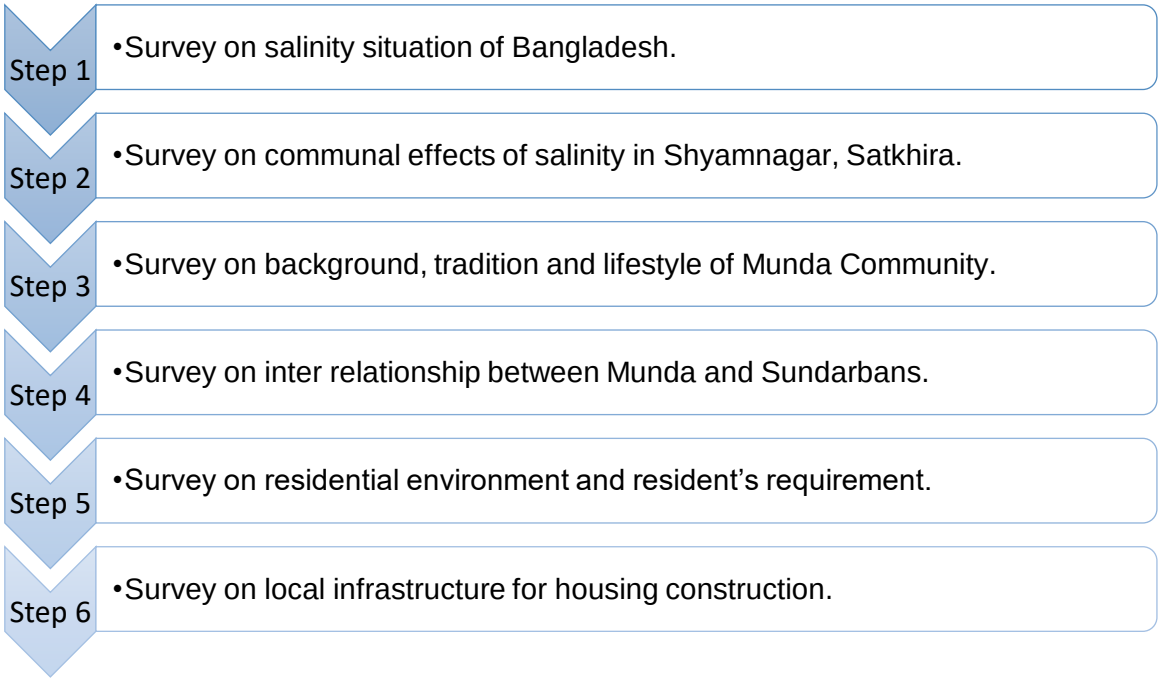


Figure 12: The key steps that were taken considering the research questions

Firstly, the salinity scenarios of Satkhira and different data related to salinity were collected from different papers, organizations and websites. Effects of salinity on Munda community were collected from field survey.

The diverse history, culture and tradition of Munda people and their connection with the Sundarbans were collected from field survey in the target area. Mostly the elderly people provided the information's. Different article and papers on the Munda people were reviewed.

A few surveys were conducted on 1) the local residential environment and requirements, 2) the local infrastructure for housing construction, and 3) the local building standards and methods in order to determine the best way to construct a long-lasting home for low-income residents in Bangladesh's southern coastal region. Current masterplan, housing type, material usage, availability of materials, material supply infrastructures, road network etc. were collected from field survey.

4 Discussion

4.1 Housing Prototype

Every year, millions of lives are put in peril and the property of impacted people throughout the world are destroyed by the pervasive and horrific phenomena known as natural disasters. Among other problems brought in by natural disasters, one of the most considerable problems is the loss of shelter. According to the United Nations High Commissioner for Refugees, 70.8 million people were forcibly displaced internationally in 2018.(Das M 2002) (Fr. Luigi Paggi S.X 2003) and approximately 14 million people are relocated each year on average.(Munda K 2018) The numbers are more frightening in Bangladesh. For instance, Cyclone Sidr, which struck the Satkhira-Khulna-Bagherhat area on November 15 with 260 km/h winds and a 6 m tidal wave and caused around 4406 fatalities and over 55,009 injuries, was the most destructive of the disasters. Over 500,000 houses were demolished, and over 900,000 were significantly damaged, affecting an average of 27 million people across 30 districts. (Huda, Shaiful 2021: 484) Everyone has the right to adequate housing for their health and well-being because it is a basic human requirement, much like food and clothing. In disaster-prone places, it is crucial to have a disaster-proof home. These communities, however, do not enjoy this luxury, and disasters routinely decimate them. Consequently, about a million homes are significantly damaged by disasters every year, with half of them being entirely demolished. The loss of a home and other possessions leaves the poor more susceptible to similar disasters and owing to financial limitations, they are unable to reconstruct themselves. In case of our considered disaster, Salinity, building houses to save the materials and structure from the effect of salinity in soil and water while maintaining traditional patterns and ensuring all the facilities is the prime target. Building disaster-resistant dwellings is needed because these will secure their lifestyle in these disaster-prone areas. The next sections will cover the planning, construction, and design elements that will increase the house's durability, hand in hand with other considerations.

4.2 Consideration

The salinity in the soil and water has a significant impact on the materials used in the area's dwellings. However, the problem is to use materials that are locally available,

modest in cost, and quickly repairable. Aside from the materials, the structure must be well-built and capable of holding the shelter together in the face of any natural disaster. Keeping all of this in mind, we planned to create a housing type that addressed the following issue:

- **Local materials:** In case of rural housing, the use of local materials is very important. They can be found easily while construction and especially for reconstruction if effected by disaster. It will minimize the costing. Also, as they are familiar with these materials, they will know using and maintaining them. The target will be maximization of the use of these same materials which was previously used to be more durable in the proposed housing prototype
- **Minimizing the effects of salinity:** The main target of building this disaster resilient housing, is to save safe shelter from saline water and soil. The common effects of salinity are that it reduces the material longevity, make them fragile and easily breakable. To protect the materials from those effects and introducing ways and structures to increase stability and durability is one of the main considerations. Such as rising the floor level, using seashell concrete as main structural element etc.
- **Maintaining tradition:** As our targeted people from an ethnic group that is slowly going lower in numbers, it was crucial to maintain their traditional housing elements and offer a house that respected their lifestyle. The patterns are also developed based on their family types, significant housing part etc.
- **Durability:** Salinity mostly effects the materials and reduces its lifetime comparing to other areas. The target is to protect the materials from this effect and increase the lifetime of the shelter. It will also help reducing cost as durable materials will not need regular replacement or fixing.
- **Low cost:** Our selected community comprises low-income people, so we had to look into the costing of building the prototype. Mostly we used local materials for that. We also looked into durability of the structure, where the costing can be like an investment, since durable material will help reducing replacement or fixing cost in the future.
- **Stability:** Our site is located in such an area where cyclone and flood are also a regular calamity beside salinity. So, the prototype is designed to survive through other calamities too and features are added to not only increase the building stability but also a protection shelter in the roof which can be used as storage on other times.
- **Post disaster housing reconstruction:** After a disaster, it is crucial to consider resilience in terms of housing components for post-disaster housing rebuilding. First point to consider is minimizing the effect as much as possible. Secondly such materials should be used that can be easily found and has uncomplicated construction methods.

4.3 PLAN

4.3.1. ZONING:

The typical house plan is designed with the local spatial requirements in mind, and contains storage areas on the floor as well as in the ceiling. The ceiling storage can be used as refugee floor at the time of flood. The tradition of dawa (veranda) where maintained with easy circulation from the rooms, though the plinth level is uplifted up to 3.5 ft. Front dawa holds a macha ensuring cultivation of macha vegetables which was provided considering effects of salinity on food. This dawa can also be used as storage, chicken coop and living space if needed. The bathroom and kitchen as usually were provided at the back of the house to maintain the privacy. Also, in case of clusters and extended modules, the bathroom and kitchen can be shared between multiple families.

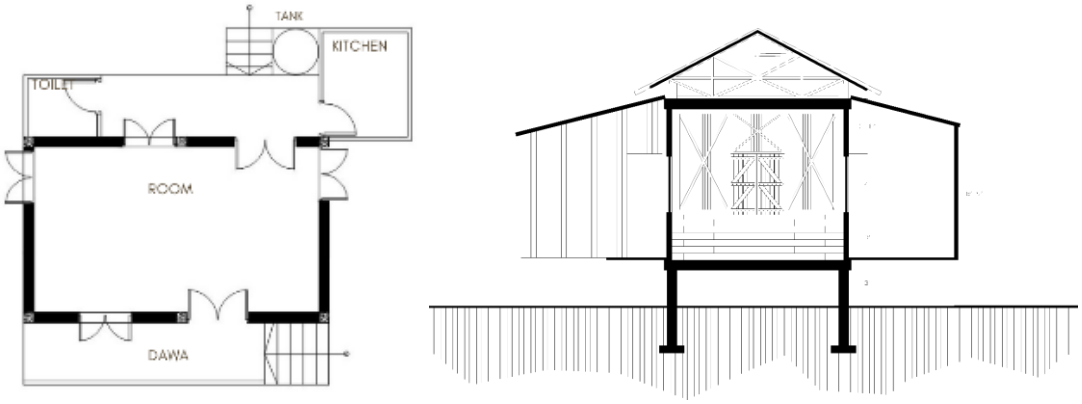


Figure 13: Prototype 1 plan and section (single family)

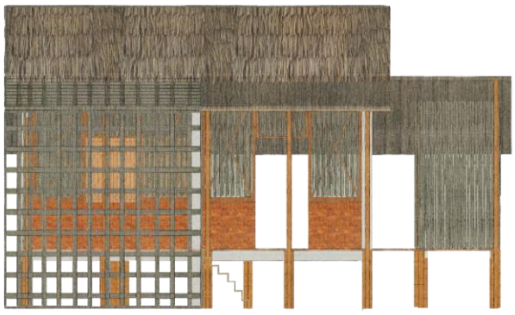


Figure 14: Front Elevation

Figure 15: Back Elevation

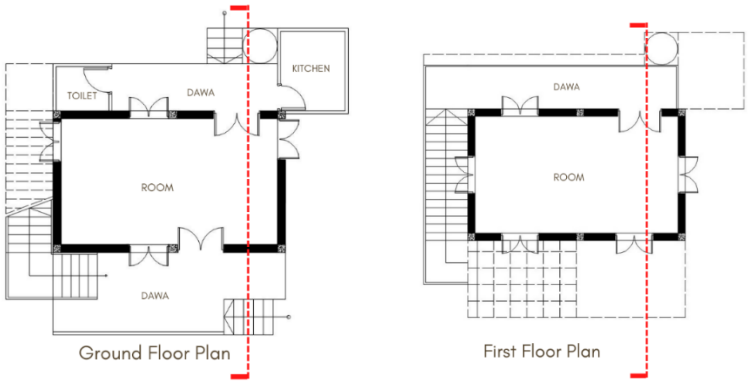


Figure 16: Prototype 2 plan (single family extended house)

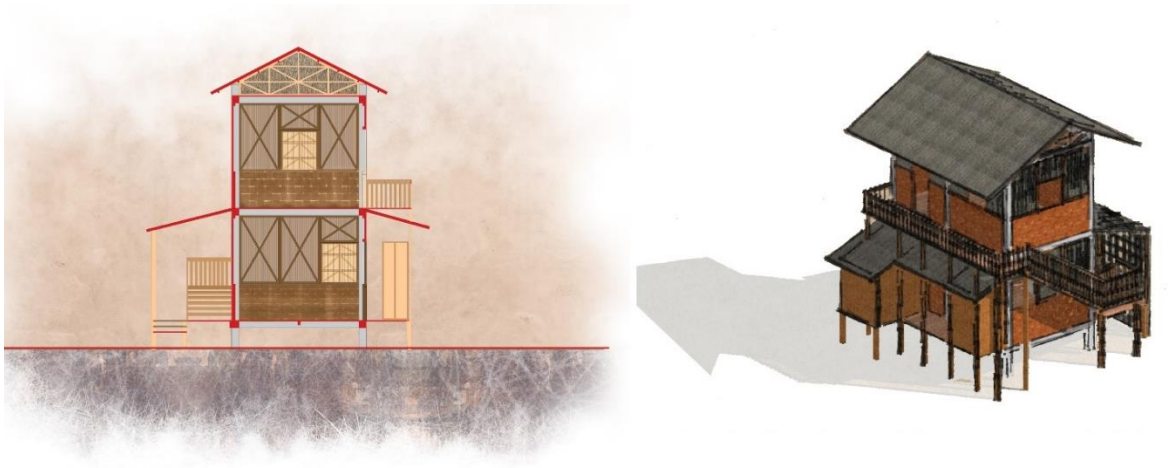


Figure 17: Single Family house (extended)

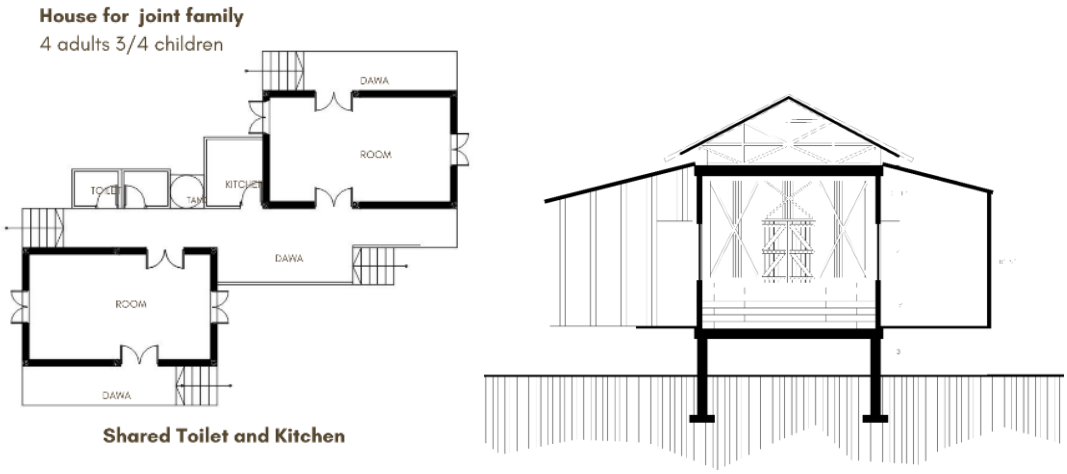


Figure 18: Prototype 3 plan and section (Large family)

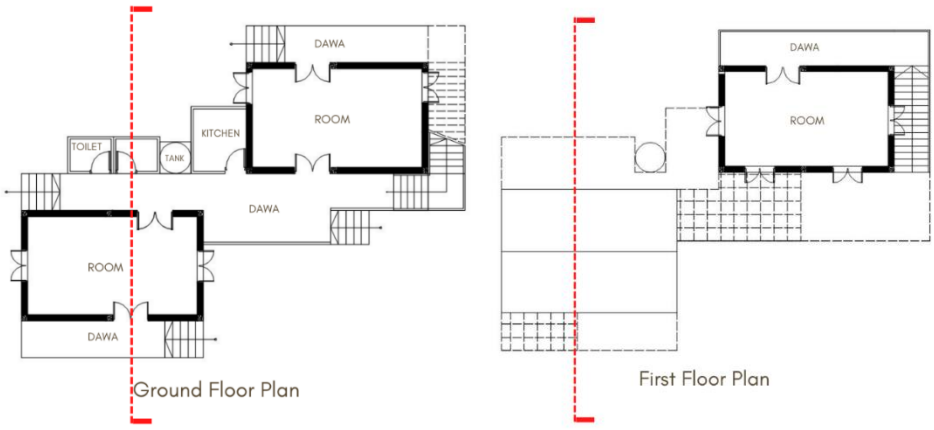


Figure 19: Prototype 4 plan (Large family extended)

Figure 20: Prototype 4 (Large family extended)

4.4 Materials

We have chosen the materials as per the requirements of low of cost, easily available and durability. Also, we have given attention to maintain their traditional housing outlook to avoid making them feel unfamiliar. Muli bamboo infill in the modular system adds contextual essence and makes the structure approachable to local Munda's.

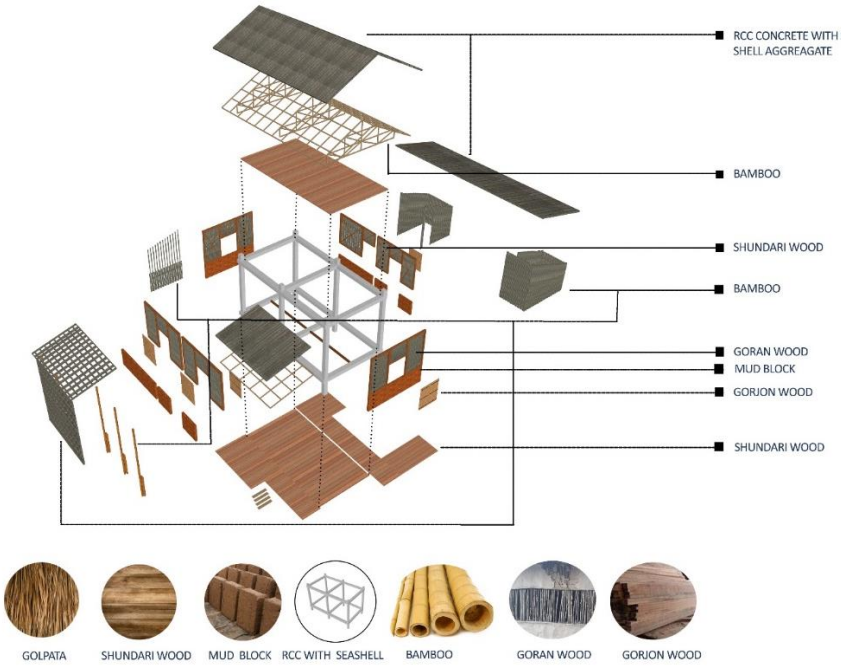


Figure 21: Exploded axono with materials

4.5 Joint Details

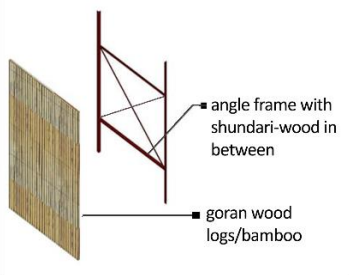


Figure 22: Cross bracing module details

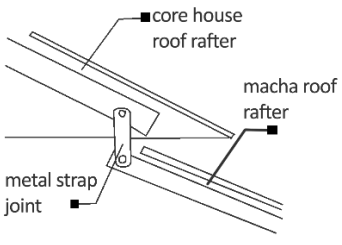


Figure 23: Two roof joint

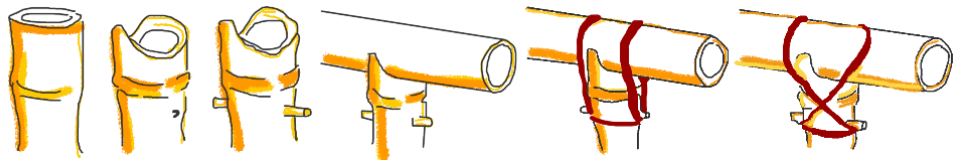


Figure 24: Galvanized Tie

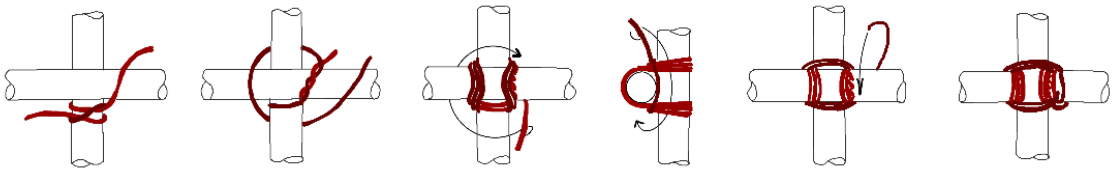
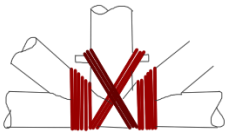


Figure 25: Lashing tie



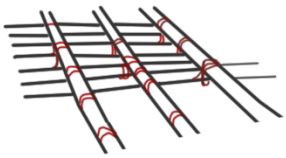


Figure 26: Bamboo joint for truss and roof skeleton

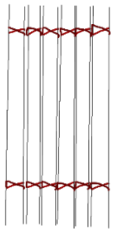


Figure 27: Joints in walls

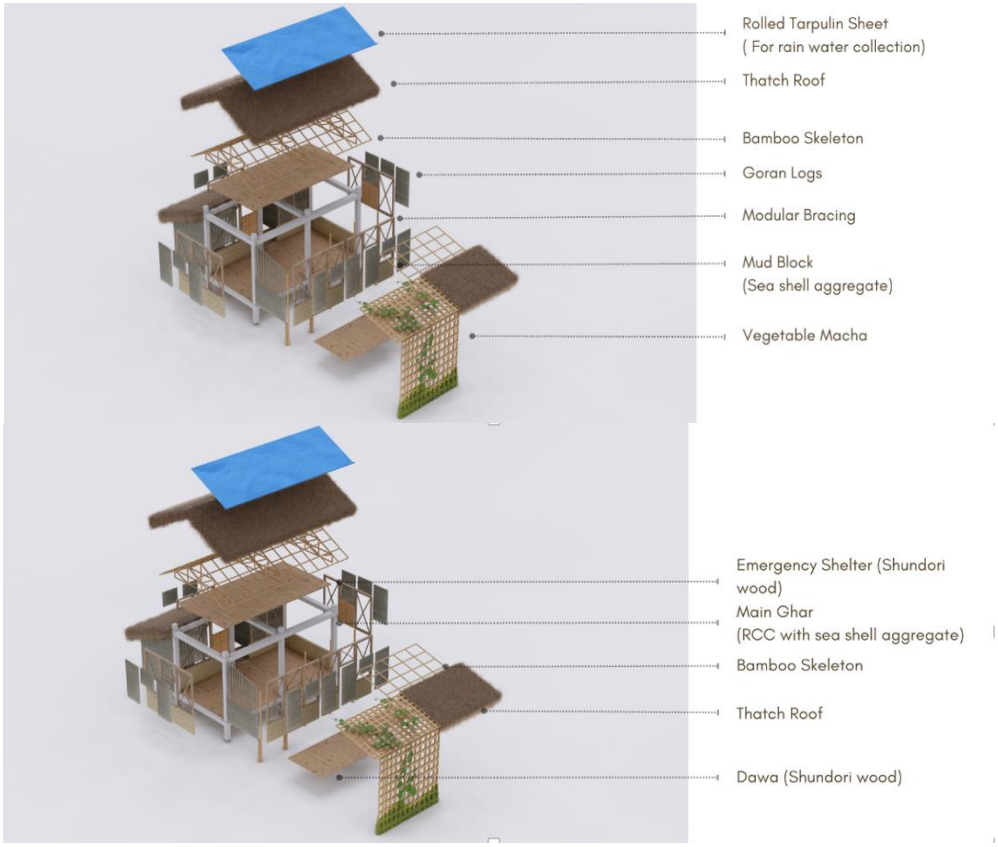


Figure 28: Exploded axono with materials

4.6 Structural Details

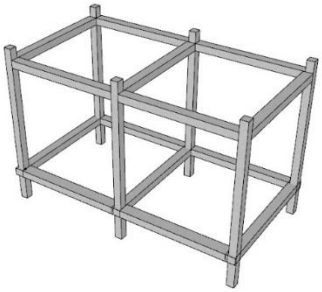


Figure 29: Concrete structure of column- beam

Figure 30: Roof skeleton

5 CONCLUSION:

Due to severe salinity and frequent natural disasters, the Munda population in Sundarbans coastal region of Bangladesh confronts several difficulties. They heavily rely on the Sundarbans for their livelihood and spiritual practices, considering it their natural haven. But their ability to participate in society and their overall wellbeing are hampered by poverty and restricted access to necessities like food, healthcare, and education because of Salinity.

The purpose of our study was to assess how salinity affected the Munda population in the Satkhira region of Burigoalini. We looked into the durability and quality of the building materials that were on the market about how salt affected dwellings. We also highlighted the community of Munda's historical, cultural, and existential characteristics, which are in risk of extinction.

Considering all these situations, we designed an economical, cost-effective, and disaster-resistant modular structural system as a solution to these issues. By offering the Munda people safe and environmentally friendly housing options, this approach hopes to protect their traditional identity.

The results highlight the necessity of supporting and intervening specifically to help the Munda community. The implementation of environment friendly housing options that take salinity into account was our main priority. By doing this, it will be possible to safeguard the distinctive way of life and cultural heritage of the Munda people while also promoting a more resilient and just future for them.

Acknowledgements

This investigation is based on the Design Studio work of Level 4, Term II, Session 2022-23 of Department of Architecture CUET under the supervision of Shajib Paul, Assistant Professor and Syeda Tahmina Tasnim, Assistant Professor, Department of Architecture, CUET. Thanks to the Department of Architecture, CUET for providing all academic facilities.

References

Naser, A. M., Wang, Q., Shamsudduha, M., Chellaraj, G., & Joseph, G. (2020). *Modeling the relationship of groundwater salinity to neonatal and infant mortality from the Bangladesh Demographic Health Survey 2000 to 2014.* Geohealth, 4(2). https://doi.org/10.1029/2019gh000229.

BADC 2011 [Bangladesh Agriculture Development Corporation Annual Report 2010-11].

The human cost of disasters: an overview of the last 20 years (2000-2019), (2020). In UNDRR. https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019.

Das,M (2002), Book: *Adibashi Mundader Jibon Boichittro.*

Dasgupta, S., Kamal, F. A., Khan, Z. H., Choudhury, S., & Nishat, A. (2014). *River Salinity and Climate Change: Evidence from Coastal Bangladesh.* In World Bank policy research working paper. https://doi.org/10.1596/1813-9450-6817.

Hossain, M. A. R., & Hasan, M. R. (2017). *An assessment of impacts from shrimp aquaculture in Bangladesh and prospects for improvement.* In FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. https://doi.org/10.13140/RG.2.2.16693.37605

Huda, S. (2021). *The Mundas an ethnic community in the south-west coastal region of Bangladesh: Buno/kuli/Sarna/Horoko, Indigenous people during the British period coming from Ranchi.* Sociology and Criminology, 9(7), 1–16. https://doi.org/10.35248/2375-4435.21.9.224

Huda, M. S. (2022). *The Social Work with the Munda Community: The Indigenous People in the Sundarbans Areas of Bangladesh (Buno/Sardar/ Kol/Kuli/Ho/Sarna/Harohan/Horoko/Adibasi/Tribe). Anthropology and Ethnology, 5(1).* https://doi.org/10.23880/aeoaj-16000162

Islam, Md. T., Charlesworth, M., Aurangojeb, M., Hemstock, S., Sikder, S. K., Hassan, Md. S., Dev, P. K., & Hossain, Md. Z. (2021). *Revisiting disaster preparedness in coastal communities since 1970s in Bangladesh with an emphasis on the case of tropical cyclone Amphan in May 2020.* International Journal of Disaster Risk Reduction, 58, 102175. https://www.sciencedirect.com/science/article/abs/pii/S2212420921001412?via%3Dihub

Islam, A., Islam, M. S., & Wahab, A. (2016). *Impacts of climate change on shrimp farming in the South-West coastal region of Bangladesh.* Research in Agriculture, Livestock and Fisheries, 3(1), 227–239. https://doi.org/10.3329/ralf.v3i1.27881

Kamal M, Barman V (2010*),* Book: *Adibashi Jonogosthi.*

Kamal, M (2010) *Indigenous people of Bangladesh, Ethnographic research.*

Hossain, Md. K. (2012). *The Life and Social Pattern of Munda Community of Two Selected District of Bangladesh: An Empirical Social Survey* [MS thesis]. Khulna University.

Munda K (2012) Executive Director of SAMS (Sundarban Adibasi Munda Sangastha) *Autobiography of the indigenous people of the south- western part of the country*.

Munda K (2018) Executive Director of SAMS (Sundarban Adibasi Munda Sangastha*) In the Sundarbans areas Munda Jatisattar Etihas o Oytijjo.*

Munda, R. D. (2014). *Adi-dharam:the religious beliefs of the Adivasis of India. sarini, BIRSA & adivaani.*

Rafique Ahmed (2021) Available from: *Banglapedia* https://en.banglapedia.org/index.php/Climate (accessed 22 Feb 2023)

Roy, S. (2022) *Integrating Resilience through Adaptability and Transformability: Ecologically Responsive Design Approach in Case of Southwestern Coastal Region of Bangladesh. In Resilient and Responsible Smart Cities*: Volume 2 (pp. 31-41). Cham: Springer International Publishing.

Sarkar S (2018), *The Identity of Adibashi Ethnicity* IBS Seminar, Volume -19.

Housing and Building Research Institute. (2018). *Standard guideline for rural housing in disaster prone areas of bangladesh.* https://sheltercluster.s3.eu-central1.amazonaws.com/public/docs/standard_guideline_for_rural_housing_in_disaster_prone_areas_bangladesh1.compressed_0.pdf

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AI AND AQUAPONICS FOR SUSTAINABLE FARMING: Challenges faced by farming in coastal regions of Bangladesh.

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Abstract: The farming quality of the soil decreases as a result of soil degradation, erosion, urbanization, land conversion and salinization. As result sustainable agriculture techniques are used to lessen the loss of farming quality. Aquaponics, a sustainable agricultural technique, is like a dynamic ecosystem that intertwines aquaculture and hydroponics. The system grows fish and plants in a mutually beneficial relationship that's alike to a dance, each organism contributing to the other's growth. The aim of the research is to implement the techniques into village farming. AI can gather real-time data on environmental factors such as temperature, humidity, and pH levels, enabling proactive adjustments to maintain optimal conditions. This study will show aquaponics technique can contribute in sustainable farming as well as to make the village more resilient to any calamities. The study will use a complete descriptive qualitative method and require a detailed examination of secondary materials in order to collect pertinent data. This research aims to demonstrate the potential of aquaponics to transform modern agriculture while also examining its viability through a thorough investigation of two local case studies.

Keywords: Aquaponics, sustainable agricultural, AI, ecosystem, resilient.

Introduction:

Artificial intelligence (AI) is the ability of robots to perceive, synthesize, and deduce information, as opposed to the natural intelligence exhibited by people and other animals. The term "intelligence" refers to the capacity for knowledge, reasoning, abstraction, and inference of meaning (Copeland, 2023). In 1956, the academic field of artificial intelligence was established. This was followed by innovative techniques, commercial success, and increased financing (Clark, 2016). Machine learning that is heavily statistical and mathematical has dominated the discipline in the first two decades of the twenty-first century. This approach has been very effective in solving many difficult issues in both business and academics (Russell & Norvig, 2003). Aquaponics is a method of growing food in which the nutrient-rich waste water from aquaculture is given to hydroponically produced plants. Aquaculture is the practice of keeping aquatic creatures in tanks, such as fish, crayfish, snails, or prawns (Rakocy, 2012). Aquaponics has a long history, while the Aztecs and South China are said to have invented it first (Boutwelluc, 2013). The name aquaponics comes from the terms hydroponics, which is the practice of growing plants without soil, and aquaculture, which is the practice of raising fish in a confined environment (youmatter, 2020). The production of food with modern aquaponics is somewhat more environmentally friendly and technically more effective. The majority of the time, fish are housed in big tanks, while plants are cultivated hydroponically, or without soil (K., Panda, Padhi, & Surendra, 2016). According to The Global Land Outlook (Convention to Combat Desertification, 2017), a third of the planet's land is badly degraded and fertile soil is being lost at a pace of 24 billion tonnes annually. The area of irrigated land has quadrupled and agricultural productivity has grown threefold during the last 20 years. However, 20% of the world's agriculture, 16% of its forest, 19% of its grassland, and 27% of its rangeland are all seeing declining productivity (Encyclopedia, 2020). According to the UN Food and Agriculture Organization, we only have 60 years of harvests remaining at the present rates of soil erosion, which are mostly caused by bad farming practices.

In Bangladesh's coastal regions, almost 40 million people work in agriculture (Statistics, 2011). Bangladesh's economy is based mostly on agriculture.. In the fiscal year 2011–12, agriculture accounted for 19.41% of the nation's GDP (including fishing), while 47.5% of the labor force is

employed in the sector (Review, 2013). The farming methods in these regions are always under jeopardy in addition to natural calamities. Coastal agriculture has seen a recent transformation (Hoanh, 2006, pp. 237-248). Due to its physical location, Bangladesh's coastal areas are more susceptible to climate change than other sections of the nation. Shrimp farming has significantly changed the coastal communities' social and economic landscape since the 1980s (Department of Fisheries. Dhaka, 2010).

This research aims to identify the possible benefits and establish sustainable farming practice through aquaponics for a smart village. This study creates an imaginative picture of a smart community compared to primarily analyzing local case studies. By doing this, it intends to highlight how aquaponics could transform farming practices.

Literature study

Aquaponics is a term that emerged in the 1970s, although the concept has ancient roots, though its initial occurrence is debated (Bradley, 2022).The lowland Maya may have been the first to practice one branch, followed by the Aztecs, who cultivated plants on rafts on the surface of a lake about 1,000 AD. Some regard the Aztecs' cultivation system of agricultural islands known as chinampas to be the first version of aquaponics for agricultural purposes. Chinampas are canal networks with stationary manmade islands where crops are grown utilizing nutrient-rich mud and water from the canals. Plants were raised on stable (and occasionally movable) islands in lake shallows in the early Chinampa systems. Nutrient-rich sewage excavated from the Chinampa canals and adjacent cities was then manually irrigated the plants above (“History of Aquaponic System,” n.d.). Another branch of aquaponics may be found in South China, Thailand, and Indonesia, where the growing and farming of rice on paddy fields in conjunction with fish are described as early aquaponics systems (Fred, 2021).

In several Far Eastern nations, these polyculture agricultural techniques grew fish such as the oriental loach, swamp eel, common and crucial carp, and pond snails in the paddies (Dabbadie et al., 2019). The ancient Chinese used a symbiotic system of integrated aquaculture in which finfish, catfish, ducks, and plants coexisted. Aquaponics uses 90% less water than traditional cultivation (Kozai, Niu, & Masabni, 2021). The fish act as the "canary in the coal mine," compelling the

aquaponics farmer to be honest. Aquaponics is a method of simulating the natural symbiotic relationship between fish and plants. (Attanà, 2023). Fertilizer is required by even traditional organic farms to enhance their soil. These fertilizers can be damaging to the overall health of the soil and watershed. Even with grow lights, aquaponics consumes less energy than conventional commercial farming ("Benefits of Aquaponics - Evergreen Lane Farm," 2015). Aquaponics requires all electrical energy, thus alternative energy systems like as solar, wind, and hydroelectric can be used (Karimanzira & Rauschenbach, 2018). To provide drinking water to farming regions in many parts of the world, expensive irrigation systems are required. Third-world countries generally lack the financial resources, arable land, and technological capabilities to produce enough food, particularly protein, to maintain their human populations healthy. Human ingestion of pesticide residues on fruits and vegetables, as well as hormones in chickens, hogs, and cattle, has raised concerns about human health. Pesticides and fertilizers are harmful to wild birds and animals. Pesticide and fertilizer runoff from local agriculture also pollutes local waterways (ponds, rivers, and streams) ("Environmental Implications of Excess Fertilizer and Manure on Water Quality," 2023).

Over time, technology has changed how farming is done, and it has had a wide range of effects on the agriculture sector. There will be increasing pressure on the land since only an additional 4% of the planet's surface will be cultivated by 2050, when the population is projected to rise from 7.5 billion to 9.7 billion ("Chapter 5: Food Security — Special Report on Climate Change and Land," n.d.). Agriculture is the primary employment in many nations across the world. Farmers will thus need to work harder with less resources. The same report estimates that in order to feed an additional two billion people, food output must rise by 60%. Traditional approaches, nevertheless, are unable to meet this enormous demand. This is pushing farmers and agricultural businesses to develop fresh strategies for raising output and cutting waste. As a result, Artificial Intelligence (AI) is progressively becoming a part of the technical advancement of the agriculture sector. To feed an additional two billion people, the task is to boost global food output by 50% (Hanson, n.d.).

Farming in the coastal regions of Bangladesh comes with a lot of problems, and these issues affect the food we eat, the jobs people have, and the natural world around us. The difficulties that farmers

face in these areas are like a big puzzle with many pieces, and these pieces are all connected. One of the main problems is that salty seawater can sneak into the farms because the sea levels are rising, and the tides are strong. This salty water can hurt the crops and make them not good to eat. This makes it hard for people to have enough food to eat, and it also makes farmers lose money because they can't sell their crops (Ali et al., 2019). When the weather is not friendly, farmers have a hard time growing their crops and taking care of them (Islam et al., 2019). Climate change and the rising sea levels also make it hard for farming in the long run. It's like the land where we grow our food is being taken away by the sea. This is bad because it makes people move away from their homes, and it also means there's less food to eat (Haque et al., 2020).

AI-powered solutions will help farmers increase productivity while also enhancing crop quality, quantity, and ensuring a quicker time to market. Thousands of data points on temperature, soil, water use, weather, etc. are generated daily by farms. This data is used in real-time by artificial intelligence and machine learning models to get insightful knowledge, such as when to plant seeds, which crops to choose, which hybrid seeds to choose for higher yields, and other things. Precision agriculture, often known as artificial intelligence systems, is assisting in enhancing the overall quality and accuracy of harvests (Javaid, Haleem, Khan, & Suman, 2023). AI technology aids in the detection of pests, plant diseases, and undernutrition in farms. Artificial intelligence (AI) sensors can identify and target weeds before deciding which herbicide to use in the area (Gülen, 2022). This lowers the need for herbicides and lowers costs. Many technical firms created robots that accurately monitor weeds with spray guns by using computer vision and artificial intelligence. These robots can reduce the amount of pesticides that are typically sprayed on crops by 80% and the cost of herbicides by 90%. (Talaviya, Shah, Patel, Yagnik, & Shah, 2020).By substantially reducing the amount of pesticides required in the fields, these smart AI sprayers can increase the quality of agricultural output while also bringing about economic efficiency.Modern computer-integrated artificial intelligence applications made the development of computing systems—particularly processors with Graphical Processing Units (GPU) embedded—essential. Deep learning, a new category that has been created as a result of this, is now comprised of new approaches and models. On networks of synthetic neurons, deep learning techniques are founded. They have been shown to provide great utility when optimized for a variety of tasks (classification,

regression, picture segmentation, object identification, etc.), where both feature extraction and decision-making are trained end-to-end. The detection and diagnosis of plant illnesses, the prediction of plant water content, and the identification of plant species are just a few of the agricultural applications where deep learning models have excelled. There are several more possible uses for deep learning in smart aquaponics systems in addition to its contributions to aquaculture, including fish recognition and classification, age and size estimation, behavior analysis, and feeding decisions (Saleem, Potgieter, & Mahmood Arif, 2019). Farmers can quickly see problems like leaf darkening or wilting, which can be early symptoms of disease or insect infestation, by utilizing computer vision to evaluate photos of crops(Advising, 2023). To optimize planting, irrigation, and fertilizing, precision farming makes use of real-time weather, soil moisture, and crop health data (Haryanto et al., 2019).

If thorough monitoring, control, and management are used throughout the system, modern aquaponics systems may be more effective and successful (Haryanto et al., 2019).

Aims & Objectives:

The main goal of this research is to provide a forward-thinking demonstration of how aquaponics might be used in rural areas to create and sustain an environmentally sound and enduring farming methodology. Following objective are mentioned of the study.

- To evaluate aquaponics' effects on regional agriculture's sustainability.
- To determine whether aquaponics can be successfully implemented in rural villages.
- To determine the obstacles and restrictions related to the implementation of aquaponics in these areas.
- To provide practical recommendations for establishing and maintaining sustainable aquaponics farming practices in rural settings

Methodology

Data collection

The paper used qualitative research method. The research is structured into two distinct phases. This first section explores the history, components, methods of use, and benefits and drawbacks of aquaponics. A range of sources, such as books, academic journals, organizational reports, journal articles, and internet media, are used to collect secondary data. In the second stage, two nearby locations that actively employ a variety of farming techniques, likely to aquaponics, are physically visited. After that, the information gathered from both sources is systematically combined and examined. This synthesis enables the formulation of recommendations and the exploration of the potential of aquaponics in contributing to sustainable farming practices within rural settings.

Study area

Study areas were selected two coastal area namely, Bhashachar under Noakhali District Shymnagar Upazila under Satkhira of Bangladesh.

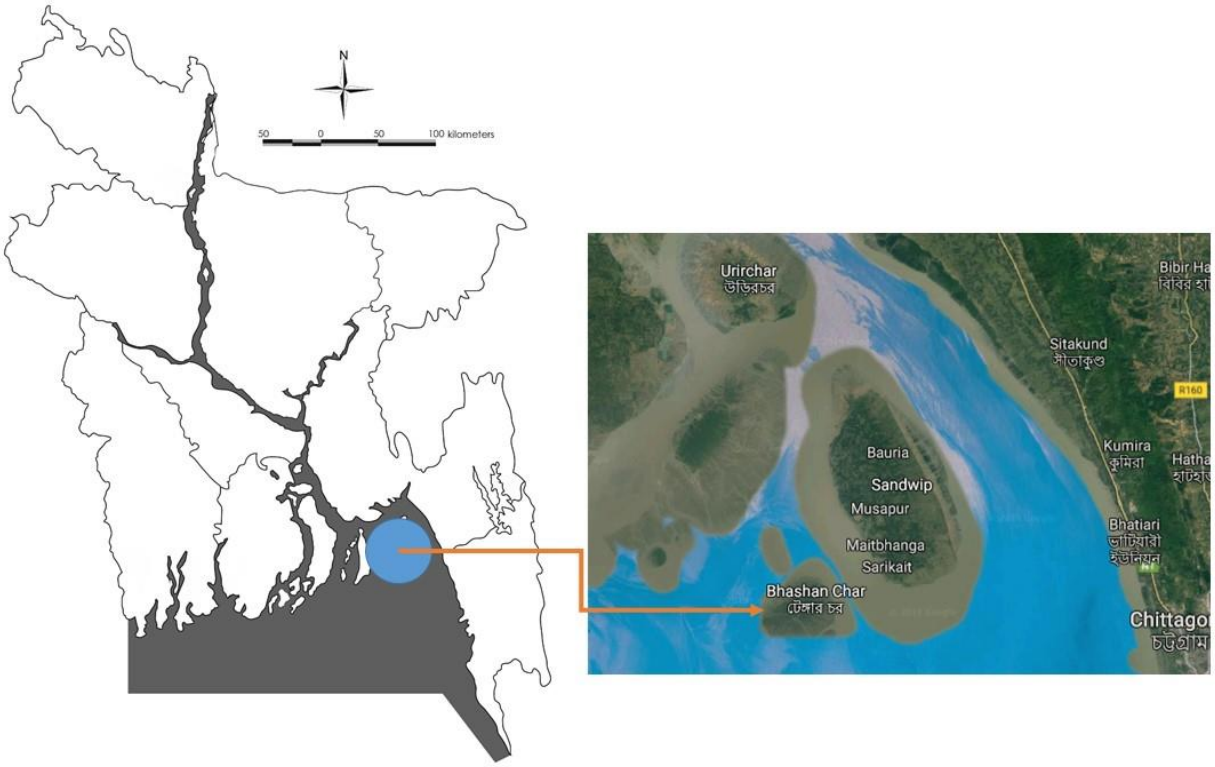

Figure A: "Bhashanchar" located in the map of Bangladesh

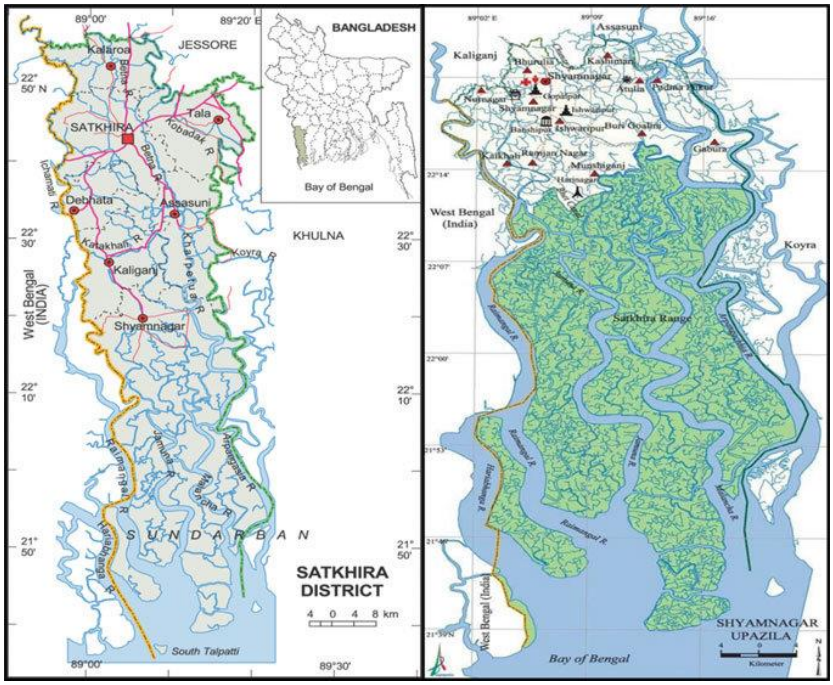

Figure B: Map Of Sarkhira Disrict (Left) & Shyamnagar Sub-District (Right)

Discussion

Case study 1: Bhashachar

BhashanChar or formerly known as Thengar Char literally means floating island as this island or Char gets partially flooded in monsoon seasons and is susceptible to storm surges. Around the time of 2020, a part of Rohingya people were resettled here under the project of Ashrayan-03 by Bangladesh Government. The whole plan was to provide them temporary shelters along with livelihood opportunities among which wage workers, cash for works and others were included. At least 24% of Rohingya people residing at VashanChar depend on sectors like agriculture, fisheries and livestock.

Figure C: Bhashanchar Area

As the resources were limited compared to the amount of displaced people the government had to relocate, the agriculture sector of this Char had to be innovative and climate smart; one of which was integrated farming or aquaponics in this case.

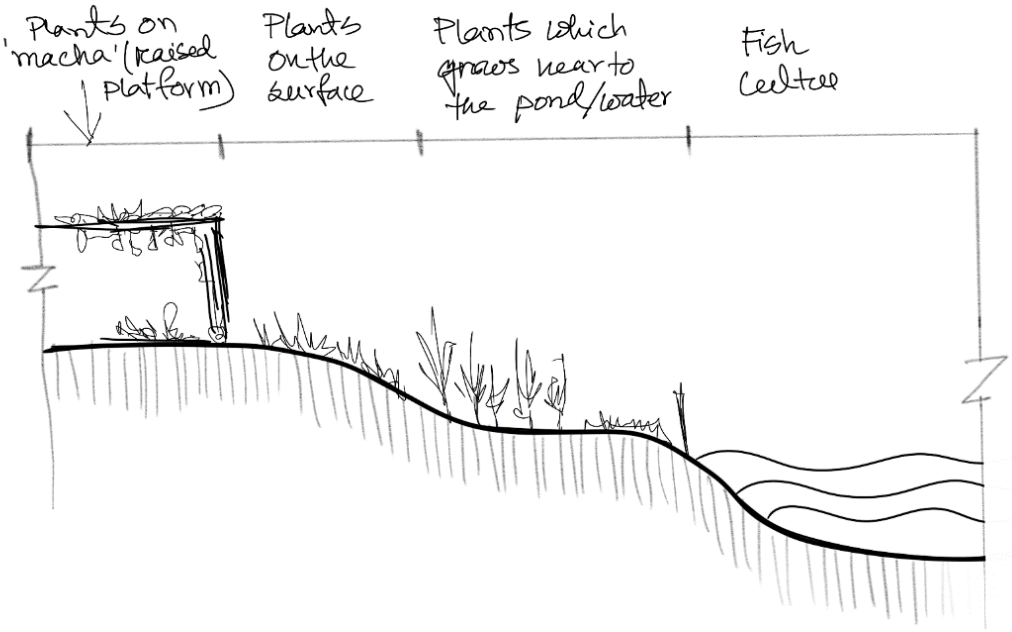

Figure D: Section of the farming model

BhashanChar does not still have the salinity intrusion problem in soil and water like some of the regions in coastal belt of Bangladesh, but the source of freshwater is limited still. With the help of NGOs like BRAC, a freshwater lake was established in one of the market places within the Char. The lake serves as the primary source of drinking water as well as water supply for irrigation and livestock rearing. At least 18% people in the island are involved in some form of agriculture- mostly women. The lake serves as the hub for integrated farming but there are other practices like- vertical farming, low bed seeding, tower farming etc. The lake is huge and belong to the community as a whole. The lake has various surrounding vegetation on different levels. The bank of the lake has vegetation like- laal shak, pui shak, mula shak etc (shown in figure C). Just beneath the bank there are macha or fences built to support vegetables like- gourds, pumpkins, spinach, beets, bitter gourds etc. At the ground level, just beside water there are vegetables like- kolmi shaak etc. As the lake is freshwater and recharged regularly through rainfall, there are freshwater fishes that are being cultivated like- ruhi, katla, paangash, silver carp, mirror carp etc. As the lake is used for daily necessities, no significant amount of chemicals or pesticides is to be used. The fish gets enough food through the nitrification process of these vegetables growing near/on the bank.

Figure E: Low Bed Seeding

The process is an example of good agricultural practices (GAP) and definitely a sustainable one but there are some limitations to this as well. First of all, the production rate is not that great for the crops and vegetables being grown there. Also, as this is just one lake and there are not enough spaces for this kind of aquaponics to experiment, the community is not heavily dependent on the technique. Though there are limitations, integrated crop-fish farming offers a solution by contributing to food, income, and nutrition. There is untapped potential in the lands and waters, especially for increasing fish production through aquaculture in low-lying rice fields with a warm climate and fertile soil. Sustainable fish production involves various practices, including soil considerations and local demand. While sustainable fish farming systems are site-specific and individualized, several general principles can guide growers in selecting appropriate management practices: species selection suited to the site and farm conditions, intensification and diversification of fish and crops, proper management, efficient input use, and consideration of farmers' goals.

Case study 2: Shyamnagar, Shatkhira

Shyamnagar of Shatkhira is considered one of the most climate vulnerable places in the coastal part of Bangladesh mainly due to the adverse climatic impacts on soil and water resources of this region. The upazilla faces a critical water scarcity and livelihood options are quite limited due to rising salinity levels on soil and water. So much so that people are being migrated internally elsewhere to find jobs and settle. But against all odds, some people are striving to their existence and practicing integrated agriculture with the assistance of some local NGOs and the government. The region was once quite popular for its agricultural crops but during the ‘90s there was a growing interest on saline water prawn cultivation which eventually has increased the rate of salinity in the soil and water. As a result, most crops do not grow well now.

The Shyamnagar region is quite vulnerable but also acts as an adaptation laboratory for the entire coastal belt of the country. So many potential techniques of good agriculture are there and if proper technology for AI assistance is involved, the production rate could be doubled.

Figure E: Left (Vertical Garden), Right (planting in soaked banana tree)

People have adapted to this increasing salinity level through different CSA (climate smart agriculture) techniques such as using soil mulch, integrated farming-fishing-livestock, tower farming, floating bed seeding etc. In Shyamnagar upazilla of Shatkhira district most of the villagers have adopted some sorts of alternative farming and specially aquaponics. There have been examples of growing vegetables in fences like- gourds, bitter gourds, pumpkins and different sorts of beans etc. At the same time those ponds have fishes that can tolerate high level of saline water. Another practice is cultivation of white prawns instead of regular prawns because they do not need that high level of saline water and still their production rate is pretty good.

Design Vision (Hypothetical Module of a Village)

The goal of the "smart village" concept is to equalize digital opportunities for rural and urban communities by bridging the digital barrier between them. Ancient villages, with agriculture as their main source of income, were formed by historical, cultural, and environmental elements, in contrast to modern smart communities. For social interaction, defense, and effective land usage, houses were frequently grouped together.

Figure 1 Village scenario

In order to optimize water consumption, fertilizer application, and crop monitoring, this may require the use of sensors, data analytics, and precision farming methods. In order to provide clean and sustainable energy solutions, smart villages frequently emphasize the utilization of renewable energy sources, such as solar or wind power. To fulfil the community's energy demands, this may entail setting up solar panels, mini-grids, or micro grids.

Figure 2 Modular units of smart village

Figure (2) represents multiple units of household with multiple fish tank. To provide the best conditions for fish and plants, the system consists of several fish tanks, grow beds, water pumps, aeration systems, bio filters, and automated monitoring systems. The main element of an aquaponics system is fish tank. It contains the fish and offers a healthy environment for their growth. The type and quantity of fish being grown determines the tank's size and layout. The plant cultivation takes place in the grow bed. To support the plant roots and offer stability, it is typically filled with a growth media, such as gravel, expanded clay pellets, or coconut coir. The fish tank's water pours into the grow bed, feeding the plants nutrition. The water is moved back and forth from the grow bed to the fish tank using a water pump. It guarantees a constant flow of water, feeding the fish tank with oxygen and providing nutrients to the plants

Figure 3 Module household

Figure (3) Depicts a scenario of a single household using Aquaponics with the help of solar powered energy source. Growing both necessary flora and fauna to survive sustainably as a family unit. This water body can also be helpful in terms of retaining rainwater. In the previous figure we have shown a hypothetical illustration of these single units working together as a community and harvesting fish and vegetables.

Figure 4 planting in smart village

Figure 5 Typical scenario of smart village

The residents' quality of life is improved by the inclusion of aquaponics in the smart community. Food insecurity is decreased and health outcomes are improved when fresh, wholesome food is readily available throughout the year. Because of the smart village's dedication to sustainability and environmental protection, everyone may live in a cleaner and healthier environment.

90% less water is used in aquaponics than in conventional farming. A closed-loop system for recycling water and fertilizers saves water. No hazardous fertilizer escaped and into the water shed. Farms are forced to apply a lot of fertilizers in an effort to preserve nutrient-rich soil. Eventually, those extra fertilizers find their way into the rivers, where they have a variety of negative side effects a tremendous amount of fresh water evaporates or is otherwise wasted with conventional farming methods. Third-world countries often lack the financial resources, arable land, and technology to produce sufficient food, and in particular enough protein to maintain the health of their human populations. There are also health concerns raised by humans consuming pesticide residues on fruits and vegetables and hormones in chicken, pork and beef. Wild birds and animals are adversely affected by pesticides and fertilizers.

Findings

Social Benefit

a) Specialized training was required at the research site to sustain the farming method. If learners acquire technical understanding about AI tools, it would be highly advantageous for them to highlight AI and aquaponics as educational benefits.
b) With the growing urban population, aquaponics can address food security and infrastructure issues in urban areas, including "food deserts. Aquaponics in urban settings with the help of AI can serve multiple functions, such as interior greening and use in social institutions.
c) Aquaponics can help improve livelihoods and food security in extreme climate condition by providing both protein (fish) and vegetables. In favorable climates, simple, low-tech aquaponics systems can be effective in providing sustainable food sources in low and medium income countries.

Economic benefits

a) Traditional crop production and fish farming have significant negative environmental impacts, including soil erosion, pollution, and greenhouse gas production. Aquaponics systems, which combine plant production and fish farming, reduce environmental impact and generate minimal waste.
b) Reducing fish feed costs through alternative feeds or reduced fish meal and oil content can improve both environmental and economic benefits.
c) Aquaponics is cost -intensive. The cost of labor and energy is a critical factor, however, it can be balanced by skilled labor and help of AI.

Conclusion

Combining ancient wisdom with modern technology may bring about solutions to our demise. We cannot deny the impact and implementation of Artificial Intelligence these days. Since Agriculture is one of our fundamental aspect of survival as a species it is a matter of time we rethink and reinvent it. Earth's atmosphere is deteriorating by the minute and we should make the effort to re-consider the archaic ways of growing our foods. We believe with the proper use of state of the art technology combined with aquaponics a new frontier can be discovered in the field of Agriculture. In order to lead a healthy and robust life as an integral part of the ecosystem we humans need to have access to fresh source of crops. Artificial intelligence and machine learning have the potential to reduce the excessive use of water, pesticides. It can also be precise in terms of providing nutrition to the pants and aquatic creatures. As we have discussed in this paper, a smart village does not only mean less human labor but also a vibrant and healthy environment. We are merging the past and the present in order to forge a better future.

References

Ali, A. et al. (2019). Impacts of salinity intrusion on agriculture in coastal regions of Bangladesh. Journal of Environmental Management, 233, 399-407.
Boutwelluc, J. (2013). "Aztecs' aquaponics revamped". Napa Valley Register.
Clark, J. (2016). "Why 2015 Was a Breakthrough Year in Artificial Intelligence".
Copeland, B. (2023, June 16). From www.britannica.com: . www.britannica.com
Department of Fisheries. Dhaka, B. (2010). *Fishery Statistical Yearbook of Bangladesh.* Dhaka.

Encyclopedia. (2020). *Declining agricultural land | World Problems & Global Issues |* . From The Encyclopedia of World Problems: http://encyclopedia.uia.org/en/problem/132940

Hoanh, T. P. (2006). *Managing diverse land uses in coastal Bangladesh.*

K., Panda, P. &., Padhi, S. &., & Surendra. (2016). Aquaponics: An innovative approach of symbiotic farming. *International Journal of Bioassays*.

LeCun, Y., Bengio, Y., & Hinton , G. (2015, May). Deep learning. *nature*. doi:https://doi.org/10.1038/nature14539

Rakocy, J. E. (2012). "Aquaponics-Integrating Fish and Plant Culture", Aquaculture Production Systems. pp. 344–386. From doi:10.1002/9781118250105.ch14

Review, B. E. (2013). *Economic Review.*

Russell, S. J., & Norvig, P. (2003). Artificial Intelligence: A Modern Approach (2nd ed.).

Statistics, B. B. (2011). *Population and Housing Census Report.* Dhaka: Ministry of Planning. Dhaka, Bangladesh.

youmatter. (2020, May 16). From https://youmatter.world/en/definition/aquaponics-sustainable-benefits-system

Bradley, K. (2022, April 12). Aquaponics: A Brief History of This Integrated Fish & Veggies System. Retrieved from https://www.milkwood.net/2014/01/20/aquaponics-a-brief-history/

Fred. (2021, December 14). The History of Aquaponics. Retrieved from https://horticultureadvice.com/the-history-of-aquaponics/

Dabbadie, L., Stankus, A., Yuan, D., & Halwart, M. (2019). Report of the special session on advancing integrated agriculture-aquaculture through agroecology, Montpellier, France, 25 August 2018. FAO eBooks. Retrieved from https://agritrop.cirad.fr/594534/

Attanà, S. (2023, April 6). Saving soil and water with aquaponics - H-alo. Retrieved from https://h-alo.eu/saving-soil-and-water-with-aquaponics/

Benefits of Aquaponics - Evergreen Lane Farm. (2015, February 23). Retrieved from https://www.evergreenlanefarm.net/benefits-aquaponics/

Karimanzira, D., & Rauschenbach, T. (2018, January 1). Optimal Utilization of Renewable Energy in Aquaponic Systems. https://doi.org/10.4236/epe.2018.106018

Balsom, P. (2020, September 29). Water Usage In The Agricultural Industry. Retrieved from https://htt.io/water-usage-in-the-agricultural-industry/

Environmental Implications of Excess Fertilizer and Manure on Water Quality. (2023, February 21). Retrieved from https://www.ndsu.edu/agriculture/extension/publications/environmental-implications-excess-fertilizer-and-manure-water-quality

Wang, Y., Yang, T., & Kim, H. J. (2023, April 24). pH Dynamics in Aquaponic Systems: Implications for Plant and Fish Crop Productivity and Yield. https://doi.org/10.3390/su15097137

Chapter 5 : Food Security — Special Report on Climate Change and Land. (n.d.). Retrieved from https://www.ipcc.ch/srccl/chapter/chapter-5/

Hanson, J. R. R. W. T. S. C. (n.d.). How to Sustainably Feed 10 Billion People by 2050, in 21 Charts. Retrieved from https://www.wri.org/insights/how-sustainably-feed-10-billion-people-2050-21-charts

Javaid, M., Haleem, A., Khan, I. H., & Suman, R. (2023, March 1). Understanding the potential applications of Artificial Intelligence in Agriculture Sector. https://doi.org/10.1016/j.aac.2022.10.001

Gülen, K. (2022, July 25). AI In Agriculture: Computer Vision And Robots Are Being Used For Higher Efficiency - Dataconomy. Retrieved from https://dataconomy.com/2022/07/25/ai-in-agriculture/

Talaviya, T., Shah, D. N., Patel, N., Yagnik, H., & Shah, M. (2020, January 1). Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides. https://doi.org/10.1016/j.aiia.2020.04.002

Saleem, Potgieter, & Mahmood Arif. (2019). Plant Disease Detection and Classification by Deep Learning. *Plants*, *8*(11), 468. https://doi.org/10.3390/plants8110468

Karimanzira, D., & Rauschenbach, T. (2019). Enhancing aquaponics management with IoT-based Predictive Analytics for efficient information utilization. *Information Processing in Agriculture*, *6*(3), 375–385. https://doi.org/10.1016/j.inpa.2018.12.003

Goddek, S., Delaide, B., Mankasingh, U., Ragnarsdottir, K., Jijakli, H., & Thorarinsdottir, R. (2015). Challenges of Sustainable and Commercial Aquaponics. *Sustainability*, *7*(4), 4199–4224. https://doi.org/10.3390/su7044199

Lobillo-Eguíbar, J., Fernández-Cabanás, V. M., Bermejo, L. A., & Pérez-Urrestarazu, L. (2020). Economic Sustainability of Small-Scale Aquaponic Systems for Food Self-Production. *Agronomy*, *10*(10), 1468. https://doi.org/10.3390/agronomy10101468

Rajalakshmi, M., Manoj, V. R., & Manoj, H. (2022). Comprehensive Review of Aquaponic, Hydroponic, and Recirculating Aquaculture Systems. *Journal of Experimental Biology and Agricultural Sciences*, *10*(6), 1266–1289. https://doi.org/10.18006/2022.10(6).1266.1289

Udanor, C., Ossai, N., Nweke, E., Ogbuokiri, B., Eneh, A., Ugwuishiwu, C., . . . Christiana, A. (2022). An internet of things labelled dataset for aquaponics fish pond water quality monitoring system. *Data in Brief*, *43*, 108400. https://doi.org/10.1016/j.dib.2022.108400

Jan, F., Min-Allah, N., & Düştegör, D. (2021). IoT Based Smart Water Quality Monitoring: Recent Techniques, Trends and Challenges for Domestic Applications. *Water*, *13*(13), 1729. https://doi.org/10.3390/w13131729

Vergeer, A. (2022, March 25). The Benefits of Aquaponics. Retrieved from https://gogreenaquaponics.com/blogs/news/what-are-the-benefits-of-aquaponics

Vardali, S., Papadouli, C., Rigos, G., Nengas, I., Panagiotaki, P., & Golomazou, E. (2023). Recent Advances in Mycotoxin Determination in Fish Feed Ingredients. *Molecules*, *28*(6), 2519. https://doi.org/10.3390/molecules28062519

MANAGEMENT for freshwater fish culture. (n.d.). Retrieved from https://www.fao.org/fishery/docs/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e10.htm

Rizal, A., Dhahiyat, Y., Zahidah, Andriani, Y., Handaka, A. A., & Sahidin, A. (2018). The economic and social benefits of an aquaponic system for the integrated production of fish and water plants. *IOP Conference Series: Earth and Environmental Science*, *137*, 012098. https://doi.org/10.1088/1755-1315/137/1/012098

Kozai, T., Niu, G., & Masabni, J. G. (2021). *Plant Factory Basics, Applications and Advances*. Academic Press.

Haryanto, Ulum, M., Ibadillah, A. F., Alfita, R., Aji, K., & Rizkyandi, R. (2019). Smart aquaponic system based Internet of Things (IoT). *Journal of Physics: Conference Series*, *1211*, 012047. https://doi.org/10.1088/1742-6596/1211/1/012047

Goddek, S., Joyce, A., Kotzen, B., & Burnell, G. M. (2019). *Aquaponics Food Production Systems*. Springer.

Advising, P. (2023, April 27). The Most Common Aquaponics Problems. Retrieved from https://gogreenaquaponics.com/blogs/news/the-most-common-aquaponics-problems-and-how-to-fix-them

Pesticide residues in food. (2022, September 15). Retrieved from https://www.who.int/news-room/fact-sheets/detail/pesticide-residues-in-food

SMART IRRIGATION FOR SUSTAINABLE RURAL DEVELOPMENT: A STUDY OF NALBARI IRRIGATION CIRCLE

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Abstract: *As the global* population is growing*, the demand of food required to adequately feed people is increasing. In this regard United Nations Sustainable Development Goal Number 2 which is about creating a world free of hunger that is "Zero Hunger" by 2030 is playing an important role. And for achieving that proper water management is required both to increase the food production and to reduce the waste of water. Irrigation is the most critical input for increasing the agricultural production to meet the food requirement of increasing population. Solar powered smart irrigation is mainly used for supplying optimum amount of water for maximum growth of the crop. The government of India has already taken many initiatives for ensuring energy security for farmers in India. Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) project intends to give greater financial security as well as more sustainable water access to the farmers by generating solar electricity on their farms. The major goal of this scheme is to add solar capacity of 30,800 MW by 2022 including roughly 20 lakh off-grid pumps. In Assam total irrigation potential created through Govt. Irrigation Schemes for the year 2020-21 is 1041822 hect. out of which 17988 hect. is created through Pradhan Mantri Kreshi Sinchayee Yojana - Har Khet Ko Pani (Solar & Electrical) scheme. Smart irrigation is a powerful water management tool so its use in the agricultural land of the state of Assam is very important. In this paper an effective case study of smart irrigation in Nalbari district of Assam (India) is carried out with an objective to assess the social, economic and environmental sustainability of smart irrigation towards the achievement of the sustainable goals. This will help the researchers and farmers to better understand the smart irrigation techniques and will provide sufficient knowledge to carry out different irrigation related activities. So in near future Smart irrigation will be one of the prime directions to make sustainable rural development in Assam.*

Key words: *Energy Efficient, Zero Hunger, Sustainable Development, Water Management, Smart Irrigation.*

1. Introduction

Agriculture is the central pillar of Indian economy. Because of the population growth the demand for food is growing. Since cultivable land is limited and the amount of ground water is decreasing so proper land and water management is required to meet the required food demand. According to the Population Census of 2011, nearly 69% of the Indian population resides in rural areas. In this regard Irrigation will play an important role in achieving sustainable rural development. Solar powered irrigation systems (SPIS) reduce energy costs for irrigation. The main reason behind using solar powered irrigation system is because it could be deployed in places with inadequate or no grid power. Now farmers have control over supply of electricity and water through solar water pumps (SWP). So a lot of emphasis is given in using renewable source of energy. But water waste due to improper water supply management in irrigation is still a matter of concern which leads to the decrease of ground water. Since majority portion of the agriculture land of Assam falls in rural area, so the water supply management in irrigation will be major step towards sustainable rural development of Assam. The intention of this work is to develop a smart irrigation process for proper water management in drip irrigation farming. The SMART irrigation system consists of different devices used for different purposes such as control, monitoring, detection and action of water supply. In this study a farm near Pagladiya River of Nalbari district of Assam, India is chosen for the development of the solar powered SMART irrigation as shown in the Google Map (Figure 1). The layout of the farm is as shown in the figure 2. The process is mainly used in the irrigation of Banana plants.

Figure 1: Place of the farm in the Google Map - Nalbari district, Assam, India

Figure 2: Farm layout near Pagladia river of Nalbari district

2. Literature Review

According to Bureau of Energy Efficiency, Ministry of Power, Government of India there are about 19 million agricultural pump sets presently used in India and around 2.5 to 5 lakh new pump sets are installed every year. This agriculture power consumption is 22% of total electricity consumption. And this growing electricity load is becoming a challenge for electricity utility in India. Along with that water scarcity has a huge impact on food production. According to the International Water Management Institute, agriculture accounts for about 70% of global water withdrawals. So decreasing ground water level is another threat to the production of food for the fast growing population. So solar powered smart irrigation is the only solution for this water and energy crisis. In an article by Zaher et al. (2018) is about the design of Automated Smart Solar Irrigation System (ASSIS) which is water and electricity efficient and powered by solar panels to make it eco-friendly. A distributed network of sensors was connected, wirelessly, to a control unit that was responsible for both controlling and monitoring the irrigation process. The weather condition was constantly monitored to see the need of irrigate the soil. A water pump was used to store the water in an elevated tank and a drip tape was used for slow and efficient distribution of water to all the crops. The power supply and irrigation system were constantly controlled and an alarm was used in case of emergencies. Users could

remotely monitor both the temperature and the pH of the soil via their laptops or smart phones. This Automated Smart Solar Irrigation System (ASSIS) is very effective and allowed saving of water, and uniform irrigation to all areas. In the article by Rout et al. (2018) is about the design and implementation of an Internet of Things based solar powered smart irrigation system with control and monitoring features. In this proposed model of smart irrigation system ESP8266 was used as its main controller. In the article by Al-Ali et al. (2019) is about the Internet of things (IoT) solar energy powered smart farm irrigation system. This system utilizes a single board system-on-a-chip controller with built in Wi-Fi connectivity and it is connected to a solar power system. The controller reads the soil moisture and temperature and according to the outputs it operates the irrigation pump. This system has three operating modes - local control mode, mobile monitoring-control mode, and fuzzy logic-based control mode.

In line of the above discussion the objectives of the current research work are as follows –

a) Development of a solar based drip irrigation system for supply of water in a banana farm
b) Deploy of soil moisture monitoring system in the irrigation process
c) Water management by monitoring the water usage during the irrigation process.

3. Proposed System

The proposed solar powered smart irrigation system is set to incorporate in a farm near Pagladiya River of Nalbari district of Assam. Here solar energy from solar panels is used to run a pump to extract water from bore well which is latter supplied to the plants through drip irrigation system. The irrigation facility is mainly used for the growth of Banana plants. There are about 200 numbers of Banana plants. These are planted in row wise with 10 numbers of plants in each row. In conventional methods two pumps are used, one for pumping the water from bore well to a reservoir and another pump is to supply the water from reservoir to the field. But in the proposed system only a single stage energy consumption pump is used to pumped the water from bore well to the reservoir from which a simple valve mechanism controls the flow of water into the field. It reduces the amount of energy use. The valve is controlled using a microcontroller which regulates the flow of water into the field depending upon the moisture requirement of the land. In this system a soil moisture sensor is used which detects the amount of moisture present in the soil and when the moisture of the soil varies from the predefined range, the water supply will be switched on or off accordingly. Moreover this smart irrigation system allows farmers to automate the irrigation processes through Internet of things (IoT) via SMS, email and other online interfaces. Figure 3 shows the basic architecture of the proposed SMART irrigation.

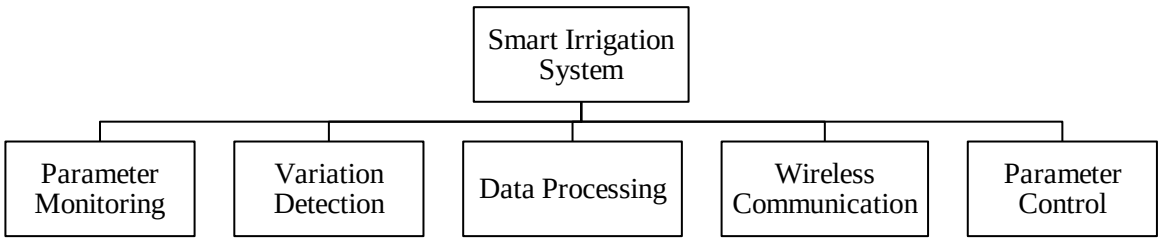

Figure 3: Basic architecture of the SMART irrigation

4. Methodology

The major objective of this work is to form an economic and environmentally suitable SMART irrigation system for the sustainable rural development in Assam. Keeping in view that the drip irrigation is used which is a powerful technique that can reduce the water consumption by 50-60% and increase crop yield by 20-30%. Along with that soil moisture sensors are used for controlling the water supply. The methodology used in this work can be divided in to four parts as follows –

A. Supply of water through Drip Irrigation

Drip irrigation is the most efficient way of water supply for the growing of crops. The water is delivered through system of pipes and valves to the root zone of individual plants. In the present study a drip water supply network is created for the growing of banana plants which are at a distance of 5 to 6ft from each other. For increasing the productivity of banana plants a large quantity of water is required. It is seen that for normal growth, a banana plant require 25 mm of water per week. A comparison is done regarding the growth of banana plant with and without drip irrigation. But for increasing the operational effectiveness and to ensure efficient water supply a constant control and monitoring system is required. For that the solar powered smart irrigation system is proposed.

B. Sensing of the parameters

A sensor can be defined as a device that sense or detect the farm parameters for decision making by the controller. The sensors are basically low cost capacitance based type, which work in the principle of a dielectric device. The sensors can be placed in the root zone of the Banana plants which measure the moisture content of the soil and send the reading to the controller. The actuators consist of relays and water pump and when the soil moisture varies from the predefined range it receive signals from the controller and subsequently release the water to the farm land. A 20 KW solar panel use for the supply of the electric energy to run the water pump. The block diagram of the system is as shown in the figure 4

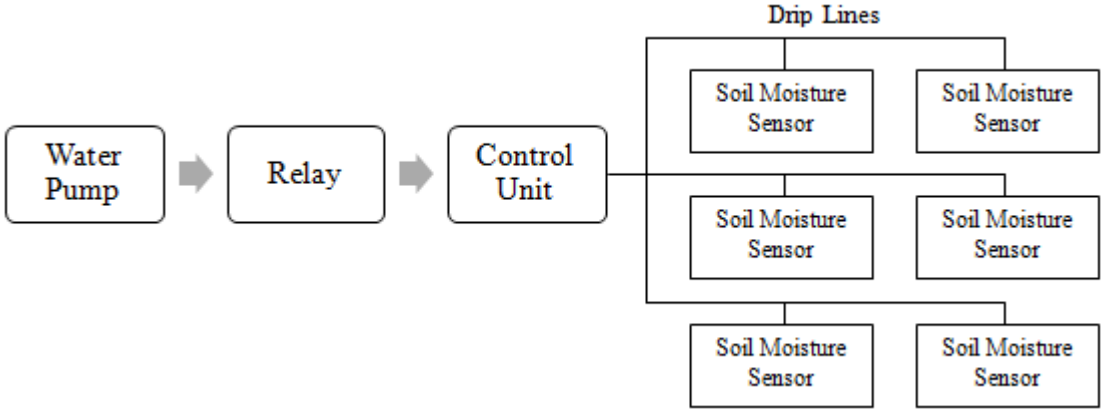

Figure 4: Block diagram of the system

C. Controlling of the data

A sensor send an output signal of different parameters which a controller receive and process it to maintain a required physical environment. The soil moisture can be measured by the sensors and they send the data to an Arduino Mega microcontroller. The controller receives the data through analog input pins. The sensors are connected using AND gate to develop a Boolean logic for sensing the moisture. When soil moisture level is very low, sensors will specify this condition by giving '0' at their output and when the soil moisture level is in desired level sensors will specify this condition by giving '1' at their output. The output of the sensors are connected to an AND gate as an input. So when the soil moisture level is very low the Arduino send signals to the water pump to supply the water in the field and when the soil moisture level is high the watering system will be stop. The flow chart of the control system is as shown in the figure 5.

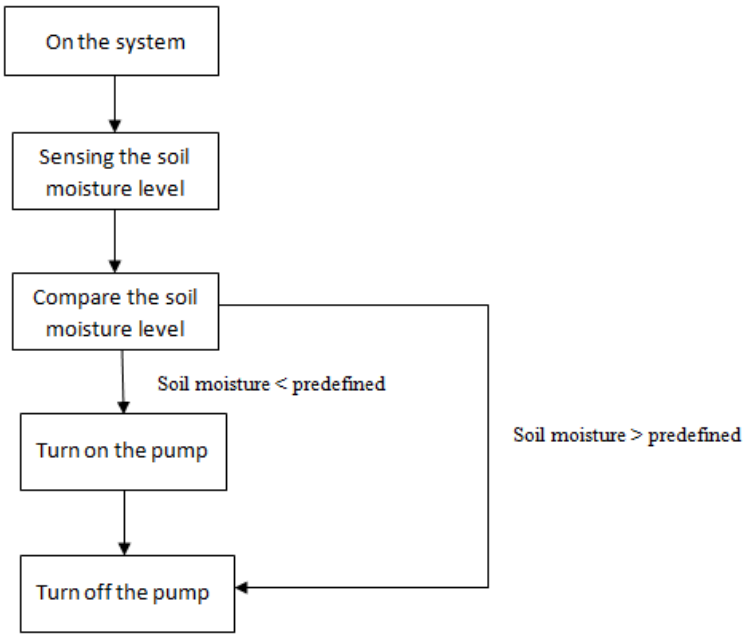

Figure 5: Flow chart of the control system

D. Communication of the control system

Communication network is one of the vital and imperative parts to attain successful irrigation water supply. There are various wireless techniques which can be used for transfer the data from the control unit to the IoT devices. Wi-Fi is one of the most effective communication technologies because of its wide range of accessibility. Here a communication layer can be established between the smart irrigation system and a cloud server. A Wi-Fi module is used, which allows the microcontroller to access the Wi-Fi network. Once the Wi-Fi is connected to the internet, the irrigation process can be controlled from anywhere in the world.

5. Results and Discussion

During the growth of any plant soil moisture play a very critical role. In the present work drip irrigation system for banana plant is used for maintaining the optimum soil moisture level for better growth and to increase the productivity. Figure 6 shows the banana farm where drip irrigation is used and figure 7 shows the drip irrigation used in it.

Figure 6: Banana Farm

Figure 7: Drip irrigation used in banana plant

The growth of the banana plant with and without drip irrigation system is compared. It is found that the water supply in drip irrigation system is much lower than the conventional water supply. The drip irrigation helps to save 50-60% of water. The average time requires from planting to shooting (vegetative) of banana plant is about 8 months but by using drip this time can be reduced by almost one month. And about 2 month is required from shooting to harvest (flowering and yield formation) which can be further reduced by optimum supply of water through the drip irrigation. It can be concluded that drip irrigation increases the yield by 20-30%. Latter a solar powered SMART irrigation system is proposed to monitor and control the water supply to increase the productivity by using renewable source of energy.

6. Conclusion

Water management is a critical factor in the cultivation of any crops. As a developing state Assam require a lot of emphasis on the utilization of energy and management of the water supply for the sustainable development of the rural areas of Assam. In the present work a study of drip irrigation in banana plants is done and a solar powered smart irrigation system is proposed to increase the effectiveness of this drip water supply process. It is found that drip irrigation helps to save 50-60% of water and increase the yield by 20-30%. By using the SMART irrigation system optimum amount of water can be supplied, moreover it will reduce the human intervention. The excess electrical energy generated by the solar panels can be given to the grid supply, which can be utilized in other purposes. So this solar power SMART irrigation will be a major step against the energy crisis and for the sustainable rural development in Assam.

References

Al-Ali, A.R., Nabulsi, A.A., Mukhopadhyay, S., Awal, M.S., Fernandes, S., Ailabouni, K. (2019) *IoT-solar energy powered smart farm irrigation system*, Journal of Electronic Science and Technology, Volume 17, Issue 4

Agriculture demand side management, Bureau of Energy Efficiency, Ministry of Power, Government of India

Fact Sheet on Agriculture Demand Side Management (AgDSM), Press Information Bureau, Government of India, Ministry of power, dated 09-October-2015

Rout, K.K., Mallick, S., Mishra, S. (2018) *Solar Powered Smart Irrigation System Using Internet of Things*, 2nd International Conference on Data Science and Business Analytics (ICDSBA)

Zaher, A., Hamwi, H., Almas, A., Al-Baitamouni, S., Al-Bathal, M. (2018) *Automated smart solar irrigation system*, Smart Cities Symposium 2018

Dynamics of local and foreign contractors in developing countries: The case of Tanzania

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Abstract: *Local contractors in developing countries such as Tanzania face various challenges to remain competitive in their respective industries. These challenges are numerous and stem from both internal and external variables. By contrast, foreign contractors are less impacted by these variables owing to numerous favorable conditions that enable them to prosper. This study aims to identify and analyze these variables and reveal what contributes to foreign contractors outperforming local contractors, despite numerous initiatives taken by the governments of these developing countries to support their local construction industry. The paper adopted semi-structured interviews and thematic analysis to assess industry experts' perspectives from two key stakeholder groups involved in infrastructure construction project delivery, including engineering consultants, Class I contractors, clients, and institution. These industry experts were selected using the purposive sampling approach. A total of 21 industry experts were interviewed. The findings revealed various variables contributing to the lack of success of local contractors. In addition, the findings showed that while foreign contractors pose challenges that threaten the survival of local contracting companies, they play a significant role in sustaining the industry through financial capital, timely delivery of projects, knowledge transfer, and technology transfer. Thus, the formulation of effective policies that seek to capitalize on the strength of foreign contractors and mitigate the obstacles faced by local contractors can lead to improvements in the performance of local contractors and the overall growth of the local construction industry. This study highlights strategies that can be adopted by the governments of developing countries to increase the competitiveness of local contractors by leveraging foreign contractors who take a significant share of projects.*

Keywords: *foreign construction firms, local construction firms, developing country, Tanzania, infrastructure projects.*

1 Introduction

In Tanzania, the recent increased investment in public infrastructure projects has led to the rapid growth of the construction industry. These projects, however, have been largely executed by foreign construction firms leaving behind the local construction firms (Kavishe and Chileshe, 2020). This low market share of the local construction firms reflects the systemic challenges faced by the local construction industry. Among other issues, this lack of participation in high value projects has been attributed to inadequate capacity of the local construction firms to undertake large-scale infrastructure projects (Burke, 2007; Saadan, 2013). Conversely, foreign construction firms are more involved in these projects because of their superior technical capacity and funding originating from their respective countries (Muhegi and Malongo, 2004; OBG, 2018). For example, certain foreign construction firms enjoy material and equipment subsidizes from their country. Further, since they bring in foreign currency, they also benefit from tax subsidies. This makes it very difficult for local construction firms to compete (OBG, 2018). Figure 1 presents the proportion of local to foreign firms, both consulting engineers and contractors, in Tanzania and their respective market share in terms of project value (Kikwasi and Escalante, 2020).

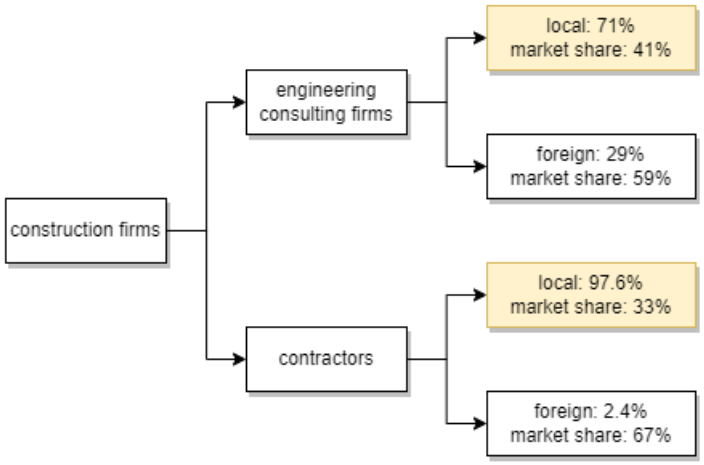

Figure 1: Relative market share of local and foreign construction firms (Ntiyakunze, 2011; UNESCO, 2018; Kikwasi and Escalante, 2020)

It can be observed from Figure 1 that although the foreign construction firms comprise a small percentage of the overall population of firms in the construction industry of Tanzania (i.e., 29% of local engineering consulting firms and less than 3% of the contracting firms are foreign), they take up a significant market share (59% of the market share goes to engineering consulting firms, while 67% of the market share goes to the contracting firms). Examining these figures, indicates that the issue is more acute for contractors as compared to the engineering consulting firms.

Understanding the root cause of this disparity can facilitate the process of identifying measures to address this issue. This is important since heavy reliance on foreign contractors can have an adverse effect on the sustained growth of local contractors.

Accordingly, the present study seeks the opinion of industry experts practicing in the Tanzanian construction industry to identify the various challenges, benefits, and possible solutions on the topic of foreign contractors.

The main objectives of the present study are:

1. Determine the challenges posed by foreign contractors to local contractors
2. Determine the benefits offered by foreign contractors to local contractors
3. Discuss policies for addressing challenges faced by local contractors due to foreign contractors

2 Literature review

Developing countries face the challenge of having their local contractors compete with foreign contractors who, owing to their relatively large capacity, are able to undertake large-scale public projects. For example, according to ECPMI (2019), in Ethiopia, most of the construction works are conducted by foreign construction firms since they possess the expertise to handle major projects. Belay et al (2021) notes that while the participation of foreign construction firms in Ethiopia leads to more competition in development projects, it also injects novel technologies and construction methods in the local construction industry. In addition, it allows the local construction firms to further develop. In Ghana, a similar pattern is observed. According to Osabutey et al. (2014), the local construction firms lack the capacity to handle complex projects. As noted by Owoo and Lambon-Quayefio (2020), large foreign firms are able to benefit from winning large projects owing to their large capital which make them immune to potential late payments from the government. This consequently means that local contractors are unable to compete. In Zambia, foreign contractors account for 85% of the public projects by value of works (Tembo *et al.*, 2022). In Nigeria, Oke et al. (2018) stress the significance of foreign contractors to the economic development of the country owing to the increase in complex projects. In Sri Lanka, Ashokkumar et al. (2023) notes that data showed that the foreign contractors bid 30% lower than the lowest local bidders.

Similar to the situation faced by the above developing countries, the Tanzanian construction industry is dominated by foreign contractors. In particular, the recent growth in the construction industry driven by investment in infrastructure projects has been mainly undertaken by foreign contractors (Kavishe and Chileshe, 2020). The lack of contribution from the local contractors has been attributed to numerous issues. For example, Kikwasi and Escalante (2018) indicate that insufficient management skills, financial base, and capital were among the issues that prevented local contractors from competing with their foreign counterparts.

The above discussion reveals the benefits and the challenges posed by foreign contractors operating in developing countries. While these variables may be similar, it is important to conduct a detailed analysis of the interplay between local and foreign contractors to identify key issues and propose interventions tailored to the Tanzanian context.

3 Methodology

The present study adopted semi-structured interviews to seek the opinion of industry experts involved in public sector projects in Tanzania. Thematic analysis was then used to assess the findings. The present study sought the perspectives of industry experts belonging to four key stakeholder groups involved in infrastructure construction project delivery, including engineering consultants, Class I contractors, clients, and institution.
With respect to sampling, Robinson (2014) proposed a four step approach to selecting a sample for qualitative research. This approach includes defining the target population, determining the sample size, devising a sampling strategy, and recruiting the sample. Accordingly, this study adopted the above framework to recruit participants for the study as follows:

- Industry experts with specific attributes were targeted. These attributes include having practiced in the Tanzanian construction industry and having been involved in the delivery of public sector projects.
- In terms of sample size, this study conducted 21 interviews with industry experts. The interviews were terminated when theoretical saturation was reached whereby new data did not reveal new information (Saunders *et al.*, 2012).
- Purposive sampling was adopted to select industry experts who possessed knowledge of the practices of foreign contractors in the public sector.
- Potential industry experts who met the above criteria and who consented to be interviewed were selected.

In all, a total of 21 industry experts were interviewed. Table 1 provides a summary of the industry experts who were interviewed in the present study.

Table 1: Summary of industry experts' profile

Participant	Position	Years of experience	Organization type	Educational level
A	Director	> 20	Consulting engineer	PhD
B	Civil engineer	5 – 10	Contractor	Bachelor
C	Civil engineer	< 5	Consulting engineer	Bachelor
D	Water engineer	< 5	Consulting engineer	Masters
E	Site engineer	5 – 10	Contractor	Bachelor
F	Engineer	< 5	Client	Bachelor
G	Director	> 20	Consulting engineer	Masters
H	Architect	> 20	Consulting engineer	Bachelor
I	Civil engineer	> 20	Consulting engineer	Bachelor
J	Civil engineer	5 – 10	Consulting engineer	Bachelor
K	Civil engineer	11 – 15	Consulting engineer	Bachelor
L	Civil engineer	> 20	Consulting engineer	PhD
M	Quantity surveyor	11 – 15	Client	PhD
N	Civil engineer	< 5	Client	Bachelor
O	Technical director	16 – 20	Consulting engineer	Masters
P	Civil engineer	11 – 15	Client	Masters
R	Manager	5 – 10	Institution	Bachelor
S	Highway engineer	> 20	Consulting engineer	Bachelor
T	Civil engineer	16 – 20	Consulting engineer	Masters
U	Civil engineer	> 20	Consulting engineer	Bachelor
V	Quantity surveyor	5 – 10	Contractor	Bachelor

4 Findings

This section discusses the various aspects of foreign and local contractors and how they impact each other.

4.1 Foreign contractors

4.1.1 Capacity of foreign contractors

Foreign contractors have more financial capacity when compared to local contractors. According to industry expert A, foreign contractors engage in construction projects which exceed the capacity of local contractors. In particular, industry expert A notes:

> *And some of the projects they [foreign contractors] are constructing, you wouldn't even go near them. A local contractor wouldn't even dare to go near them. You see because [in] class 1, is that there's class 1 and class 1, ok. They're not all the same. Class 1 are not all the same. You'll see in class 1 there's maybe 10 [different categories] classes. Now, these guys [foreign contractors] are at the very top*

In Tanzania, contractors are categorized into seven classes, with class I representing the largest contractors who are allowed to undertake construction projects of unlimited value (Kikwasi and Escalante, 2020). As noted above, though there are class I local contractors, they are small in comparison to class I foreign contractors.

The possession of capital is a major distinction between foreign and local contractors and contributes to the success of the former. According to industry expert B, foreign contractors have the advantage of having capital at their disposal in contrast to local contractors. In particular, participant 2 notes:

> "*Our counterparts [foreign contractors] can survive because they have large capital*"

Similarly, industry expert C supports this view and notes that:

> *The [foreign] company has equipment, the [foreign] company is financially stable*

This possession of capital also means that the foreign contractors are immune to late payments from the clients, which is a common challenge faced by contractors undertaking public projects in Tanzania. For example, industry expert C notes that:

> *Because, if, maybe, if we assume the government enables that project, a foreign company can say, "…me I can drive this project with my own funds until it's complete, then you can pay me."*

Similarly, industry expert D reinforces this view by stating that:

> *Yes, foreign contractors as well, yes. They … have a lot of cashflow so even if they have delays in payment, they can still do their job and wait for the payments*

4.1.2 Competition from foreign contractors

Foreign contractors pose considerable competition to the local contractors depriving them of work on major projects. For example, industry expert C notes that, while the local contractor can be technically capable, their lack of experience in undertaking large-scale projects mean that they do not win these projects:

> *So, it's a [local contractor] you can deprive of work when he [the foreign contractor] competes with someone who technically might be good but you have not seen undertake large projects.*

Industry expert E concurs with this view and states that:

> *That is, projects, let's [say] projects of billions, they [the government] consider a lot foreign [contractors]. Large projects. Because they have equipment. Different from local [contractors]*

Industry expert F agrees with this view and notes that local contractors are lacking in equipment and capital:

> *The challenge is the local contractor not having enough equipment and also capital.*

Industry expert G also notes that foreign contractors are able to win bids by bidding low:

> *The [foreign] contractors have come, they're bidding low, you know. So, that is a challenge. That one is there*

Furthermore, foreign contractors are able to win projects owing to the backing of their respective governments. In particular, industry expert H notes that:

> *Our counterparts [foreign contractors] get backup from their banks, "how much [funds] are needed? Here you go. How many billions? 30? Here you go". That way. "Equipment? Here you go". How many equipment do you see come down at the port, brand new, we're told are going to road projects. Where do they come from? It's not that [the foreign] contractor has procured those just for the project. No. They have received backup support from the government.*

This aligns with OBG (2018) where it was noted that Chinese contractors are able to leverage subsidizes on material and equipment from their country in addition to tax subsidizes by bringing foreign currency. This consequently means that local contractors are unable to compete.

4.1.3 Contribution of foreign contractors

Foreign contractors play an important role in supporting the Tanzanian construction industry through technology and knowledge transfer. For example, the significance of foreign contractors is highlighted by industry expert H who notes:

> *… we're rising because [of] foreign contractors. They're helping us rise. … Today, if we say all foreign contractors should be expelled or deprive of jobs. They should have no work. We'll go back. Not that we'll stand in the same place, we'll go back. Because we don't have technology, we don't have …*

Industry expert I and industry expert J also stress the role of foreign contractors in knowledge transfer:

> *… like SGR, there's a lot of new construction ideas that we've learned from those [foreign contractors] … Tunneling is something that is not common in East Africa and piling … the piling is different. Yes, they make it easy … like if I go a bit technical, like post-tensioning of beams. … it's a technology that's not very common in Africa. So, they came and showed us how to do it. We used to learn those in books.*

These participants highlight the significance of foreign contractors in terms of technology and knowledge transfer to the local construction industry. Therefore, while foreign contractors pose challenges, they also serve to further develop the capacity of local contractors. This is possible as local contractors may be engaged as subcontractors under foreign contractors as highlighted by industry expert F and industry expert K:

> *In our construction of the modern rail of SGR … the contractor engaged local contractors. [A local contractor] was engaged which was undertaking the cutting of × mountains …… so they [local contractors] are usually forced to subcontract.*

In addition, from the clients' perspective, foreign contractors who are financially capable represent an advantage as they can proceed with the delivery of the project without payment. For example, industry expert L notes that:

> *If you don't pay timely, you [the client] are expecting to have a contractor who is well financially equipped, his cash flow is good, and he is not depending on a project. He has to take money from somewhere, from financial institutions and fund your project. That's why [foreign contractor] they are having this aid from their governments*

4.2 Local contractors

Local contractors face many challenges and thus tend to discontinue not long after their establishment. For example, industry expert A notes that:

> *a lot of them [local contractors], a lot of them die between maybe first 10 years. They just die.*

Similarly, industry expert M notes the same:

> *majority of these [local] construction companies die before their time*

The cause of failure can be owing to many variables. This section discusses some of these variables according to the interviewed industry experts.

4.2.1 Lack of capacity of local contractors

As reported by several industry experts, late payment is a chronic issue affecting public projects in Tanzania. In light of their limited capacity, local contractors are especially affected by these late payments. According to industry expert N:

> *… to push the project without the [client] giving them money. So, they [local contractors] have to like wait … until the [client] gets the money, to give it even the advance [payment] to do the job. … He [local contractor] doesn't have money, he has to rely on the [client], anything from scratch. Even that [fund] to initiate [the project] with, you find he doesn't have …*

In other words, local contractors are heavily reliant on timely payment. Without the payments, the local contractors find themselves unable to progress with the work. In fact, industry expert N underscores that local contractors need advance payment in order to be able to undertake mobilization activities and commence the project. This reliance on the client's payment is also echoed by industry expert D who notes that:

> *… because most [local] contractors actually depend on the client's payment. Not a lot have money to just do the job and wait for the payment*

4.2.2 Implications of late payment on project delivered by local contractors

In combination with their lack of capacity, late payments by clients can have significant negative impacts on local contractors. For instance, industry expert O stresses the various challenges that local contractors face when payments are delayed:

> *… when it comes to the contractors, this is where the risk is because you need the money fast to pay workers at site, you need money to buy materials, you need money to pay any other subcontractor around him. So, if he doesn't get paid on time, then what happens, he will eventually just decide to demobilize from site … because he cannot move.*

Noteworthy, untimely payment can compel a local contractor to demobilize in order to prevent costs from accumulating, negatively impacting the progress of the project. These late payments can also have negative implications on the quality of work delivered, as noted by industry expert P:

> *… the quality of work also reduces because most local contractors rely on the payment of interim payment certificate (IPC).*

Further, these late payments can also escalate the costs of the contractors due to delays. For example, industry expert R notes the impact of weather on projects that are delayed:

> *… but because of late payment the construction will fall during the period of … rainy seasons … So, you might find their people are constructing either foundation or whatever, the area gets flooded. So, now the cost of protecting the area to not be flooded or the water in the area that has been flooded by the rain, it's higher cost. Maybe the material has been washed away. The foundation trench also has been [flooded]. Some material been piled around like sand and aggregate also*

> *being washed away. Why? It's because you delayed … because the contractor mobilized the whole material on site to commence the work and …*

From the perspective of the client, these late payments incur additional costs in terms of interest charges by the contractor. This is particularly true for foreign contractors who are able to loan money from their respective countries at low interest rates. According to industry expert S:

> *IPCs is very high, very high [significant challenge]. And this greatly effects the cost … sometimes they can go to cost overrun because the employer needs to repay interest … so, to the employer it is a burden. … delays in paying so the employer … incur interest of late payment and the project is not utilized at the time it was expected so he is late in using the project*

Industry expert T reinforces this view by stating that:

> *interest goes there, the bank continues to finance, so people like them [foreign contractors] because of their ability to finance, [work] doesn't stop because of payment [issues]. It [work] can be done until it is completed … but know that you [the client] will come and [be] hit [by] the interest. Because every certificate … for example, …, every company has a … commercial manager … His job is to follow up on those invoices, to make sure that if the previous [payment] certificate I was not paid, therefore the one that follows, I will be given interest of the previous [payment] certificate … That way … So, them they don't struggle because [of funds], it's there, they have loaned [at a] small interest [rate back in their respective countries]. Here [in Tanzania], the interest here is larger than there.*

However, as noted by industry expert U local contractors typically do not owe interest despite the delays in payment in the hopes of securing future contracts from the same client:

> *And we, in addition, you know even we Tanzanian don't owe interest because you will find that the client is the same. If you have a disagreement with him, do you think he will shortlist you? Therefore, we … overlook so that things progress … so we can complete the project and leave … we can fight with him. Yes, he can pay later, but after that you might be blacklisted. They will not explain to you but you will be blacklisted there.*

From the above discussion, it can be seen that local contractors, due to their limited financial capacity, rely heavily on timely payments by the clients. Late payments can have negative impacts on the delivery of the project, including late commencement, slow progress, poor workmanship, and cost escalation due to delays in completing the project.

4.2.3 Lack of support from financial institutions

If payments are not forthcoming, a local contractor might opt to seek loans from financial institutions. However, this alternative funding source also poses a challenge as noted by industry expert V:

> *But here in Tanzania go and ask for a bond of 6 million, they will tell you bring a*

collateral.

Industry expert U also notes that the interest rates offered by local banks are not attractive:

> *Capital has become a problem [for local contractors]. And when banks loan you, you pay 20% interest [rate]. You have to have a large collateral. It becomes a problem. [Further,] the bonds have a bad price.*

This is in contrast to foreign contractors who receive support from their countries, as noted by industry expert V:

> *They, for example, [contractor from some country] are given support by the[ir] government. So, there's a bank of [some country] which if you need a bond, even if its 8 billion, even if its 10 billion, they are ready to give you.*

5 Discussion

Among the issues threatening the survival of local contractors that were reported by the industry experts was fierce competition brought by foreign contractors operating in the industry. A possible way to address this issue might be through assigning more preference to the local contractors or joint venture requirement between local and foreign contractors as proposed by OBG (2018). In fact, Kikwasi and Escalante (2020) note that the Public Procurement Act makes provision for giving more preference to local contractors or a partnership formed between local and foreign firms. However, Chileshe et al. (2021) notes that despite this initiative, local contractors continue to face stiff competition from foreign contractors. With respect to joint venture, Said Tekka and Mustapha Msangi (2020) note that either partnership or joint venture between local and foreign contractors for public construction projects is an important policy action as it facilitates the transfer of knowledge, skills, and technology. This is also reinforced by Minja et al. (2013) who note that through joint ventures the issues faced by local contractors, such as lack of finance, equipment, and management skills, can be addressed. Accordingly, Minja et al. (2013) proposes the introduction of an incentive scheme in the form of tax relief for foreign contractors who enter a joint venture with local contractors. However, industry expert U cautions that in some cases joint ventures can be disadvantageous to local firms as the foreign firms can dictate the payment terms which might be unfavorable to the local firm.

Though the above issue has been addressed to varying degrees by the introduction of various schemes, a key fundamental issue contributing to the lack of success of the local contractors as reported by the industry experts was untimely payment by the clients. Foreign contractors, by contrast, owning to their financial resources and backing from their respective countries are less impacted by these challenges. In fact, as noted by two of the industry experts, foreign companies serve to generate money from the interest they charge for late payment. Thus, late payments not only have a negative impact on the performance and success of the local contractors, they also mean significant funds are lost by the government in the payment of debts owed to foreign contractors. Timely payments, therefore, are essential to the success of local contractors, for although they might not have the capital to support the project, they possess the technical capacity. By ensuring

timely payment, the client will empower the local contractors to grow and eventually achieve the capacity of foreign contractors.

Another issue reported by the industry experts leading to the lack of success of local contractors was the lack of financial support from financial institutions. It was noted that these institutions provide loans at high interest rates which makes it very unattractive to local contractors. This need for support from the financial institutions is underscored by NBS (2010). Hence, the financial institutions could support the local contractors by providing loans at lower interest rates. This need for financial support was also emphasized by industry expert V and industry expert H where they draw comparison with foreign contractors receiving financial support from their respective financial institutions.
The Contractors Registration Board (CRB) has launched numerous schemes aimed at promoting the growth of local contractors in the Tanzanian construction industry. For example, In 2001, the CRB launched The Sustainable Structured Training Programme Board aimed at increasing contractors technical and management skills (Rwelamila and Abdul-Aziz, 2021). In 2002, the CRB established the access to work opportunities initiative to address the challenges faced by local contractors who were unable to access work opportunities as a result of not fulfilling bid requirements (Rwelamila and Abdul-Aziz, 2021). In the same year, the CRB launched the Contractors Assistance Fund aimed at assisting small- and medium-sized contractors secure bid security and advance payment security (Rwelamila and Abdul-Aziz, 2021). CRB also established the “Deliberate Programme to Develop Civil Works Contractors”, a program aimed at enhancing the capacity of civil works contractors in executing high value road project. CRB has also hosts numerous seminars and workshops. The purpose of these seminars has been to raise awareness on emerging issues in the industry.

While these are commendable efforts to support the local contractors, more effort is needed to address the challenges faced by local contractors. Chief among these challenges is the issue of late payment and financial support for local contractors.

6 Conclusion

While the presence of foreign contractors in the local construction industry presents challenges to the local contractors in the form of competition, they provide the main thrust to the continued growth of the construction industry. As noted, by one of the industry experts, the removal of foreign contractors will be detrimental to the growth of industry given their significance. It was noted that the performance of local contractors can be enhanced through introduction of policies that aim at promoting the transfer of knowledge, skills, and technology from the foreign contractor to the local contractor. Polices such as joint venture serve as an effective means of achieving this target. In addition, policies such as preference schemes that assign greater preference to local contractors or a partnership between local and foreign contractors can also be effective. However, the issue of delayed payment needs to be addressed as it was reported to be a major barrier to the development of the local contractors. This explains why the current policies have not been effective in achieving their intended goals. Timely payments will mean that local contractors are able to participate in more projects, gain more experience, and expand their capacity. Furthermore, as the local contractors continue to grow, they would become less reliant on foreign contractors to secure projects through partnerships.

References

Ashokkumar, P., Wiratunga, I. V. H. and Kulatunga, A. K. (2023) 'Adaptation of Scrum and Web-Based Integrated Techniques to Construction Sector of Sri Lanka', in Lecture Notes in Civil Engineering. doi: 10.1007/978-981-19-2886-4_48.

Belay, S., Goedert, J., Woldesenbet, A., Rokooei, S., Matos, J. and Sousa, H. (2021) 'Key BIM Adoption Drivers to Improve Performance of Infrastructure Projects in the Ethiopian Construction Sector: A Structural Equation Modeling Approach', Advances in Civil Engineering. doi: 10.1155/2021/7473176.

Burke, C. (2007) 'China's entry into construction industries in Africa: Tanzania and Zambia as case studies', China Report. doi: 10.1177/000944550704300304.

Chileshe, N., Kavishe, N. and Edwards, D. J. (2021) 'Critical factors influencing the bid or no-bid decision of the indigenous small building contractors in Tanzania', Construction Innovation. doi: 10.1108/CI-09-2019-0098.

Ethiopian Construction Project Management Institute (ECPMI) (2019) Roadmap for adoption and implementation of BIM technology in the Ethiopian architectural, engineering and construccction (AEC) industry. Addis Ababa.

Kavishe, N. and Chileshe, N. (2020) 'Factors influencing bid/no bid decision of foreign contractors in Tanzania', in ARCOM 2020 - Association of Researchers in Construction Management, 36th Annual Conference 2020 - Proceedings.

Kikwasi, G. J. and Escalante, C. (2018) 'Role of the Construction Sector and Key Bottlenecks to Supply Response in Tanzania', WIDER Working Paper.

Kikwasi, G. J. and Escalante, C. (2020) 'The Construction Sector in Tanzania', in Mining for Change. doi: 10.1093/oso/9780198851172.003.0012.

Minja, S., Kikwasi, G. and Thwala, W. (2013) 'A Study of Joint Venture Formation between Construction Organizations in Tanzania', Australasian Journal of Construction Economics and Building - Conference Series. doi: 10.5130/ajceb-cs.v1i2.3164.

Muhegi, B. and Malongo, J. (2004) 'Globalisation: A Challenge to the Construction Industry in Tanzania', International Symposium on Globalisation and Construction.

NBS (2010) Integrated Business Survey: Construction Industry Report. Dar es Salaam.

Ntiyakunze, S. K. (2011) Conflicts in Building Projects in Tanzania: Analysis of Causes and Management Approaches. Royal Institute of Technology (KTH): Stockholm, Sweden.

OBG (2018) The Report: Tanzania 2018: Boosting local construction capacity a policy priority for Tanzania.

Oke, A. E., Aghimien, D. and Adedoyin, A. (2018) 'SWOT analysis of indigenous and foreign contractors in a developing economy', International Journal of Quality and Reliability Management. doi: 10.1108/IJQRM-11-2016-0210.

Osabutey, E. L. C., Williams, K. and Debrah, Y. A. (2014) 'The potential for technology and knowledge transfers between foreign and local firms: A study of the construction industry in Ghana', Journal of World Business. doi: 10.1016/j.jwb.2013.12.009.

Owoo, N. S. and Lambon-Quayefio, M. P. (2020) 'The Construction Sector in Ghana', in Mining for Change: Natural Resources and Industry in Africa.

Robinson, O. C. (2014) 'Sampling in Interview-Based Qualitative Research: A Theoretical and Practical Guide', Qualitative Research in Psychology. doi: 10.1080/14780887.2013.801543.

Rwelamila, P. D. and Abdul-Aziz, A.-R. (2021) Improving the Performance of Construction Industries for Developing Countries: Programmes, Initiatives, Achievements and Challenges, Improving the Performance of Construction Industries for Developing Countries. doi: 10.1201/9780429322471.

Saadan, R. (2013) ROLE OF COMMERCIAL BANKS IN DEVELOPMENT FINANCING IN TANZANIA: A CASE OF CONSTRUCTION SECTOR. Mzumbe University. Available at: http://scholar.mzumbe.ac.tz/bitstream/handle/11192/3013/MBA-CM_ Rahim Saadan_ 2013.pdf?sequence=1.

Said Tekka, R. and Mustapha Msangi, S. (2020) 'Effects of Strong Government in Attaining Outstanding Performance on Construction Projects: Stakeholder's Opinions in Tanzania', Industrial Engineering. doi: 10.11648/j.ie.20200402.15.

Saunders, M., Lewis, P. and Thornhill, A. (2012) Research Methods for Business Students. 6th edn, Synthese. 6th edn. Harlow: Pearson Education Limited.

Tembo, C. K., Muleya, F. and Phiri, E. (2022) 'Demystifying performance difference between local and foreign contractors through organisational culture', Built Environment Project and Asset Management. doi: 10.1108/BEPAM-02-2021-0029.

UNESCO (2018) TANZANIA AND UNESCO.

RURAL HOUSING MODULE TO IMPROVE SURVIVAL AMIDST CYCLONES

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Abstract: *Bangladesh is one of the most disaster-prone countries in the world. Cyclones are foremost among them. Most often, cyclones strike Bangladesh's coast. Most of the coastal population in Bangladesh is impoverished, landless, and reliant on the environment. This study portrays the living condition of cyclone-prone areas in Bangladesh and the vulnerable community in these areas. A coastal region has been chosen for this study where cyclones affect the most. This study has focused on existing homes in the selected study area and the process of building and maintaining a system to face frequent cyclonic storms and storm surges. This survey concluded the need for affordable cyclone-resilient housing with environmentally friendly construction materials. This study aims to find ways to make structures more resistant to wind damage and less prone to cyclonic effects. The necessary information was gathered by asking various related questions to about 60 people from a community in Barisal. By studying the site map and analysing the previous cyclonic wind and tidal surge directions, a program list was created where all the necessary amenities are included. This paper gives research-based thinking about a low-cost house in Barisal that can be a prototype in many cyclone-prone areas and reduce the devastating effects of cyclones worldwide.*

Keywords: *Disaster resilience, Rural housing, Cyclonic effects, Housing affordability, Low-cost housing.*

1 Introduction

Bangladesh is one of the most climate-sensitive countries in the world. Our country is frequently subjected to weather events. Cyclones are prominent among them. A tropical cyclone brings very violent winds, torrential rain, high waves, and, in some cases, very destructive storm surges and coastal flooding. Most often, cyclones strike Bangladesh's coast. A considerable portion of the coast is harmed by at least one significant cyclone every three years. Rural communities of the coastal area are at risk of being impacted by social and environmental changes. Also, climatic changes affect the people of the coastal regions. The majority of the coastal population in Bangladesh is impoverished, landless, and reliant on the environment—loss of life and livelihood, harm to settlements, infrastructure, and agriculture. The fisherman community is significant among the vulnerable communities in the coastal region. However, they are unprivileged, and their houses are at high risk of wind pressure due to cyclones. A secure shelter that will protect people from the ravages of cyclones and their impact is becoming extremely necessary. To combat and survive cyclones, homes must be structurally resilient to cyclonic phenomena such as torsional wind pressure and tidal surge. For the coastal region, cost-effectiveness is crucial so that all types of people, especially marginalized people, where the majority are fishermen, can make an effort.

This study has been focused on existing homes in the selected study area of a vulnerable community and the process of building and maintaining a system so that they can face frequent cyclonic storms and storm surges by collecting information on shared knowledge and collective experiences of the people in all aspects of house building. This study aims to find ways to make structures more resistant to cyclonic wind and tidal surges and cost-effective prototype shelters, and they can be used as a prototype in all cyclone-affected areas.

2 Literature Review

2.1 Cyclones in Bangladesh

The coastal districts of Bangladesh are prone to cyclones and tidal surges. They are subjected to excessive damages frequently. Since 2000, among all cyclones, SIDR, which swept via the Bangladesh coast on 15 November 2007, damaged the coastal region the most. The whole Patuakhali, Barguna, and Jhalokati districts have been hit hard utilizing the tidal surge of over five meters (16 ft) (Tamima, 1970).

The survey and study of the Multipurpose Cyclone Shelter Programme report (Part IV, Volume IV), published by the Bangladesh University of Engineering and Technology and Bangladesh Institute of Development Studies, investigates the spatial variability of proper assistance needs during cyclone hazards in the Latachapli Union, Kalapara Upazila, and Patuakhali districts (July 1993) (Haq, 2017).

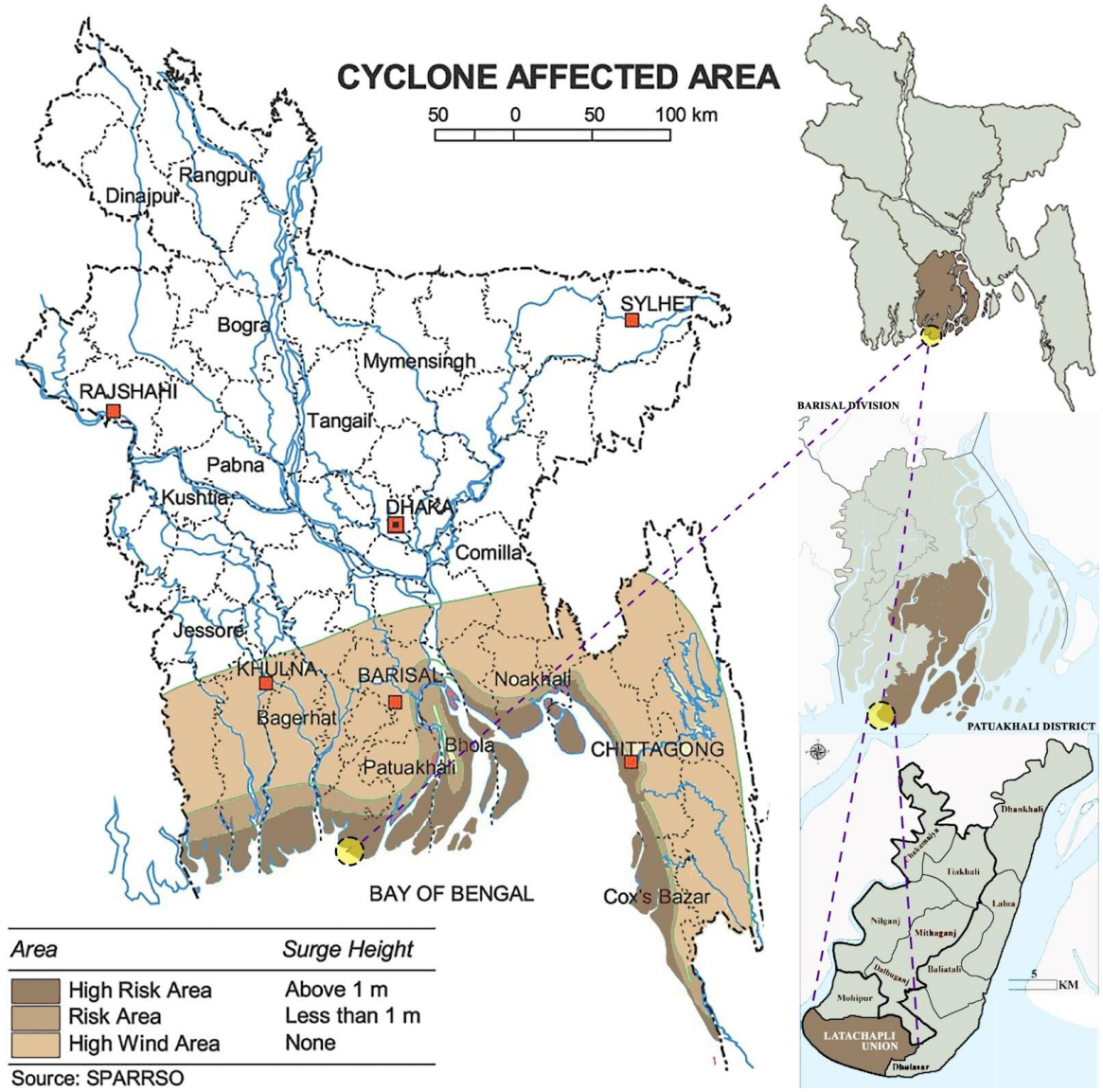

Figure 01: Cyclone-affected coastal regions in Bangladesh

2.2 Effects Of Cyclone on Rural Housing

High winds rarely blow over houses; instead, they are split apart by the fast-moving winds above and surrounding the structure. This reduces outside pressure and creates suction on the walls and roof, equivalent to an explosion.

Also, there are some catastrophic failures of building components. Like in the case of foundation, the uplift pressures caused by cyclone winds can potentially uproot some structures entirely. In contrast to designing for gravity loads, the cyclone-resistant design calls for a larger (or heavier) foundation for lighter buildings. Masonry Homes are typically thought to be cyclone safe. Unreinforced masonry walls have been destroyed due to the loss of roofs. Also, careful attention to the connection details is essential for safely constructing timber houses. It is a dangerous combination that has frequently resulted in catastrophe in that lightweight timber buildings are vulnerable by nature and have poor

connections. In most cases, the seismic hazard determines how reinforced concrete frames are designed.

The causes of failures of roof sheeting are typically insufficient fastening mechanisms, insufficient sheet thickness, and low fastener frequencies in the locations where increased wind suction is known to occur. Besides, recent cyclones were notable for the longitudinal splitting of rafters, where the top parts vanished, and the bottom portions remained in place. Glass is always susceptible to flying debris. The hardware, including the latches, bolts, and hinges, is another vulnerability for windows and doors. Unreinforced masonry frequently collapses during powerful cyclones. Most at risk are parapets with cantilevers. However, columns and ring beams supporting the walls have kept them safe (Arya & Agarwal, 2007).

There are also some damaging effects on houses like the following Fig. 02:

1. Due to the high wind pressure and improper connection of the house to the footings, it can be blown away.
2. Roofing materials not anchored can be blown away.
3. High wind speed makes Lightweight verandah roofs more susceptible to damage.
4. When cyclones are followed by prolonged periods of severe rain, the house may also sustain flooding damage; rain causes building contents to spoil as roofing sheets fly off.

Figure 02: Damaging effects of cyclones on houses (adopted from Agarwal, 2007: 5).

2.3 Barisal: The Study Area

In Barisal, the Latachapli union under the Patuakhali district is the most vulnerable region, as cyclones mostly hit hard in this coastal area. The coordination of Lata Chapli Union is 21.9861° north range and 90.2422° east. The Union is beneath Kalapara Upazila, Patuakhali District, in Barisal Division. It is located in the South–Western coastal region, essentially flat land surrounded by the aid of the Bay of Bengal and Andharmanik Mohona. The Kuakata sea beach adjoins this Union. Due to its geographical vicinity, the area is highly at risk of natural disasters. The mainland is covered with a mangrove forest named “Lebur Chor" from the West side (Islam et al., 2018). Latachapli has 7% reserved forest area on the South and West sides. It has 73% agricultural land, 8% household, and only 2% market area. Most land use is homogenous and rural (Islam et al., 2018). Where land has lower topographic height, water logging is frequent in that area.

2.3.1 Previous Cyclonic Data Analysis in Barisal

Cyclone Sidr had the highest wind velocity among cyclones after 2000. The rural structures were damaged severely because of this. Also, Water levels are rising, and waterlogging is a big issue during and after the cyclone. During cyclone Nargis, the water level rose about 13 feet. It was highest among other cyclones. Storm surges occur during cyclones from the Bay of Bengal too. Storm surges took massive form during SIDR. It was

about 18 feet high. Low-lying areas were highly affected and experienced devastating effects, as shown by the charts in Fig. 03.

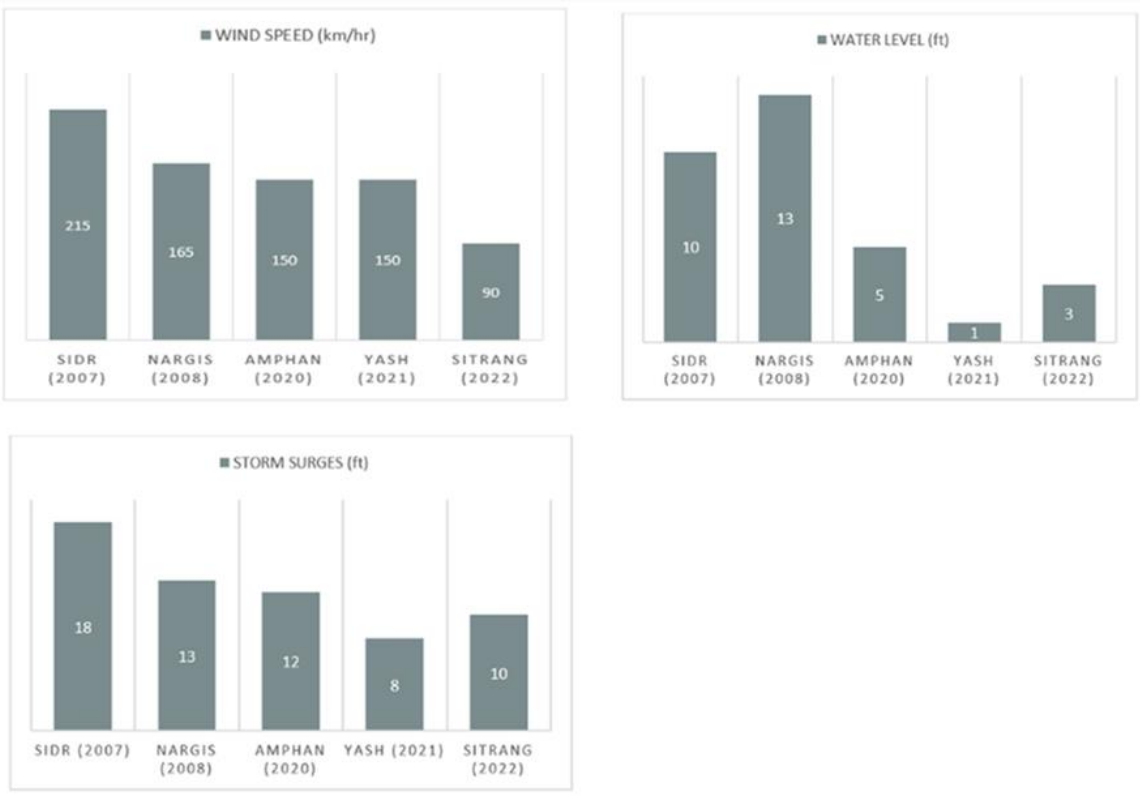

Figure 03: Wind Speed, Water level, and storm surges of previous cyclones in Bangladesh (Haque et al., 21 C.E.) ;(IFRC. 2020) ;(IFRC, 2021) ;(The Financial Express, n.d.)

From the southwest and southeast corner, storm wind pressure strikes the Union. A cyclone storm is a blow that can sweep away rural households very quickly. Forest preservation intensification can minimize the risk.

2.3.2 Study Area Analysis

Middle Khajura is selected as the study area because the community is suffering so much from cyclones because of not having the proper infrastructure in which they dwell. The community people can be categorized as marginal people. Their homestead needs to be more resilient to cope with the devastating effects of cyclones. The state of catastrophe households continues to be a severe problem, especially for the most vulnerable families. The location of the study area is shown in Fig.04.

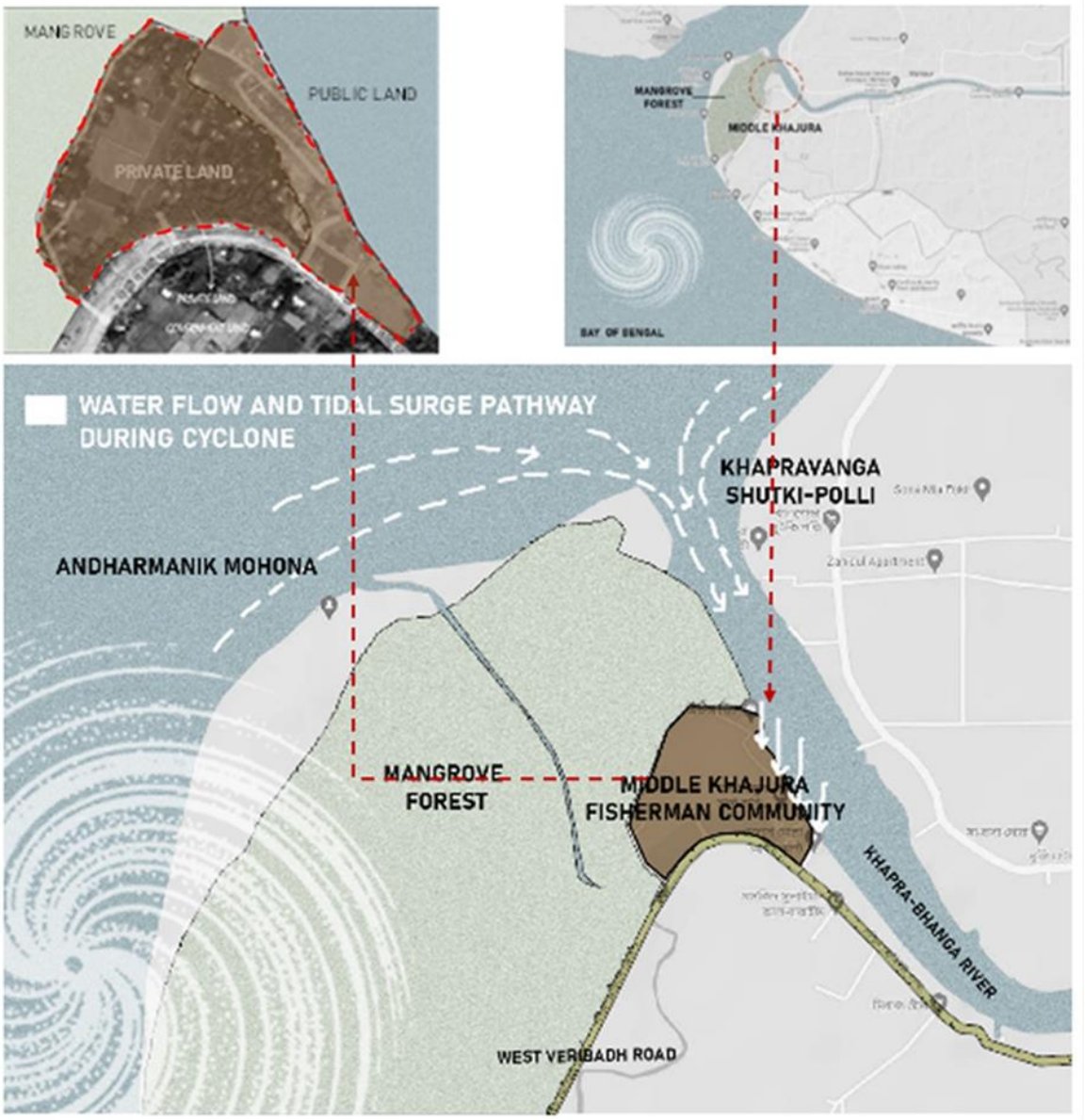

Figure 04: Site area analysis

The waves did not immediately impact this region due to its location shielded by the embankment. The severe wind caused the most damage as the wall protected the community from the tidal surge due to the cyclone. There, the riverbank was strengthened by the concrete blocks made on-site, and this work is in progress.

As a cyclone-prone area, cyclone shelter is a must for them. However, it is so far. It is situated at a distance of 6146ft (1.8 km) from the study area. Nevertheless, it is a sad fact that, during the cyclone, the shelter cannot protect them. Because shelter is built on low-lying land, and it gets flooded.

2.3.3 Existing Housing Module

One module consists of 10 houses. There are a total of 2 columns and four rows of houses. The house is linear in shape. The government provided a specific plan for them. Nevertheless, later, they rearranged the plan to meet their choice of activities, such as Dining, Living, Bedroom, Kitchen, Courtyard, and Storeroom. Each house is about 52 feet in length and 12 feet in width. The modules are shown in fig. 07 and 08.

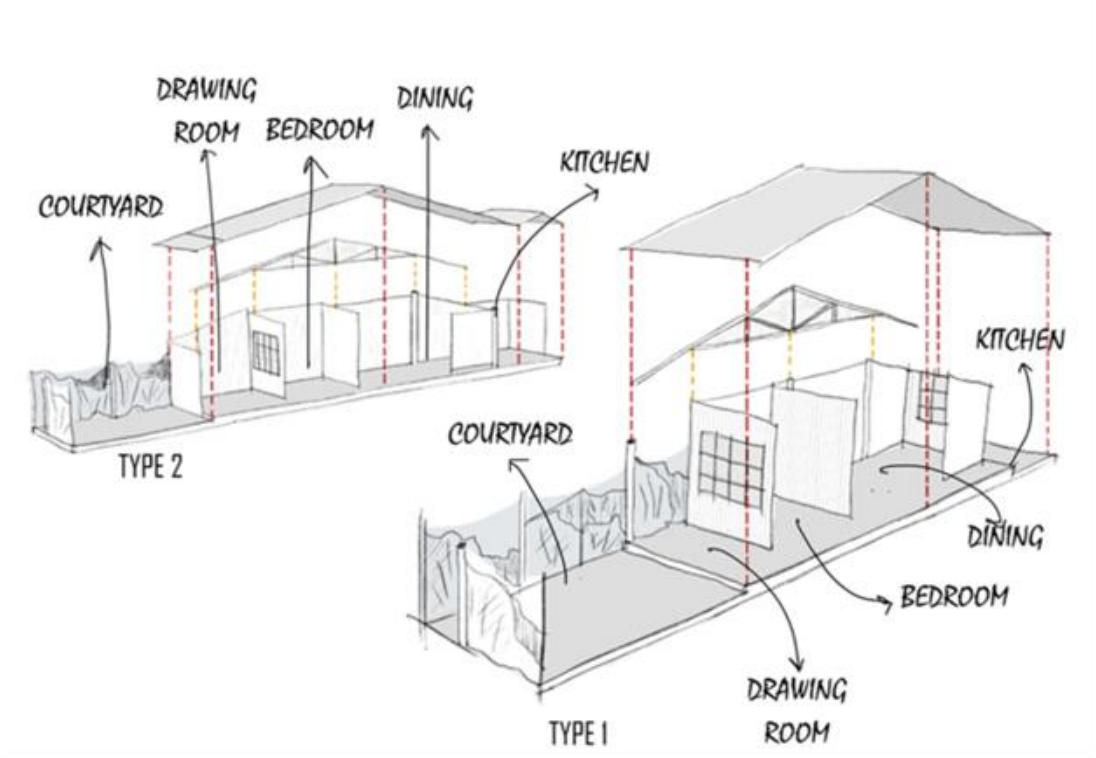

Figure 05: Existing one module of house

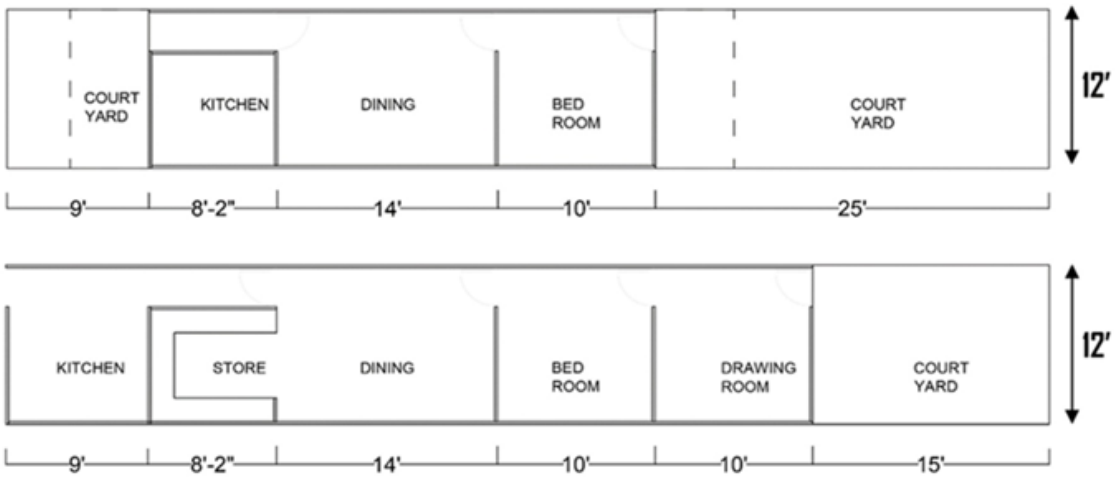

Figure 06: Structure after extended by users.

Generally, in addition to their house, they have a small courtyard where they can incorporate different activities for their own needs (poultry, making fishing nets, vegetables, spices, fruits, etc.), and the surplus is sold to the market, ensuring a minimum or partial income. Some used the courtyard for tree plantations covering the front of their house areas. (Fig 09)

Figure 07: Uses of courtyards

3 Methodology

During the field visit in the selected region, we implemented the following methodology:

- Selection of appropriate places affected by the cyclone.
- Elaboration of a specific survey about housing and household situations.
- Visiting houses and surveying specific households.
- Assessment of the capacity of 4 local construction supervisors experienced in traditional housing (level of expertise, availability of local human resources, local technologies used).
- Analysis of several documents about the district and the Cluster Shelter platform.

4 Discussion

4.1 Proposed Cyclone Resilient Housing Module

Everyone has the right to have suitable housing for their health and well-being since it is a basic human need, like food and clothing. Having a home protected from natural catastrophes in disaster-prone locations is crucial. The resilient homestead cluster development exemplified how economic, social, and environmental actions may be incorporated into one building. The lifestyle, adaptability, and post-disaster recovery of coastal residents were considered to increase resilience. This paper focuses on resilient house prototypes based on the families' financial circumstances. Design strategies with adaptable materials were made available to the residents. Better-off households might utilize durable materials to construct their stilted homes.

4.1.1 Concept And Form Generation

In Bangladesh, People in the coastal areas developed a natural way to mitigate the effect of the tidal surge during cyclones by the plantation of coconut trees that create a barrier

by their stems. When a tidal surge attacks land, water passes through the coconut tree. However, these trees redirect and mitigate the water force.
We took this concept and applied it to the structural system of the housing module. So, houses will act as a natural system and not oppose nature. We used the shear wall in the direction of the water flow during the cyclonic effect. The water will go through the shear wall and mitigate the tidal surge's velocity. During the cyclone, torsional force generates and blows away the structural systems in rural and urban areas. The shear wall is an excellent structural element to take the effect of this torsional force.

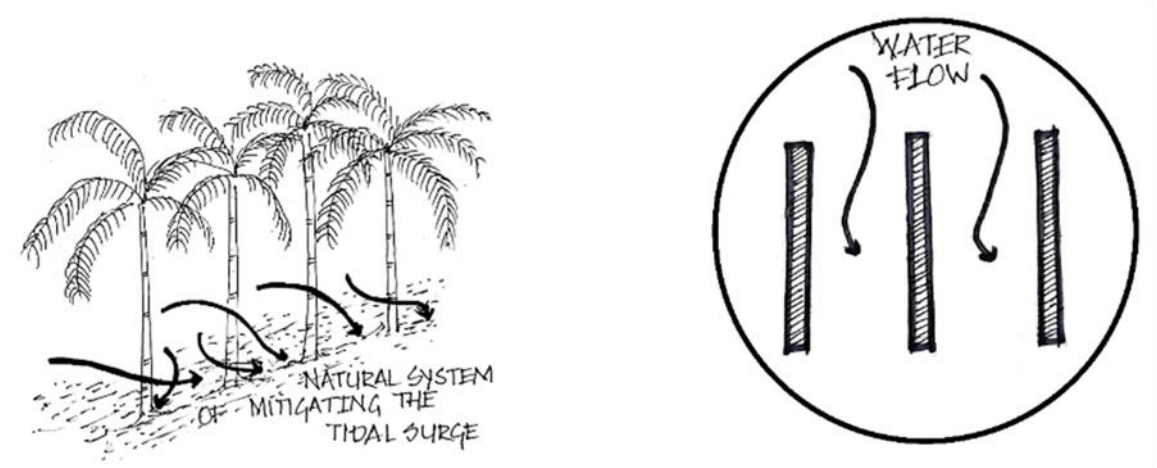

Fig 08: Form generation concept

4.1.2 Basic Homestead Module

The existing floor area of the house is about 350 square feet. But they need more space to live in, so we provide them with approximately 600 square feet of permanent space to live comfortably. This floor area is divided into two floors. About 100 square feet are planned as common circulation spaces.

The basic module has a 330 sq. ft sleeping space on the first floor. A 115 sq. ft area is shared as a bedroom and living room. About 100 sq. ft is a common circulation space and veranda between two families, meaning one family uses approximately 45 sq. ft of space on the first floor. About 80 sq. ft is planned as kitchen space on the ground floor, and 65 sq. ft is a cattle shed. Though everyone does not have cattle, this space can be used for multiple purposes by the owners. About 90 sq. ft area is planned as dining space. The 135 sq. ft base is prepared for a future extension so households can extend their house with essential structural elements like bamboo and wood to fulfill the needs of an increasing number of family members and other necessities.

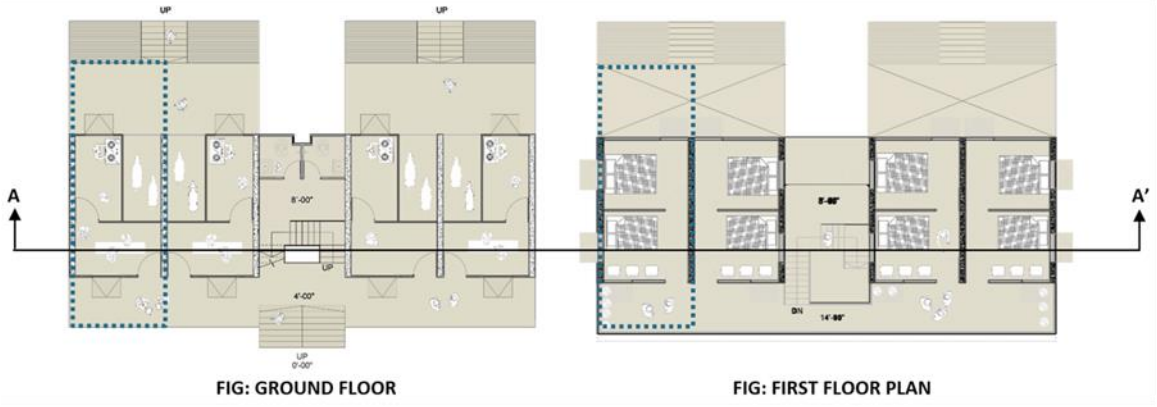

Fig 09: Ground and first-floor plan.

Fig 10: Front and side elevation

The plinth level is 4' higher than the ground level. In the rainy season, the water level rises about 3'. We chose mud for the plinth level to make it more cost-efficient and easier to build. As a result, people can easily make it if it decays in time and by natural calamities. This plinth will also create a robust shear wall and columns base. Due to this height, people can live safely despite the rise of seasonal water in the rainy season. The maintenance of this floor type is easy, too.

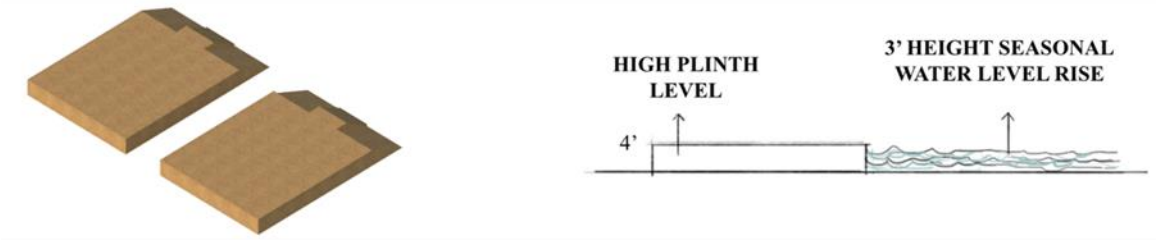

Fig 11: Plinth level

4.1.3 Wind Loads And Wind Flow On The Module

The shape and structural components of the houses let the wind flow without interruption. In the module, torsional wind can be handled during cyclonic periods by a shear wall and column structure. In the standard period, households will use bamboo walls that are cheap and repairable. The figures show that the shear wall lets the wind flow through the gap quickly, where, and how the wind will hover above the roof. A hipped roof is used so the wind can flow efficiently without harming the roof or other structures.

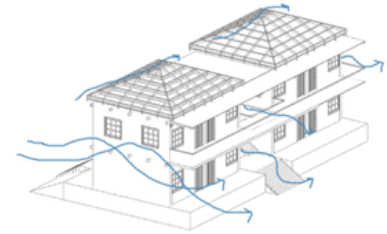

Fig 12: An axonometric view

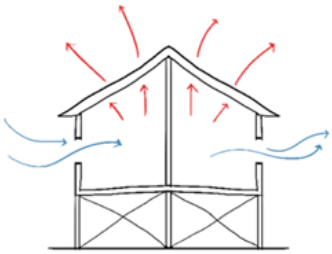

Fig 13: Wind Loads on the module

Fig 14: Wind flow on the module.

The shorter surface of the houses will be orientated in the direction of the wind flow. The shear wall will be parallel to the wind flow. These figures show the direction of wind on housing modules.

4.2 Construction Techniques, Structural Components, And Details of the Module

4.2.1 Resilient Features

The shape of the house is derived from the ratio of approximately 1:2 to make the building profile strong. It also leads to the simplicity of the plan, creating a more robust cyclone-resistant structure instead of scattered blocks. It prevents the form from collapsing onto itself from cyclones. Using a hip roof instead of a freestanding wall is a helpful strategy to avoid damage to walls and roofs in cyclone-prone zones.

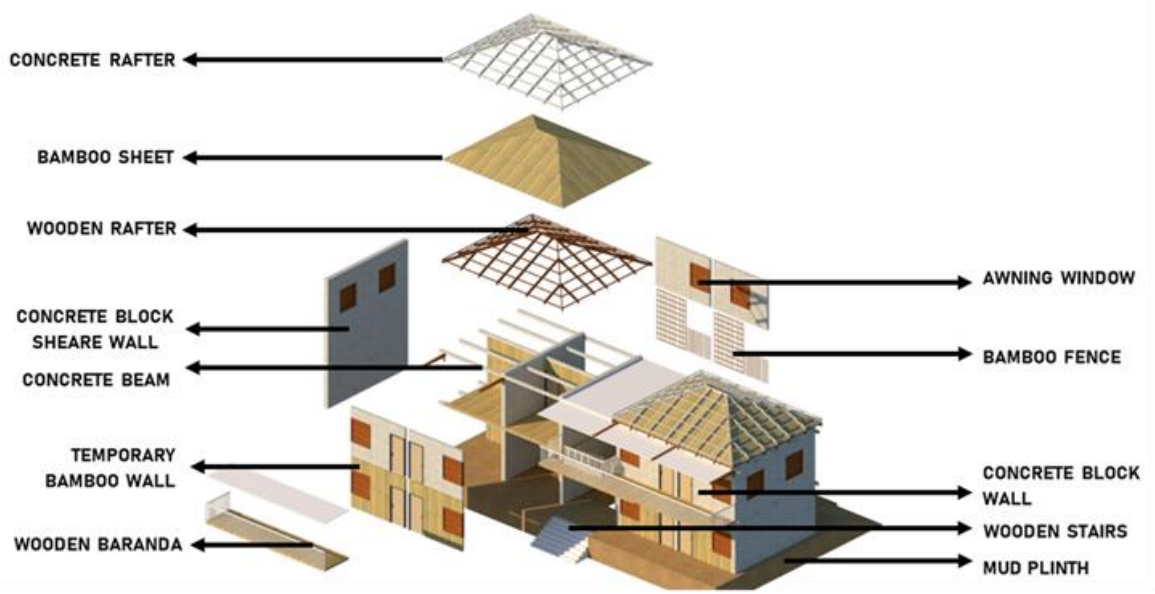

Fig 15: Materials of the module

4.2.2 Foundation Details

An RCC footing is used in this module. It is about 4 feet deep from the ground level. This footing creates a strong foundation for the storied building made with a shear wall.

Fig 16: Foundation detail of the house

4.2.3 Floors And Stairs

Due to cost-effectiveness and durability, mud is used as floor finishing material on the ground floor. Moreover, it offers fire-resistant thermal insulation in both summer and winter. The upper floor is made of wooden plank for its long-lasting features and availability. The wooden floors are also cost-effective and easily replaceable.

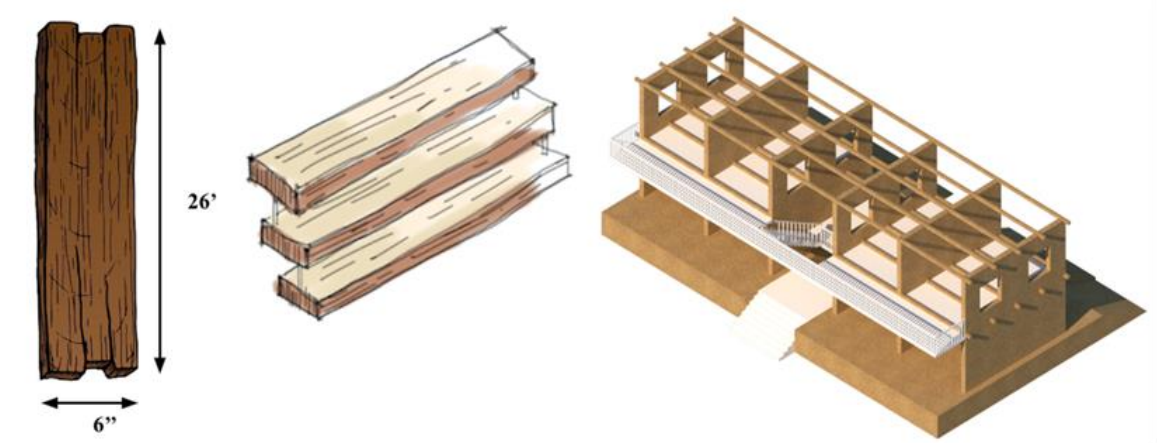

Fig 17: Floor and stair detail

4.2.4 Shear Wall And Beams

Exterior walls function as shear walls that protect a building structure from lateral wind forces. Concrete hollow blocks with steel reinforcing bars make up the shear wall. Reinforcement is employed to strengthen the impact of concrete block masonry on wind loads. Through the gaps between the concrete blocks, reinforcing steel rods are positioned vertically and horizontally because it is inexpensive and gives building structures a lot of strength and stiffness. As a result, this type of shear wall is preferred.

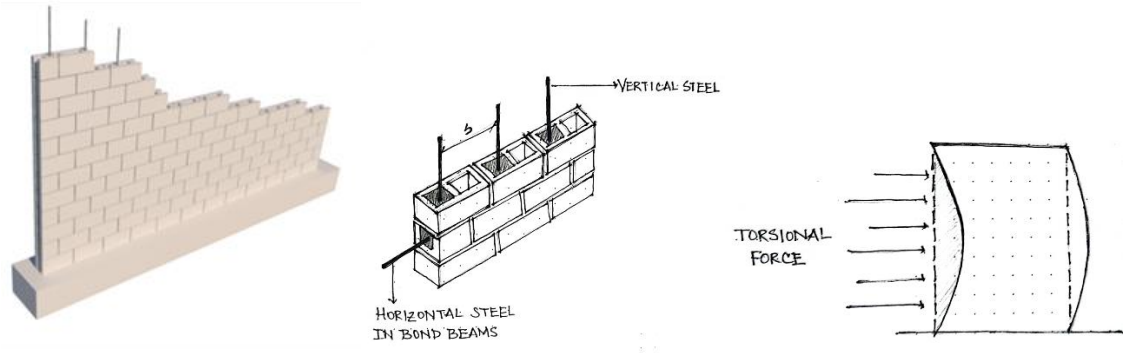

Fig 18: Wall detail of the houses

Horizontal beams will support the shear wall against the external shear load. It also works as the support for the floors. It is cheap and can be cast on-site.

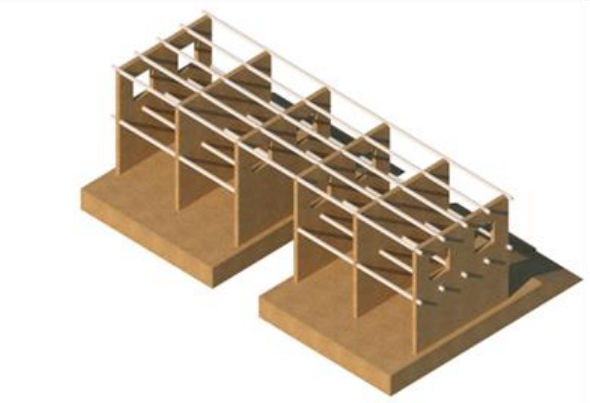

Fig 19: Use of concrete beam

4.2.5 Temporary Walls

The module has used two types of walls. Besides the concrete hollow block shear wall, the nonstructural temporary partition wall is made of dry bamboo. In this case, large-diameter culms are split into two halves, and the cross-section at the nodes is removed. The first layer of culms is laid side by side with the concave face upward. The second is placed over the first with the convex face upward (Arkalpana, 2010). It makes the wall lighter and easy to remove in a cyclonic period so that the tidal surge can pass through without damaging temporary walls. People can use the wall after the cyclonic effect.

Fig 20: Temporary walls

4.2.6 Openings

The openings are wooden awning windows that are simple to operate and provide 100% ventilation. It is advantageous for obtaining natural lighting and ventilation, as well as for making the most of the wall space and preserving privacy. The awning window also works as a sunshade. And it works better during the high-speed wind (Pros & Cons - Awning Windows, 2021) (Honig, 2022).

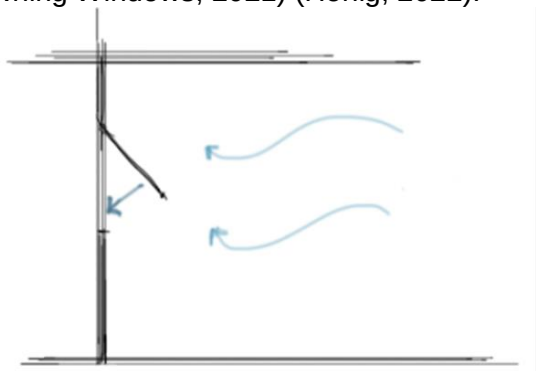

Fig 21: Awning window

4.2.7 Roof Structure And Roof Cladding

The roof is mainly called a pyramidal roof - one of the most resilient roof designs is a pyramidal one. It can endure strong winds and is self-bracing. A house's top floor or attic can gain height due to a pyramid roof, which facilitates water runoff with a steep slope (Barton, 2023). The roof structure consists of three layers. The first layer is made of wooden straps, the second is made of vertically halved bamboo, and the third layer is made of concrete straps.

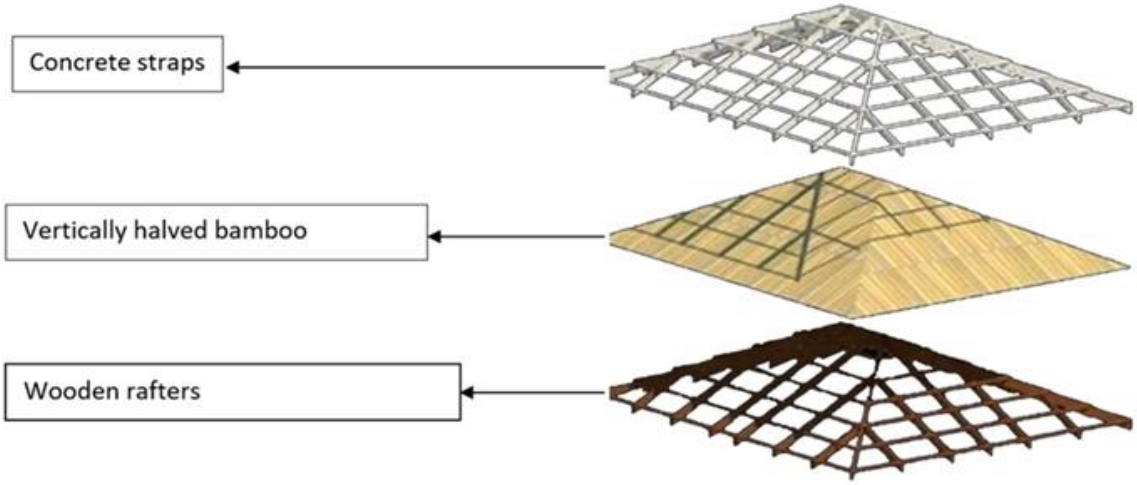

Fig 22: Roof structure

The simplest form of bamboo roof covering is built with the method of a temporary wall. In this case, bamboo is divided into two parts vertically and placed by interlocking.

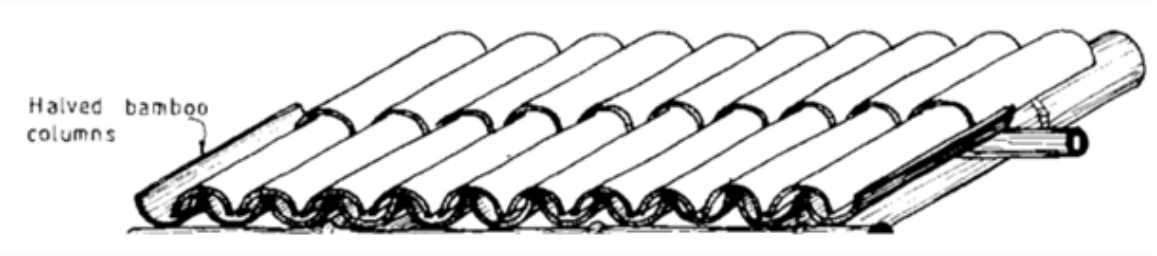

Fig 23: Bamboo binding technique (adopted from Walker, n.d.: Fig-5.66)

This roof has no gable ends. Rafters cross diagonally from the corner and join the ridge board a short distance from the house's ends. Other shorter rafters, known as jack rafters, run from the wall plate to the hip rafter. The rafters are fastened to neatly fit into the wall plate when the ridge is firmly set (Arya & Agarwal, 2007). R.C. concrete straps also increase the roof's resistance against cyclone wind.

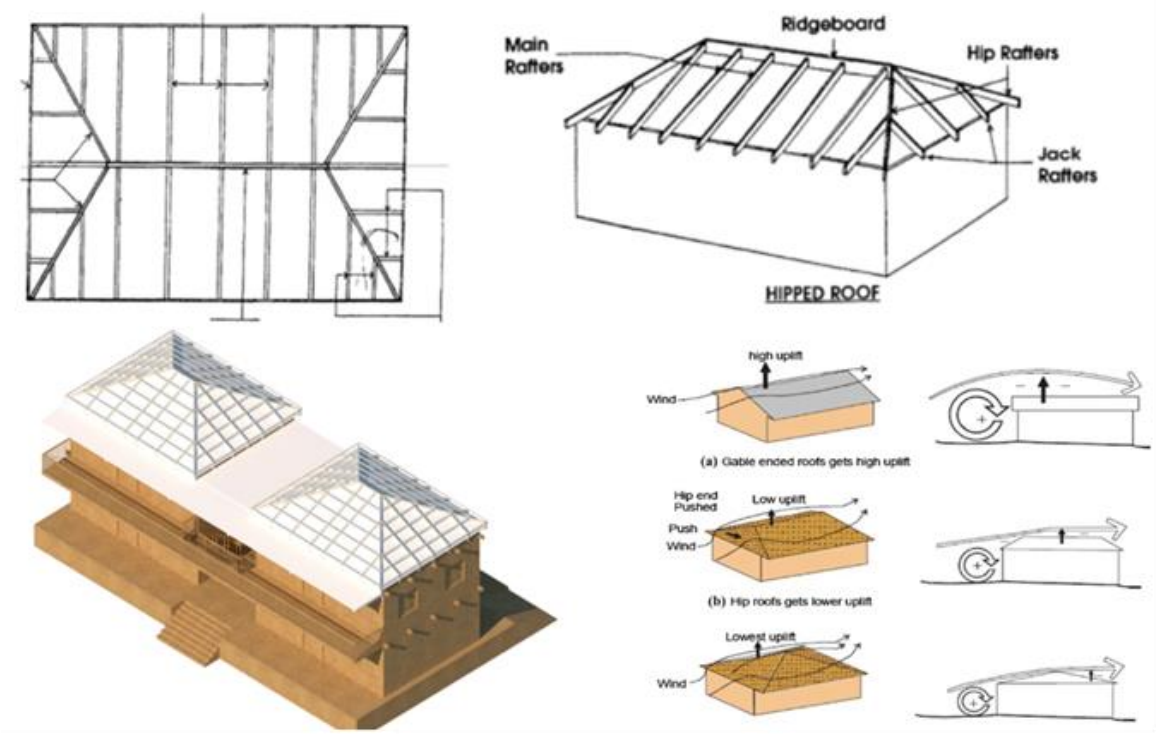

Fig 24: Roofing technique (adopted from Arya & Agarwal, 2007: 12) (adopted from Singh & Roy, 2019: 232)

5 Conclusion

Human fatalities arising from cyclone hazards in the coastal areas of Bangladesh have occurred mainly in the nearby coast and isolated settlements. The coastal region of Barisal District is identified as the most geographical risk zone due to cyclones. Moreover, that is why we have selected middle Khajura under the Latachapli Union, as it is one of the vulnerable regions among the coastal areas. The paper describes their vulnerability through household activity and the structural characteristics of their house, economic status, and livelihood strategy. The findings also reflect broader comments from studies

on disasters and development that increasingly emphasize the long-standing awareness of community-based approaches. By studying and surveying their conditions and housing modules, we decided to use locally available materials and low-cost construction methods, which will save them from cyclonic effects.

As a developing country, the infrastructure of Bangladesh is also maintaining international standards and vision. Nevertheless, the rural people here are ignorant about this. A concrete block shear wall is more resistant to torsional load and is cost-effective. Knowing about this construction method will save them money and protect them from disaster by which they will survive in the long run.

The housing we designed is structurally and environmentally sustainable to tolerate cyclonic effects such as wind pressure, tidal surge, water logging, etc. People can make this kind of prototype with poor economic conditions, and it can be repaired if the modules face damage. As a result, the government can also help them by providing necessary materials and creating proper scope to maintain the socio-economic infrastructure of the housing.

Acknowledgements

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References

Arya, A. K., & Agarwal, A. (2007). Cyclone Resistant Building Architecture. UNDP, Disaster Risk Management Programme. https://nidm.gov.in/PDF/safety/flood/link2.pdf

Barton, K. (2023). What is a Pyramid Roof? Homedit. https://www.homedit.com/pyramid-roof/
Disaster Management Bureau. (2010). National Plan for Disaster Management 2010-2015. In https://ddm.portal.gov.bd/sites/default/files/files/ddm.portal.gov.bd/page/332124ba_20b1_42cc_816b_d97d7eb4f478/npdm_final.pdf.

Haq, B. (2017). Battling the Storm - Study on Cyclone Resistant Housing. In Humanitarian Library. German red cross.

Haque, M. M., Yamada, M., Uchiyama, S., & Hoyanagi, K. (2021). Depositional setup and characteristics of the storm deposit by the 2007 Cyclone Sidr on Kuakata Coast, Bangladesh. Marine Geology, 442, 106652. https://doi.org/10.1016/j.margeo.2021.106652

Honig, T. (2022, February 23). Benefits of an awning window. Wideline Windows & Doors. https://www.wideline.com.au/benefits-of-an-awning-window-and-the-best-places-to-use-them/#:~:text=Awning%20windows%20can%20be%20placed%20higher%20on%20walls%20than%20m

IFRC. (2020). Bangladesh: Cyclone Amphan - Operation Update Report (DREF Operation n° MDRBD024). https://reliefweb.int/report/bangladesh/bangladesh-cyclone-amphan-operation-update-report-dref-operation-n-mdrbd024

IFRC. (2021). Bangladesh: Cyclone YAAS - Final Report (n° MDRBD027). In Reliefweb. https://reliefweb.int/report/bangladesh/bangladesh-cyclone-yaas-final-report-n-mdrbd027

Islam, M. A., Shetu, M. M., & Mallick, J. (2018). Climate Resilient Rural Architecture In the case of Latachapli Union and Deluti Union. In Researchgate. https://www.researchgate.net/publication/340299082_Climate_Resilient_Rural_Architecture_In_the_case_of_Latachapli_Union_and_Deluti_Union

Pros & Cons - Awning Windows. (2021, January). Bayview Windows. https://www.bayviewwindows.ca/blog/awning-windows-pros-cons/windows#:~:text=Awning%20windows%20provide%20better%20ventilation,sides%2C%20rather%20than%20the%20top

Singh, J., & Roy, A. K. (2019). Effects of roof slope and wind direction on wind pressure distribution on the roof of a square plan pyramidal low-rise building using CFD simulation. International Journal of Advanced Structural Engineering, 11(2), 231–254. https://doi.org/10.1007/s40091-019-0227-3

Tamima, U. (1970). Population evacuation need assessment in cyclone affected Barguna district. Journal of Bangladesh Institute of Planners, 2, 145–157. https://doi.org/10.3329/jbip.v2i0.9575

Walker, A. W. a. O. (n.d.). Farm structures - Ch5 Elements of construction: Roofs. https://www.cd3wdproject.org/INPHO/VLIBRARY/S1250E/S1250E0L.HTM#ROOFING%20FOR%20PITCHED%20ROOFS

BARRIERS TO IMPLEMENTATION OF SUSTAINABLE CONSTRUCTION IN INDIA

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Abstract: *The Indian construction industry was estimated to be worth three trillion INR in 2022 and is expected to be the third largest construction market by 2025. The industry is responsible for a large amount of energy consumption, which not only contributes to the emission of greenhouse gases, but also adversely impacts resources like land, waterbodies, minerals, and other naturally sourced materials. Hence, implementing sustainable construction practices across the project life cycle is essential to reducing the detrimental impacts of the industry. Despite having 3 green building rating systems (GRIHA, IGBC, and LEED) and adopting certain national level initiatives, there is an absence of a systematic regulatory framework for the incorporation of sustainability principles in the Indian construction industry. It is critical to determine the existing issues that prevail in the industry to address the barriers in a timely manner. This paper determines the critical barriers to incorporating sustainable construction in India by reviewing the academic literature, Environmental Performance Index (EPI), and Sustainable Development Goals (SDG) 2022 reports. Unskilled workforce, low productivity, lack of monitoring schemes, inadequate technology, poor team integration and collaboration are the key barriers that are deduced from the systematic literature review. The ongoing national level initiatives and schemes promoting multiple goals of SDGs are also identified. The administrative framework of the Indian construction industry includes ministries, state departments, local authorities, and regulatory councils. Every state in India has building bye laws that differ from those of other states and this has also been identified as a barrier. One of the solutions determined by experts and researchers is for the Indian construction industry to comply with the 2030 Agenda for sustainable development. In order to accomplish that, policy makers, sustainable construction practitioners, and industry professionals must develop specific grassroot level mitigation factors to counter the key barriers.*

Keywords: *Key Barriers, Construction Industry, Sustainable Construction, India*

1 Introduction

The construction industry has substantially contributed to greenhouse gas (GHG) emissions and energy consumption. According to the 2022 World Energy Outlook report, the construction industry is responsible for 27% of GHG emissions and 30% of energy consumption on a global scale (IEA, 2022). To transition towards an affirmative prevention process, the key is to aggressively plan, advocate and execute the goals of Sustainable Development (SDGs) and the Paris Agreement. India is one of the 196 participatory key players of the Paris Agreement (UNFCCC, 2015) and holds the 180th position amongst 180 nations, acquiring the lowest Environmental Performance Index (EPI) score for the year 2022 (Wolf et al., 2022). Similarly, India ranks 120th amongst all the other competitors regarding the Global Sustainable Competitiveness, whose primary focus is on the nation's performance on regulatory, ecological, social, technical, and economic dimensions (GSCI, 2022).

Enduring the rapid increase of the population and its demands, one of the outcomes is accelerated unorganized construction activities leading to high ecological depletion, gross floor area for communities, pollution, and construction - demolition waste (CWF, 2010; Goh et al., 2021; UNEP, 2022; Verma et al., 2020). The urgency to mitigate these detrimental impacts is leading us toward the implementation of sustainable construction (Bhatt & Macwan, 2016). The administration has initiated multiple schemes that focus on the environment. However, there are grassroot level barriers that exist in the Indian construction industry that need to be resolved to successfully implement the principles of sustainable construction. Identification of barriers is a critical step as it will help the responsible stakeholders and decision makers tactfully establish mitigation measures on the local and national level.

Therefore, this study focuses on the various challenges that the construction industry is currently facing. In addition, an overview of the ongoing programs and schemes related to the Indian construction industry are also discussed.

2 Overview of the Indian construction industry

The Indian construction industry is responsible for 9% of India's GDP and has a high return on investments (FIFP, 2023). This clearly indicates that the backbone of the Indian economy is heavily dependent on the Indian construction industry. It is also noteworthy that the construction sector belongs to the top three employment seeking opportunities for almost 35% of the Indian population (IBEF, 2020).

Unfortunately, the impact of the construction industry on the economy, does not reciprocate its impact on the environment. The construction industry is massively contributing to the high amount of energy consumption, which not only exponentially contributes to the emission of greenhouse gases, but also adversely impacts resources like land, waterbodies, minerals, and naturally sourced materials, etc. The rate of consumption of electricity in buildings in India has risen by approximately 450% since last two decades (Programme, 2018). Figure 1 indicates that the buildings contributed to 5% of the total carbon emission in 2019. It is important to note that the entire project cycle involves transportation, material, and energy consumption.

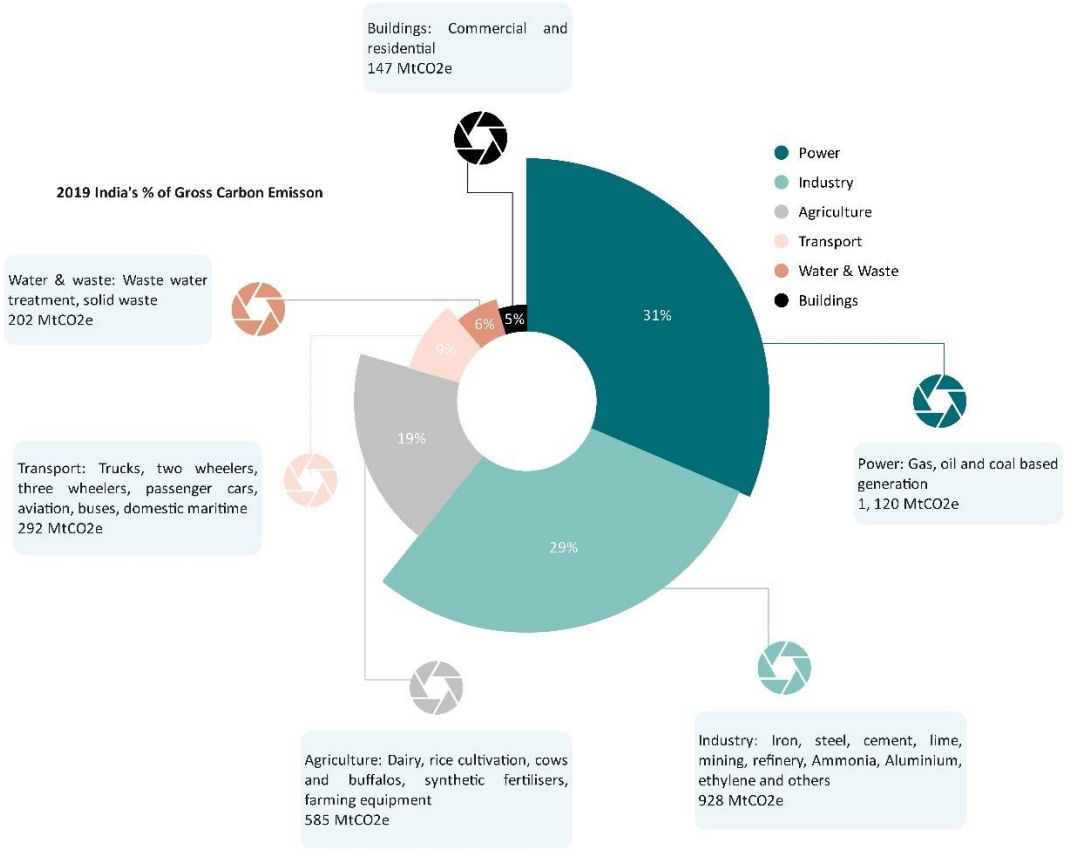

Figure 1. Gross and net emissions for 2019 based on Climate Action Tracker overall emissions for India. Adapted from McKinsey India

Similarly, this unprecedented rise in consumption is also experienced in terms of construction materials such as - aggregates, silica sand, limestone, clay, and mortar, as the consumption growth has incremented by more than 1 billion tons since 1996 (Sekhar, 2015). It has been predicted that despite India having a considerable number of limestone quarries, due to the imbalance of supply and demand, the Indian construction industry will soon encounter material unavailability problems (GRIHA, 2021). This clearly indicates that the country is on the verge of overexploiting these resources, and this adverse effect will be reflected on not just the environment but also in the economy and social aspects. For instance, the unavailability of this resource will impact the economic growth of India as it is one of the top five exporters of limestones (OEC, 2011) and will also contribute to unemployment. The construction industry is also one of the prime sources of industrial wastes, and India's construction and demolition (C&D) wastes constitute approximately 38% of the worldwide C&D waste production (Kolaventi et al., 2019). It is aggravating and unfortunate that only approximately 1% of the total construction waste generated in India is being recycled (CSE, 2020). This certainly draws attention to the 99% of the C&D wastes have been disposed in an unorganized manner causing hazards in multiple of spectrums. Figure 3 indicates the C&D wastes in few Indian cities. Mumbai, Bengaluru, Chennai, and Kolkata are Indian metropolitan cities. The absence of a monitoring scheme and the industry's unorganized nature are clearly reflected by the above-mentioned impacts.

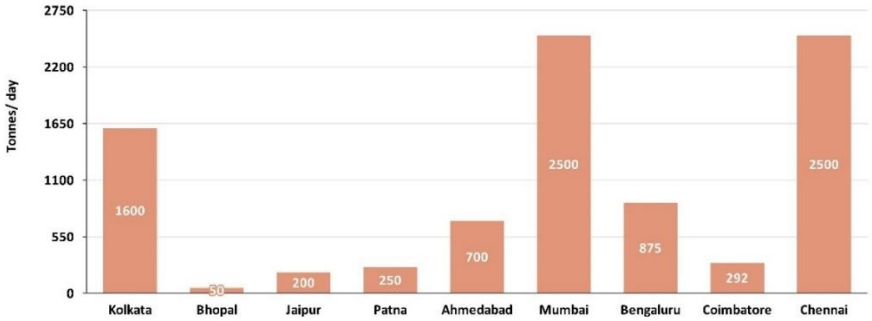

Figure 2. Construction and demolition waste generation in Indian cities. Adapted from BMTPC

Air pollution caused by construction dust is severely injurious to everyone exposed to it and long-term exposure may result in lifelong sickness and even death in a few cases (Subramanian & Abhyankar, 2019). It is majorly witnessed in the biggest cities in India such as Delhi, Mumbai, Bengaluru, and Chennai. Hence, it is clear that the negative environmental impacts caused by construction activities have consequences on society as well. Implementation of sustainable construction is therefore one of the comprehensive counter measures to tackle the above mentioned environmental, social, and economic issues.

3 Administrative framework of the Indian construction industry

The Ministry of Housing and Urban Affairs (MoHUA) in India is composed of central and state governing bodies, which resembles the administrative framework of Ministry of Skill and Development Entrepreneurship (MSDE); Ministry of Environment, Forest and Climate Change (MoEFCC); and the Ministry of Labour and Employment (MOL&E). MohUA is the policy maker; financier; coordinator between the state and central ministries; and monitoring body of housing and urban related issues in the nation (Ahuja & Basu, 2020). The MSDE conducts skill development programs across India and is responsible for bridging the gap between the demand and supply of skilled workers (MSDE, 2023). MoEFCC ensures biodiversity; forest and green land; flora and fauna; through its policies and programs. An agricultural land acquired for construction activities must be approved by the central authorities for clearance to be able to use the land for non-agricultural purposes (FICCI, 2017). MOL&E's primary role is to ensure the health and wellbeing of the construction workers (organised and unorganised) as the majority of them prevail from an underprivileged socioeconomic background. They also coordinate various skill development programs for the workers and established the 'Unorganized Workers' Social Security Act in 2008. The Infrastructure and Project Monitoring Division (IPMD) department under Ministry of Statistics and Program Implementation (MoSPI) gathers infrastructure project related information for centrally funded projects worth more than 1.5 billion USD and monitors the status of these heavily funded projects ((IPMD), 2023). The National Institution for Transforming India (NITI) Aayog was established in 2015 by replacing the Department of Planning Commission of 65 years. It focuses on implementing the SDGs in India and is not specific to the construction industry. The Construction Industry Development Council (CIDC) is also under the umbrella of NITI Aayog and is responsible for developing contract clauses for bidding purposes, cost indices for infrastructure projects, arbitration issues, and skill development programs for workers (CIDC, 2012).

The state department and local authorities are directly involved throughout the initiation, planning and design, construction, and operation phase. The Public Works Department (PWD), Local Development Authority, Municipal Corporation, and Urban Town Planner are involved in the building and construction layout approval and ensures that the building drawings and specifications are as per the NBC and ECBC (NBC, 2016). The drawings and specifications are to be authorised by the registered architect and engineer, and this is a mandate for the approval process. The building permit is provided by the local development authority after the construction drawings are approved. Prior to commencement of construction work 'No Objection Certificate' (NOC) is to be applied to the State's Forest Authority, Water, Sewerage, Electricity, Fire Service Department and Town Planner. Post obtaining all NOCs, the "Commencement Certificate" is acquired from the Local Development Authority or the Municipality which allows the owner to begin the construction practices. The owner or the client is also required to apply for electricity, water, sewerage connections to the respective state departments, as shown in Figure 3. The architects and engineers appointed for the approval of the building layout, structural plans, drawings, and specifications must be registered with the Council of Architecture (CoA) and Engineering Council of India (ECI) (NBC, 2016).

The construction building life cycle process in India is highly dependent on regulatory stakeholders, their roles, and responsibilities. Yet, there is no organised structure available for owners, clients, and other non-regulatory stakeholders to follow (Shirur, 2015). The multiple level authority approvals that are required during the initiation, design, construction, and operation phases of a building construction project in India are time consuming and impose constraints on the building construction business as additional costs are added in every stage of construction (Associates, 2023). Every state in India has a different set of building bye laws and; hence, the approval timings for building projects also differ from region to region (Doloi et al., 2017). There is an absence of a single regulatory body for the skills and development of construction workers in India as the CIDC, MOL&E and MSDE are equally responsible for training personnel. Without any clear organisational structure and integrated approval mechanism, the entire process becomes cumbersome.

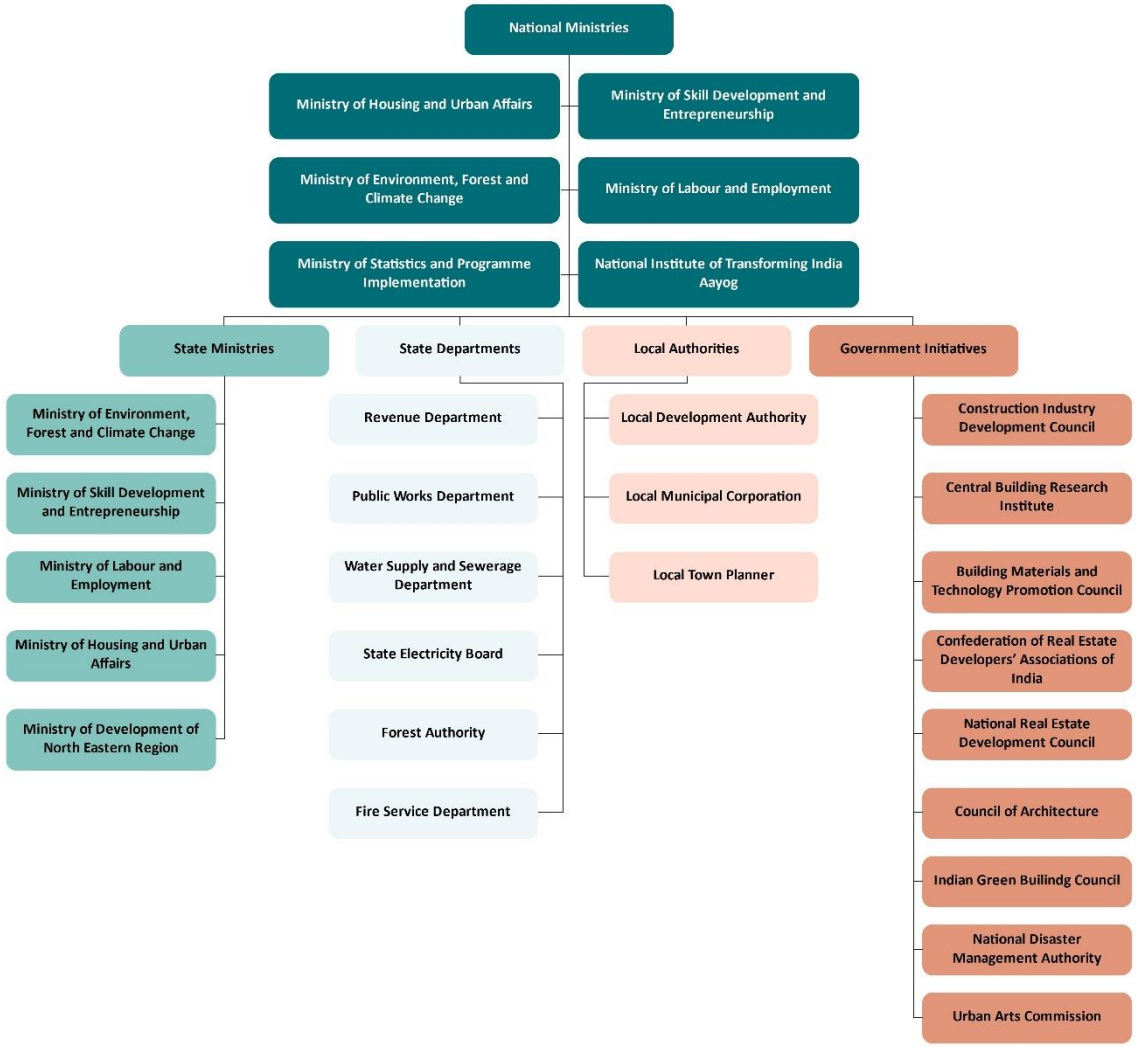

Figure 3. Indian building construction industry administrative framework

4 The evolving concept of sustainable construction

The concept of sustainability and sustainable development began in the early 1970s after scientific reports regarding the rate of depletion of ecological resources as a repercussion of multiple activities by mankind were issued by authors such Rachel Carson in her book 'The Silent Spring, 1962' and Edward Goldsmith's 'A Blueprint for Survival, 1972' (Du Pisani, 2006). The World Commission on Environment and Development (WCED) was established by the United Nation in 1983 to establish a comprehensive vision to tackle ongoing environmental issues (WCED, 1987). This resulted in the popular 'Brundtland Report' also referred to as 'Our Common Future' in 1987, which primarily defined sustainable development and hence, sustainability as satisfying the interests of the current communities without risking and jeopardising the needs of the upcoming generation (Kiani Mavi et al., 2021; WCED, 1987). The concept of sustainable construction was first introduced in 1994 at the International Conference on Sustainable Construction and was defined by Kibert (1994) as alignment of construction building practices with environmental

conservation fundamentals and thereby developing a healthy living space for the community (Kibert, 1994a, 1994b).

The concept of sustainable construction is complicated and has been an evolving process and is commonly related with the Triple Bottom Line (TBL) consideration as interrelationship of positive impacts of environmental, economic, and social dimensions of a project, as indicated by Elkington (1998). Therefore, keeping in mind the principles of sustainable construction, there is a dire need to identify multiple barriers that currently exist in India towards the implementation of sustainable construction. Unfortunately, the construction sector in India is highly unorganised and an effort has been made to lay down the administrative framework of industry. This will help us identify the varying roles and responsibilities of multiple national, state, and local stakeholders in India.

5 Methodology

This study carried out a four-phase research methodology, as shown in figure 5. A systematic literature review was carried out utilising Scopus and Google Scholar as the databases. The literature has been identified in the Phase I with the mentioned databases and keywords, as shown in table 1. A total of 246 studies were originally identified through these databases. Duplicated and non-English literature studies were excluded, which resulted in 210 studies. The abstract screening process and a full text availability of studies resulted in 53 relevant studies in phase II. In addition to scientific literature, the Environmental Performance Index (EPI) and Sustainable Development Goals (SDG) 2022 reports have also been reviewed (Sachs et al., 2022; Wolf et al., 2022). The articles are classified with respect to the various barriers identified through the selected literature, as part of phase III of the research methodology. In this phase, classification is done based on the type of barriers mentioned in the study. Barriers such as safety related issues on the construction sites and failures in the functionality of an infrastructure in the operation phase are indeed few of the vital problems that India is currently facing, however, this study only focuses on six key barriers selected in Phase IV of the research methodology.

Table 1. Themes and keywords

Theme	Keywords
Sustainable construction	"Sustainable construction" OR "building sustainability" OR "sustainability of building" OR "green buildings" OR "certified green buildings" OR "sustainability in built environment" OR "sustainability in human settlement" OR "sustainable building" OR "sustainability in building" OR "sustainable housing" OR "sustainable project" OR "sustainable construction sector" OR "sustainable construction practices" OR "sustainable habitat" OR "sustainability in construction industry" OR "sustainability in construction sector" OR "overview of sustainable construction"
Barriers	"Barriers" OR "challenges" OR "barriers and drivers" OR "critical barriers" OR "identification of barriers" OR "identification of challenges" OR "critical challenges" OR "key barriers" OR "key challenges"
Construction industry	"Construction industry" OR "built environment" OR "building industry" OR "construction sector" OR "human settlement" OR "building sector"

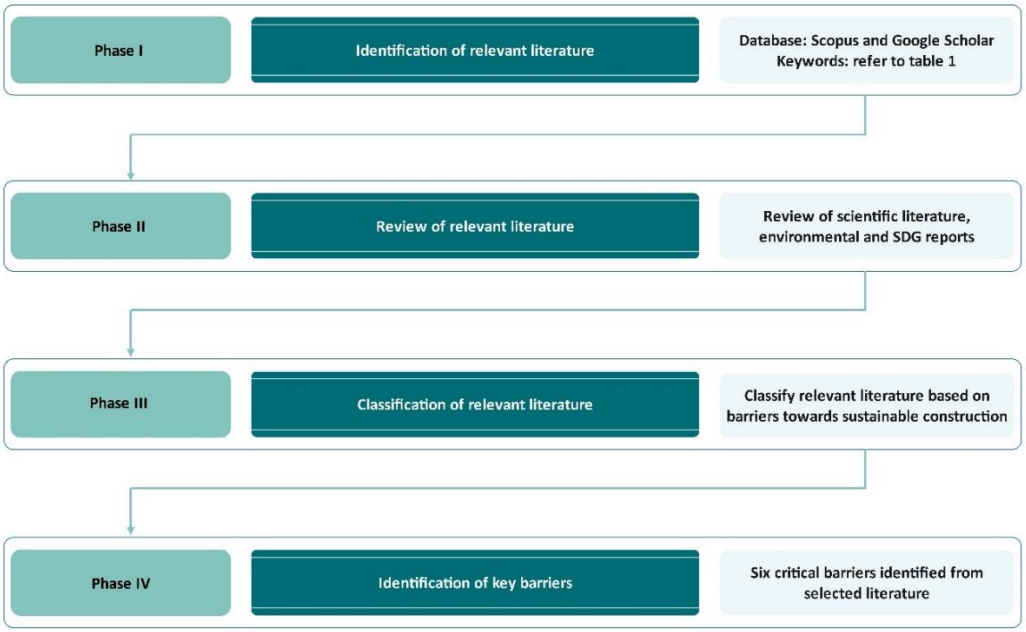

Figure 5. Research methodology for the current study

6 Key barriers to implementation of sustainable construction in India

The growing construction industry in India faces numerous internal challenges other than ecological impacts. Resolution to these challenges will help India thrive in towards the opportunities that the construction industry encompasses (Sawhney et al., 2014). Researchers have discussed the recurring cost and time overrun problems (Doloi, 2013; Doloi et al., 2012; Prasad et al., 2018); substandard planning and lack of regulation conditions (Khan et al., 2021); poor project management team collaboration (Khan & Hussain, 2016); low awareness about technology and resistance to digital conversion (Avirag Bajpai & Subhas Chandra Misra, 2021; Bijivemula et al., 2023); attitude and perception barriers (Bijivemula et al., 2023); and below par construction productivity challenges (Dixit et al., 2017). These challenges range across all building life cycle phases and are discussed in detail below.

Each challenge has its own negative outcome, which creates a ripple effect on the system. Consistent irregularities in the Indian construction industry have been ongoing since about time. However, it is imperative to recognize that integrated mitigation measures should be undertaken by not separating the ecological challenges from these internal technical barriers.

6.1 Construction cost overrun

Cost assessment, control, and management are some of the key attributes of a successful construction project. A precise monetary evaluation and quotation value of a project can only be established if the contractor is aware of the scope, project complications, materials, human resources, equipment, site conditions, construction technology provisions and overheads during project's initial phases (Baloi & Price, 2003). The trio of owner, consultant and the general contractor are considered as the key roles in potentially

resolving the complexities of the cost overrun problems if considered from the design and construction phases, as per Doloi (2013) (Doloi, 2013). The contractor's responsibility of resource and cost management is crucial in terms of successful completion, however, the design team's ability to incorporate the owner's functional and technical requirements of a project in the conceptual and design phases decreases the potential chances of any scope modifications in the future. In 2020, approximately, 25% of India's projects were encountering cost overrun challenges (Statisa, 2021). Studies conducted in India with more than 150 construction professionals ranging from 100-500 million INR projects demonstrated that inflation, poor collaboration among project team members and lack of proper planning are the reasons behind cost overruns (Wanjari & Dobariya, 2016). This indicates that cost overrun issues can occur in the construction phase while having adequate planning in the design stage. Every phase demands a cooperative team with the capability of identifying certain risks along the way.

6.2 Schedule delays

One of the key attributes of a successful project is to be achieving the scheduled completion date and maintaining it the entire project. Schedule delays are one of the most common challenges in all developing and developed countries, irrespective of the size of the building project and India is no exception in this aspect (Sambasivan & Soon, 2007); (Prasad et al., 2018). Around 50% of the projects in the Indian construction industry were undergoing time overrun problems in 2013 (Singh et al., 2018). India's construction industry performance with respect to cost and time related factors is the most unsatisfactory amongst the other Asian countries namely Bangladesh, China, and Thailand as per the comparative studies by Ahsan and Gunawan (2010). A study by Doloi et al. (2012) on 70 Indian construction industry personnel revealed that the lack of interest and absence of commitment is one the prime contributing factors of delays in construction projects. This study has not been successful in providing a pragmatic resolution to this recurring phenomenon (AlSehaimi et al., 2013). On the other hand, economic distress has been found to be the leading cause of schedule delays per the studies by Abd El-Razek et al. (2008) and Prasad et al. (2018). A new approach for dealing with construction delays will be to focus on design build projects with the motive of integrated project delivery, which has not been investigated in the mentioned studies. No mention of identifying multiple risks via risk assessment of overall construction site have not been addressed.

6.3 Lack of regulations and monitoring schemes

Lack of regulations and standardized processes is one of the major regulatory challenges that the Indian construction industry is facing (Commission, 2011). The lack of regulations is not just reflected in the construction phases but is prevalent from the very beginning of land acquisition processes encompassing inconsistencies in land record documents, ambiguous exchange of information and monetary misconduct (Sawhney et al., 2014). Statutory and project approvals regulations are complicated and an organizational structure with the mentioned roles of involved players from the government side is officially not available, which makes this entire unorganized process to be more burdensome for all parties involved in the initial phases of a building construction project (Gadekar & Pimplikar, 2014; Sawhney et al., 2014). A distinct fragmentation among standards in National Building Code of India (NBC), geoclimatic construction methods requirements and material selection per level of seismic risks, leads to the development of unsafe buildings due to breach of building norms (DTE, 2015). A refurbished national building

code acknowledging the geoclimatic conditions of India and incorporating the advanced technologies will contribute towards a high-quality building performance (Lazar & Chithra, 2021). Due to the nature of the construction business in India, the tendency for more violations in regulations and less transparency in the procedures have high occurrences (Sawhney et al., 2014). It is a complex task to organize the Indian construction industry structure in a systematic manner with stringent policies and can only be implemented by the Indian administration. Previous research has disregarded the vitality of the role of regulations and monitoring schemes in the building industry.

6.4 Poor team integration and collaboration

In addition to cost overruns and schedule delays, the construction industry is also a platform where frequent conflicts among owner-architect-contractor (OAC) occur as professionals with diverse experience backgrounds have varying perceptions, however, if these conflicts are not intervened at the right time, it may end up in a legal dispute (Cakmak & Cakmak, 2014). Conventional building construction practices in India involve the owner initiating the process and the project is contracted to the most competitive bidder after the design specifications are completed (Khan & Hussain, 2016; NBC, 2016). All building construction projects may differ in terms of scope and specifications, however, disputes are usually common across projects (Cakmak & Cakmak, 2013). The team integration and collaboration from the initiation, planning and feasibility stages would have contributed to identification of risks, overlooked design scope, and ample time to work on the amendment measures (Khan & Hussain, 2016). However, the engagement of other stakeholders - supply chain, investors, building users, society and community should also be a part of the early discussion to make a project sustainable.

6.5 Inefficient productivity and innovation

One of the key causes of Indian construction project failures is poor productivity. Contributory factors that foster low productivity onsite and it's restorative agendas have been identified in research (Iyer & Jha, 2005). There are multiple definitions of productivity that vary among industries. The amount of time, cost, volume, and weights of construction worker hours allotted to a specific project can be defined as productivity in the construction industry (Dixit et al., 2019). Construction firms usually have their own means and methods to calculate the productivity onsite. The National Productivity Council (NPC) in India was established in 1958, as a centralised platform which develops approaches and strategic management plan for continuous improvement in productivity and betterment of standards in manifold industries. The NPC also maintains a centralized productivity journal, organizes trainings based on productivity consciousness and facilitates the use of digitalisation across industries (NPC, 2023). The Indian construction productivity growth rate was consecutively negative from fiscal year 2014 to 2019 (Statista, 2022). Construction productivity is directly proportional to revenue; hence, when the productivity is negative, there is a substantial amount of economic loss (Hughes & Thorpe, 2014). Some of the primary reasons for inefficient onsite productivity are unclear communication about scope of work, allocation of resources, unavailability of equipment, additional repair work, shortage of labour, amateur workforce, insufficient construction materials, reluctance to use of advanced technology, incompetent project management skills, suffocating working conditions and inadequate safety protocols (Avirag Bajpai & Subhas Chandra Misra, 2021; Dixit, 2021; Khan et al., 2021; Makulsawatudom et al., 2004). Low productivity in construction leads to an unsatisfactory amount of work with substandard

quality as compensation for the time and money. There is a consistent pressure on laborers to maintain schedule with extra working hours. Employing new technology, tools and electronic platforms will help the industry in monitoring, maintaining schedule and effective communication. The construction industry in India has maintained resistance toward incorporating new and advanced technology, even though it's been recognized that it hampers productivity onsite as the vast majority of the team members are not qualified enough to learn and implement new technology (Arpit Singh & Subhas Chandra Misra, 2021). In addition, some construction firms are not able to afford new technology due to budget constraints as these firms have been highly dependent on manual work of workers.

6.6 Unskilled workforce and incompetency

The conventional procurement model and project management strategies contribute to a stagnant and regressive construction industry. At the same time, without sufficient skills, operating guides, awareness campaigns, regular organizational training, and professional development programs, any updated model or technology is in vain and cannot be optimized (Bijivemula et al., 2023). The construction industry in India is prevalently dependent on manual labour and archaic technology, instead of progressing toward digitalization and intelligent systems (Avirag Bajpai & Subhas C. Misra, 2021). The availability of skilled workforce is a vital tool for a successful completion of a construction project. Among the other developing nations, India has scarcity of skilled construction labor because of its high demand and low availability (Bedekar, 2017; Johari & Jha, 2019). The ratio of skilled to unskilled labor is highly polarized and only 10% of the laborers in the construction industry are certified skilled laborers (Nihas et al., 2013). This indicates a systematic failure to damage control the existing skilled labor shortage situation. The quality of training provided to the existing skilled laborers is also an area of improvement, as there is no standard training infrastructure platform in India (Johari & Jha, 2019). As organizing high quality training sessions has been one of the most mentioned solutions to this problem, it is high time for the regulatory authorities and firms to regularly update their training plans and supervise labor on site by highly skilled superintendents. It is important for construction firms to ensure that the labor can successfully deliver the project requirements in a safe and secure environment. The attitude of the leadership team of the construction firm also plays a cardinal role in having a competent team. Furthermore, regarding the management, planning of a building construction project, and site management practices, there is a dearth of official construction project management practices in India (Sreepuram & Rao, 2006). Hence, there is a lack of training across superintendents, architects, Mechanical-Electrical-Plumbing (MEP) engineers, surveyors, structural engineers, geotechnical engineers, equipment operators, and even the client (Misra & Mohanty, 2021).

There are numerous other challenges that can be identified as barriers to sustainable construction in India. Issues such as gender disparities in the industry (Kakad, 2002) and safety performances (Arpit Singh & Subhas C. Misra, 2021) have been consistent in the industry. Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED) India and the Indian Green Building Council (IGBC) are the three Green Building Rating Systems (GBRS) that exist in India. The assessment criteria regarding water and energy categories vary in GRIHA and IGBC system leading to confusion among stakeholders in choosing the appropriate assessment tool (Pamu & Mahesh, 2019). Also, this may contribute to rating the same building differently (Gangwar

et al., 2020). This indicates that having multiple GBRS in one country can lead to ambiguity and reluctance from the stakeholder's perspective, which adds to the existing challenges that the Indian construction industry is facing.

7 Addressing the key barriers

Multiple schemes are being initiated by the Government of India (GoI) to address the challenges faced by the Indian construction industry in implementing the long-term principles of sustainable construction.

The local building byelaws in India are mandated to follow the NBC to ensure safer buildings across the country (NBC, 2016). However, the building regulations are not integrated with the energy conservation factors in the case of NBC. To counter this challenge, the GOI established the Bureau of Energy Efficiency (BEE) in 2002 to make energy conservation and emission-controlled regulations for the building construction industry sector. The operational energy has been considered in terms of the Energy Conservation Building Code (ECBC), however, the embodied energy related to all building materials and construction practices are not considered (Khan & Bhusan, 2023). Figure 6 displays the government initiatives implemented by GOI.

Figure 1. Indian government schemes and initiatives. (Adapted from GOI)

Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme was launched in 2015 in almost 450 cities and towns in India with the aim of providing regular water supply, sewerage systems, potable water, green spaces and pedestrian friendly navigation in selected areas (AMRUT, 2016). Affordable Rental Housing Complexes (ARHC) focusses on the welfare and quality of living of underprivileged migrants and help the targeted population afford accommodation at reasonable rates. Per this initiative, existing unutilized accommodations will be allocated to the workers to make the best use of existing resources (ARHC, 2020). The Global Housing Technology Challenge (GHTC) was established in 2019 to implement the top construction technologies in India (Challenge, 2019).

These government schemes and initiatives are formed to adhere to the SDGs and the 2030 Agenda. Despite these initiatives, India's current SDG Index rank is 121 out of 163 and most of the objectives per goal 11 of 'Sustainable Cities and Communities' are untouched. From the above discussion, it is clear that regulatory organizations are one of the key stakeholders in the construction industry as nationwide schemes and propaganda are initiated by them. The above-mentioned initiatives are fragmented in their own ways

and there is currently no common monitoring framework as far as the construction industry is concerned.

8 Conclusion

This study identifies the critical challenges that need to be addressed by decision makers so that the barriers can be overcome at the grassroots level by all the stakeholders. It is important to note that principles of sustainable construction cannot be achieved if a project is not focused on of the life cycle perspective. These identified barriers cannot be managed with a non-integrated approach. Most of the developed countries like USA and Australia have a single green building rating system, unlike India. This also showcases the fragmented approach in which India's construction industry continues to function. The construction industry along with other industries, must have a specific monitoring framework to identify specific criteria that need to be prioritized as per the current situation. Educational campaigns and organisational learning should be initiated by construction firms to provide more hands-on learning experience to the team and workers. More challenges and barriers can be identified in the future by interviewing multiple stakeholders and engaging them during the site selection process.

References

(IPMD), I. a. P. M. D. (2023). *Programme Implementation (PI) Wing, Infrastructure and Project Monitoring Division (IPMD), Ministry of Statistics and Programme Implementation* Retrieved 1/05/2023 from https://www.mospi.gov.in/programme-implementation-pi-wing

Abd El-Razek, M., Bassioni, H., & Mobarak, A. (2008). Causes of delay in building construction projects in Egypt. *Journal of Construction Engineering and Management*, *134*(11), 831-841.

Ahsan, K., & Gunawan, I. (2010). Analysis of cost and schedule performance of international development projects. *International Journal of Project Management*, *28*(1), 68-78. https://doi.org/https://doi.org/10.1016/j.ijproman.2009.03.005

Ahuja, V., & Basu, C. (2020). Indian construction industry: Programmes, initiatives, achievements and challenges. *Improving the Performance of Construction Industries for Developing Countries*, 169-200.

AlSehaimi, A., Koskela, L., & Tzortzopoulos, P. (2013). Need for alternative research approaches in construction management: Case of delay studies. *Journal of Management in Engineering*, *29*(4), 407-413.

AMRUT. (2016). *Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Ministry of Housing and Urban Affairs, Government of India*. Government of India. Retrieved 30/04/2023 from http://amrut.gov.in/content/innerpage/the-mission.php

ARHC. (2020). *Affordable Rental Housing Complexes (ARHCs) for Urban Migrants/ Poor, Ministry of Housing and Urban Affairs, Government of India*. Ministry of Housing and Urban Affairs. Retrieved 30/04/2023 from http://arhc.mohua.gov.in/

Associates, L. (2023). India: Construction Comparative Guide Retrieved 1/05/2023, from https://www.mondaq.com/india/real-estate-and-construction/1154898/construction-comparative-guide#:~:text=Social%20security%20laws%20%E2%80%93%20such%20as%20the%20Employee's%20Compensation%20Act%2C%202009,labourers%20or%20workmen%20in%20the

Bajpai, A., & Misra, S. C. (2021). Analyzing Key Barriers for Adoption of Digitalization in Indian Construction Industry: A Case Study. In *Progress in Advanced Computing and Intelligent Engineering* (pp. 683-693). https://doi.org/10.1007/978-981-33-4299-6_56

Bajpai, A., & Misra, S. C. (2021). Barriers to implementing digitalization in the Indian construction industry. *International Journal of Quality & Reliability Management*, *39*(10), 2438-2464. https://doi.org/10.1108/ijqrm-09-2020-0318

Baloi, D., & Price, A. D. (2003). Modelling global risk factors affecting construction cost performance. *International Journal of Project Management*, *21*(4), 261-269.

Bedekar, A. (2017). Opportunities & challenges for IoT in India. *Latest Technology Magazine*.

Bhatt, R., & Macwan, J. E. M. (2016). Fuzzy Logic and Analytic Hierarchy Process–Based Conceptual Model for Sustainable Commercial Building Assessment for India. *Journal of Architectural Engineering*, *22*(1). https://doi.org/10.1061/(asce)ae.1943-5568.0000184

Bijivemula, S. K. R., Sai, S. J., & Chepuri, A. (2023). A structural equation model of stakeholder roles in the implementation of green construction strategies in the Indian construction industry. *International Journal of Construction Management*, 1-9. https://doi.org/10.1080/15623599.2023.2179568

Cakmak, E., & Cakmak, P. I. (2014). An Analysis of Causes of Disputes in the Construction Industry Using Analytical Network Process. *Procedia - Social and Behavioral Sciences*, *109*, 183-187. https://doi.org/https://doi.org/10.1016/j.sbspro.2013.12.441

Cakmak, P. I., & Cakmak, E. (2013). An analysis of causes of disputes in the construction industry using analytical hierarchy process (AHP). In *AEI 2013: Building solutions for architectural engineering* (pp. 94-102).

Challenge, G. H. T. (2019). *Global Housing Technology Challenge, Ministry of Housing and Urban Affairs, Government of India*. Retrieved 30/4/2023 from https://ghtc-india.gov.in/

CIDC. (2012). Construction Industry Development Council, An apex body dedicated to the cause of construction, Established by the Planning Commission (Government of India) and the Construction Industry. http://www.cidc.in/support/pdf/CIDC%20Corporate%20Profile.pdf

Commission, P. (2011). *Approach to the 12th Five Year Plan (2012-17)*. N. D. Government of India. http://planningcommission.nic.in/plans/planrel/12appdrft/appraoch_12plan.pdf

CSE. (2020). *India recycles only 1% of its construction and demolition waste: Centre for Science and Environment (CSE)*. https://www.downtoearth.org.in/news/waste/india-recycles-only-1-of-its-construction-and-demolition-waste-cse-73027

CWF. (2010). *Climate Works Foundation. Reducing GHG emissions in the building sector in India: A strategy paper*. N. D. C. W. Foundation.

Dixit, S. (2021). Impact of management practices on construction productivity in Indian building construction projects: An empirical study. *Organization, technology & management in construction: an international journal*, *13*(1), 2383-2390.

Dixit, S., Mandal, S. N., Thanikal, J. V., & Saurabh, K. (2019). Study of significant factors affecting construction productivity using relative importance index in Indian construction industry. E3S web of conferences,

Dixit, S., Pandey, A. K., Mandal, S. N., & Bansal, S. (2017). A STUDY OF ENABLING FACTORS AFFECTING CONSTRUCTION PRODUCTIVITY: INDIAN SCNERIO. *International Journal of Civil Engineering and Technology (IJCIET)*, *Volume 8*(Issue 6), 741–758.

Doloi, H. (2013). Cost Overruns and Failure in Project Management: Understanding the Roles of Key Stakeholders in Construction Projects. *Journal of Construction Engineering and Management*, *139*(3), 267-279. https://doi.org/10.1061/(Asce)Co.1943-7862.0000621

Doloi, H., Sawhney, A., Iyer, K. C., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management*, *30*(4), 479-489. https://doi.org/10.1016/j.ijproman.2011.10.004

Doloi, H., Week, D., & Bora, A. (2017). Role of Regulatory Framework for Supporting Construction Industry in India. *EPiC Series in Education Science*, *1*, 351-360.

DTE. (2015, 27 April 2015). *DownToEarth. CSE points out lapses in building regulations in India*. DownToEarth. https://www.downtoearth.org.in/news/urbanisation/cse-points-out-lapses-in-building-regulations-in-india-49566

Du Pisani, J. A. (2006). Sustainable development – historical roots of the concept. *Environmental Sciences*, *3*(2), 83-96. https://doi.org/10.1080/15693430600688831

FICCI. (2017). *Approval Process for Real Estate Projects in Maharashtra (Mumbai) & Suggestions to Streamline the System*. F. o. I. C. o. C. I. (FICCI). https://ficci.in/spdocument/20140/real-estate.pdf

FIFP. (2023). *Foreign Investment Facilitation Portal, Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry*. Retrieved 20/04/2023 from https://fifp.gov.in/

Gadekar, A., & Pimplikar, S. S. (2014). Success and Failure Factors of Indian Construction Companies. *The International Journal Of Engineering And Science*, *Volume 3*(Issue 6), Pages 52-58

Gangwar, G., Kaur, P., & Singh, I. (2020). Principles of Design for Sustainable Group Housing Projects in India. *Civil Engineering and Architecture*, *8*. https://doi.org/10.13189/cea.2020.080608

Goh, C. S., Rowlinson, S., & Wang, C. (2021). A Paradigm Shift from Green Buildings to Sustainable Cities: Concept and Future Direction. Proceedings of the 23rd International Symposium on Advancement of Construction Management and Real Estate,

GRIHA. (2021). *GRIHA V.2019; Volume 1. Introduction to National Rating System - GRIHA. An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment*. A. G. C. Publication.

GSCI. (2022). *The Sustainable Competitiveness Report*. S. C. C. A.-N.-S. I. License.

Hughes, R., & Thorpe, D. (2014). A review of enabling factors in construction industry productivity in an Australian environment. *Construction Innovation*, *14*(2), 210-228.

IBEF. (2020). *India Brand Equity Foundation (IBEF). Economic Survey 2020 - 2021*. https://www.ibef.org/economy/economic-survey-2020-21

IEA. (2022). *World Energy Outlook 2022*. https://doi.org/doi:https://doi.org/10.1787/3a469970-en

Iyer, K., & Jha, K. (2005). Factors affecting cost performance: evidence from Indian construction projects. *International Journal of Project Management*, *23*(4), 283-295.

Johari, S., & Jha, K. N. (2019). Challenges of attracting construction workers to skill development and training programmes. *Engineering, Construction and Architectural Management*, *27*(2), 321-340. https://doi.org/10.1108/ecam-02-2019-0108

Kakad, K. (2002). Gender Discrimination in the Construction Industry: The Case of Two Cities in India. *Gender, Technology and Development*, *6*(3), 355-372. https://doi.org/10.1080/09718524.2002.11910051

Khan, S., & Bhusan, S. (2023). India's Building Code Has a Blind Spot for a Whole Category of Emissions. Retrieved 30/04/2023, from https://science.thewire.in/environment/india-building-code-embodied-emissions/

Khan, S., & Hussain, A. (2016). Team Integration in Indian Construction Industry. *International Journal of Engineering Technology Science and Research*, *Volume 3*(Issue 4).

Khan, S., Saquib, M., & Hussain, A. (2021). Quality issues related to the design and construction stage of a project in the Indian construction industry. *Frontiers in Engineering and Built Environment*, *1*(2), 188-202. https://doi.org/10.1108/febe-05-2021-0024

Kiani Mavi, R., Gengatharen, D., Kiani Mavi, N., Hughes, R., Campbell, A., & Yates, R. (2021). Sustainability in Construction Projects: A Systematic Literature Review. *Sustainability*, *13*(4), 1932. https://www.mdpi.com/2071-1050/13/4/1932

Kibert, C. J. (1994a, 6 - 9 November). Preface. In Proceedings of First International Conference of CIB TG 16 on Sustainable Construction. Tampa, Florida.

Kibert, C. J. (1994b, 6 - 9 November). Final Session of First International Conference of CIB TG 16 on Sustainable Construction. Tampa, Florida.

Kolaventi, S. S., Tezeswi, T. P., & Siva Kumar, M. V. N. (2019). An assessment of construction waste management in India: A statistical approach. *Waste Management & Research*, *38*(4), 444-459. https://doi.org/10.1177/0734242X19867754

Lazar, N., & Chithra, K. (2021). Evaluation of sustainability criteria for residential buildings of tropical climate: The stakeholder perspective. *Energy and Buildings*, *232*. https://doi.org/10.1016/j.enbuild.2020.110654

Makulsawatudom, A., Emsley, M., & Sinthawanarong, K. (2004). Critical factors influencing construction productivity in Thailand. *The journal of KMITNB*, *14*(3), 1-6.

Misra, P. K., & Mohanty, J. (2021). A review on training and leadership development: its effectiveness for enhancing employee performance in Indian construction industry. *IOP Conference Series: Materials Science and Engineering*, *1045*(1), 012020. https://doi.org/10.1088/1757-899X/1045/1/012020

MSDE. (2023). *Ministry of Skill Development and Entrepreneurship, Government of India*. Government of India. Retrieved 1/05/2023 from https://msde.gov.in/

NBC. (2016). *National Building Code of India, Vol. 1, Part 5 - Building Materials* (European Planning Studies, Issue.

Nihas, S., Barlish, K. C., & Kashiwagi, D. (2013). Construction industry structure in India. RICS, COBRA Conference, New Delhi, September,

NPC. (2023). *National Productivity Council, Department for Promotion of Industry & Internal Trade, Ministry of Commerce and Industry, Government of India*. Government of India. Retrieved 22/04/2023 from https://www.npcindia.gov.in/NPC/User/about

OEC. (2011). *The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development. https://oec.world/en/profile/bilateral-product/limestone/reporter/ind#:~:text=Exports%20In%202021%2C%20India%20exported,most%20exported%20product%20in%20India.* Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence.,

Pamu, Y., & Mahesh, K. (2019). A Comparative Study on Green Building Rating Systems in India in terms of Energy and Water. *CVR Journal of Science and Technology*, *16*(1), 21-25.

Prasad, K. V., Vasugi, V., Venkatesan, R., & Bhat, N. S. (2018). Critical causes of time overrun in Indian construction projects and mitigation measures. *International Journal of Construction Education and Research*, *15*(3), 216-238. https://doi.org/10.1080/15578771.2018.1499569

Programme, U. N. E. (2018). 2018 global status report: towards a zero-emission, efficient and resilient buildings and construction sector. In: International Energy Agency and the United Nations Environment Programme New ….

Sachs, J., Lafortune, G., Kroll, C., Fuller, G., & Woelm, F. (2022). From crisis to sustainable development: the SDGs as roadmap to 2030 and beyond: includes the SDG index and dashboards. *(No Title)*.

Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*, *25*(5), 517-526.

Sawhney, A., Florence Yean Yng, L., Dr Carlos Formoso, D., Agnihotri, R., & Kumar Paul, V. (2014). Grand challenges for the Indian construction industry. *Built Environment Project and Asset Management*, *4*(4), 317-334. https://doi.org/10.1108/bepam-10-2013-0055

Sekhar, A. R. (2015). *Resource efficiency in the Indian construction sector: Market evaluation of the use of secondary raw materials from construction and demolition waste*. Deutsche Gesellschaft fut Internationale Zusammenarbeit (GIZ) Gmbh.

Shirur, E. S. T., Suwarna. (2015). Indian Construction Industry: Challenges for the Construction Managers. *IOSR Journal of Business and Management (IOSR-JBM)*, *Volume 16*(Issue 4), 65-69.

Singh, A., & Misra, S. C. (2021). Identifying Challenges in the Adoption of Industry 4.0 in the Indian Construction Industry. In *Progress in Advanced Computing and Intelligent Engineering* (pp. 380-398). https://doi.org/10.1007/978-981-15-6584-7_37

Singh, A., & Misra, S. C. (2021). Safety performance & evaluation framework in Indian construction industry. *Safety Science*, *134*. https://doi.org/10.1016/j.ssci.2020.105023

Singh, S., Bala, A., Dixit, S., & Varshney, D. (2018). Critical analysis of causes of delay in residential construction projects in India. *International Journal of Civil Engineering and Technology*, *9*(1), 330-345.

Sreepuram, P., & Rao, A. (2006). Build organization capabilities to utilize IT. Proceedings of the World Conference for Design and Construction, INCITE/ITCSED,

Statisa. (2021). *Share of cost overrun in infrastructure projects across India from financial year 2010 to 2021* Retrieved 21/04/2023 from https://www.statista.com/statistics/1069989/india-infrastructure-projects-cost-overrun-share/

Statista. (2022, Sep 13, 2022). *Labor productivity growth of the construction sector in India from financial year 2013 to 2019* Manya Rathore. Retrieved 22/04/2023 from https://www.statista.com/statistics/1119050/india-labor-productivity-growth-in-construction-sector/

Subramanian, N., & Abhyankar, V. G. (2019). Construction Dust Causes, Effects and Remedies. Retrieved 20/04/2-23, from https://www.nbmcw.com/article-report/infrastructure-construction/infra-real-estate/construction-dust-causes-effects-and-remedies.html

UNEP. (2022). *2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.* https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

UNFCCC. (2015). Paris Agreement to the United Nations Framework Convention on Climate Change.

Verma, S., Mandal, S. N., Robinson, S., & Bajaj, D. (2020). Diffusion patterns and drivers of higher-rated green buildings in the Mumbai region, India: a developing economy perspective. *Intelligent Buildings International*, *14*(4), 393-413. https://doi.org/10.1080/17508975.2020.1803787

Wanjari, S. P., & Dobariya, G. (2016). Identifying factors causing cost overrun of the construction projects in India. *Sādhanā*, *41*(6), 679-693. https://doi.org/10.1007/s12046-016-0498-3

WCED. (1987). World Commission on Environment

Development. Our Common Future Oxford. In.

Wolf, M. J., Emerson, J. W., Esty, D. C., de Sherbinin, A., & Wendling, Z. A. (2022). *2022 Environmental Performance Index*.

Studies on available seaweed wastes as compost organic fertilizer resources

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Abstract: *Marine red algae from the Bangladesh Bay of Bengal Hypnea Sp have been used as organic materials due to the presence of a number of plant growth-stimulating compounds. The effect of various seaweed species on plant growth and development with an emphasis on the use of this renewable bio-resource in sustainable agriculture of northern fertilizers raw materials system. Organically made fertilizers play an important role in increasing crop yield and the quality of crops promises improvements considering climate adaptation. Seaweed wastes compost was put in evaluation trials at Sreemangal, Bangladesh to evaluate its efficacy and find out the optimum dose for profitable Betel leaf production. This part of the study is directed toward the analysis of the future trend and performances of composting seaweed wastes. The science of seaweeds explores, how analysis of the future trend and performances of composting seaweed wastes. A field study was conducted at three treatments at Khasia farmers of Sreemangal Khasia betel leaf cultivation community area of Bangladesh. Seaweed wastes mixed with compost organic fertilizer dose of 25g and 50g per support tree . The highest betel leaf yield was obtained from seaweed wastes mixed with compost organic fertilizer applied to plants. Table 1. (2880 leaf). The use of seaweed based compost organic fertilizer had a positive effect of betel leaf yield. This study suggests that seaweed wastes mixed with organic fertilizer are suitable for betel leaf cultivation. Area-based conservation is a key tool for delivering the Sustainable Development Goal of responsible production and consumption and climate action.*

Keywords: *Seaweed, Plant Growth, Organic Material, northern fertilizer, Sustainable.*

1 Introduction

Seaweeds , also known as marine macroalgae, have gained attention as a potential sustainable and organic compost fertilizer resource due to their rich nutrient content and numerous environmental benefits: Seaweeds are abundant in coastal regions and have been traditionally used for various purposes, including as a soil conditioner and fertilizer. Seaweeds are rich in essential nutrients such as nitrogen (N), phosphorus(P),potassium(K) and trace elements like iron, magnesium and calcium.These nutrients are crucial for plant growth and development,making seaweed an excellent natural fertilizer source. Seaweeds are an organic and renewable resource, making them suitable for organic farming practices. When incorporated into compost,they enhance the organic matter content of the soil, improving soil structure, water retention and microbial activity.Seaweeds contain various growth promoting compounds like cytokinins, auxins and gibberellins, which act as natural biostimulants. These compounds can enhance seed germination, root development and overall plant vigor.Seaweeds have allelopathic properties that can suppress weed growth and deter certain pests, reducing need for chemical herbicides.Using locally available seaweeds for compost reduces the need for synthetic fertilizers , which canlead to nutrient runoff and water pollution. It also promotes sustainable harvesting practices, reducing the impact of marine ecosystems . Seaweed compost enhances soil structure, increases nutrient availability and encourages beneficial microorganisms, contributing to improved soil health and fertility. Incorporating seaweed compost reduces the reliance on synthetic chemicals in agriculture , aligning with organic and sustainable farming practices.Research has shown that seaweed based compost can enhance crop yields,improve crop quality and increase resistance to environmental stressors such as drought and disease. Utilizing locally available seaweeds can create economic opportunities for coastal communities and reduce transportation costs associated with importing conventional fertilizers.

Providing a safe alternative to chemical fertilizers is a crying need of present time. Although chemical crop fertilizers boost crop yield. They are also responsible for environmental pollution all around the world. Northern Organic and Balanced fertilizers provide a safe alternative to chemical fertilizers while having more agricultural output and reducing chemical fertilizer usage.

Technology based Circular Economy Model -Supplies plant food to both crop and soil in an integrated way, Increase production and reduce cost, Fertilizer can be used easily and directly by the farmers, no hassle of calculating, mixing and handling, Fertilizer also contains essential micro nutrients, Enhance crop quality and storage capacity, Safeguard the environment.Seaweeds or marine macroalgae are rich in diverse compounds like lipids, proteins, carbohydrates, phytohormones, amino acids, osmoprotectants, antimicrobial compounds and minerals. Their potentials for agricultural applications has been used since antiquity, but recents demands of organic farming and organic food stimulated much the application of organic treatments like seaweed extracts in agriculture.

The benefits of seaweeds application in agricultural field are numerous and diverse such as stimulation of seed germination, enhancement of health and growth of plants namely shoot and root elongation, improved water and nutrient uptake, frost and saline resistance, biocontrol and resistance toward phytopathogenic organisms, remediation of pollutants of contaminated soil and fertilization. In this review, scientific progress in this field was collected and critically assessed to lay grounds for further investigations and applications.

Seaweeds are the important marine resources available at negligible cost and rich indiversebioactivecompoundslikelipids,proteins,carbohydrates,aminoacids,phytohormones, Osmo protectants, mineral nutrients and antimicrobial compounds. They are key component in food, feed, and medicine since ancient times. Recent trend oforganicfarminghasexploitedthepossibleapplicationofseaweedasorganic/bio-fertilizer in agriculture. Many studies have demonstrated the benefits of seaweed in enhancing the plant growth and productivity. Added to this they are known to be a promising soil conditioner, protect the plants under abiotic and biotic stress and increase plant resistance against pest and diseases. In this chapter an attempt has been made to highlight the scientific progress on usefulness of seaweed in the context of utilization in agriculture as organic fertilizer and prospects for further research and use. Seaweeds are marine plants contributing significantly to the society, economy and environment. Worldwide suitable seaweeds farming areas cover approximately 48 million km2 across132 countries, although about 37–44 countries are active in production with only 0.001%of suitable area Froehlich et al (2019) . Seaweeds farming is one of the fast-growing sectors in the world with an annual production of ~32.4 million tonnes (wetweight) in 2018 valuedat US$11.8

billion, which is expected to rise US$22. 13 billion by 2024 Cotas etal, (2020), Froehlich (2019).

Compare to land-based crop production using expensive fertilizers and harmful pesticides, seaweeds extract nutrients from the water, purify surrounding water and maintain ecosystem health, there by sustaining a viable habitat for marine organisms Hasseltr.et al (2018). For instance, seaweeds aquaculture in China annually removes about 75,000 tons of nitrogen and 9500 tons of phosphorus that can significantly mitigate coastal eutrophication XiXiao ., et al (2017). Seaweeds remove organic pollutants, heavy metals and pathogens Munoz and Guieysse (2006), and thus used for e-leaning the environment Suresh and Ravishankar (2004).

Moreover, the symbiotic system of seaweeds and bacteria constitutes an ecological basis for natural treatment of running waters. Additionally, seaweeds are characterized by a rapid increase in biomass and contributes to climate change adaptation by protecting seashore from erosion, elevating pH and supplying oxygen to the aquatic ecosystem, and thus locally reducing ocean acidification and deoxygenating effects ChungI. *et al.* (2013), Duarte *et al.* (2017), Fernandez.et al. (2019), Krause -Jensen.et al (2015). The use of seaweeds as carbon dioxide scavengers contributes mitigation of atmospheric CO2 and in turn, reducing the effect of global greenhouse Froehlich H.E.et al (2019), Sondak et al (2017).

The book entitled “the blue economy: 10 years, 100 innovations, 100 million jobs” was the first proposal on blue economy formulation Pauli et al (2010) and the concept came out of the Rio+ 20 conference in 2012 that focused on sustainable development including ocean-based economies UNDESA(2014). The term „blue economy‟ is analogous to „green economy‟ Obura et al (2020).

where „ocean economy‟ is used by some circles such as in the European Union Garland.et al(2019).The blue economy principles are widely accepted UNECA,(2016), Wenhai et al (2019),WWF,(2020), though definitions can be varied Garland et al(2019),Hossain et al (2020),Wenhai et al(2019)]. According to Hossain et al. Hossain et al (2020), blue economy utilizes ocean resources for increasing food security, improving nutrition and health, alleviating poverty, creating new jobs, generating alternative energy, lifting seaborne trade and industrial profiles by protecting

ecosystem health and biodiversity. The vision of blue economy reflects economic development and ocean health as compatible propositions WB and UNDESA(2017).
Winder and Dix Winder and Dix A. (2016) mentioned that blue economy proposes trading the environment that allows the mobilization of environments for economic purposes. Blue economy voices low carbon with resource efficiency, which offers diversified opportunities for sustainable, clean and equitable progress in traditional
and emerging sectors UNDESA (2014). The United Nations Sustainable Development

Goals (SDGs) are a set of 17 goals has been set for a better world by 2030 that backed up by 169 targets and 231 unique indicators UN(2017). SDGs include economic, social and ecological aspects, where development are seen as separate parts. However, the „wedding cake" model focused a new way of looking at SDGs, i.e. food originates from
the biosphere/ environment and consumed by the society that involves partnership to run the economy Obura D.O.(2020), Rockstrom J.and Sukhdev P.(2017).
The global human population is expected to reach 10.9 billion by 2100 UN(2019) that
will increase pressure on the food production sectors to meet the additional demand of food and nutrition in a changing environmental condition. Seaweeds have been consumed for centuries in many societies, but the recent versatile applications in industries including food, feed, biofuel, chemical, nutraceuticals, pharmaceuticals, cosmetics as well as environmental bioremediation have helped increase global seaweeds production Scieszka .and Klewick (2019). Accordingly, seaweeds farming can play a pivotal role to overcome the anticipated challenges of food scarcity for the ever increasing world population. In this context, developing seaweeds aquaculture for diverse uses require adequate knowledge concerning the possible challenges and opportunities involved in setting up a production unit and market chain.Therefore, seaweeds farming requires consideration of social, economic, cultural, political and environmental viability to promote the activity for generating employment, income and food sustainably Rebours C.et al (2014).

The expansion of coastal and marine aquaculture can increase seafood production towards the sustainable blue economic development in Bangladesh Ahmed N. and Thompson S.(2019). Hence, the Government of Bangladesh is actively pursuing the blue
economy agenda Shaheaz .and Salma (2015),Winder and Heron (2017)Bangladesh has 24,077 km2 coastal waters within 0–10 m depth Chowdhury (2014) that may be suitable

for seaweeds production to achieve socioeconomic benefits. The objective of this study is to understand seaweeds production and its potentials role in achieving sustainable development goals and blue economic development in Bangladesh.

This part of the study is directed towards the analysis of the future trend and performances of Composting Seaweeds wastes. The following are found to be the major problem areas for the growth of seaweed based compost organic fertilizer farming in the country.

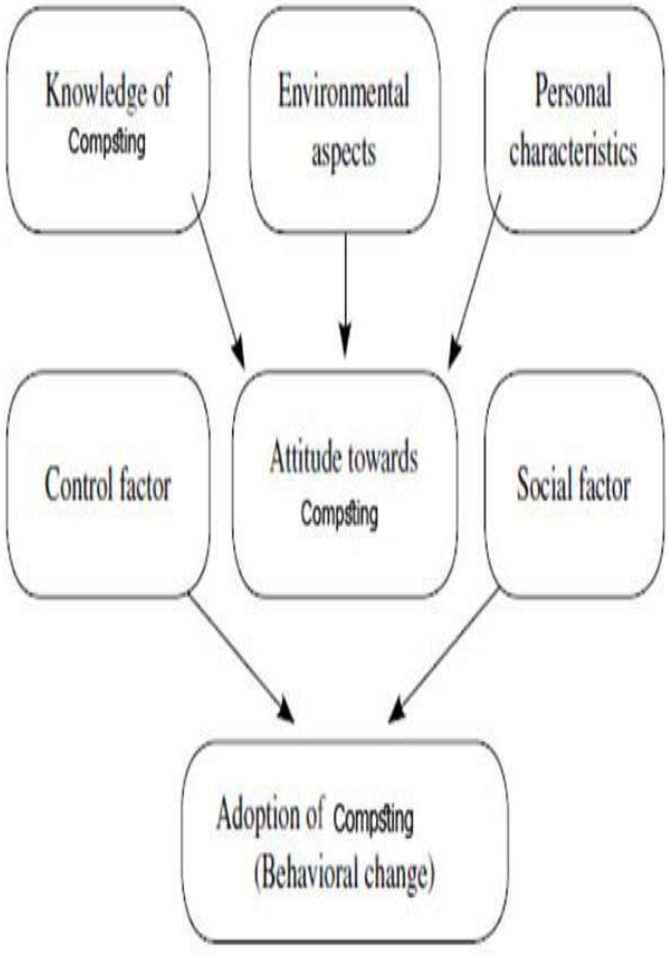


Figure 01- future trend of seaweed composting

2 The Research problems, characteristics and factors

It is a fact that many farmers in the country have illegible ideas about compost organic fertilizer farming and its advantages. Many experts and well-informed farmers are not sure whether all the nutrients with the required quantities can be made available by the organic materials. Even if this problem can be surmounted, they are of the view that the available organic matter is not simply enough to meet the requirements.

3 Significance of the study

After reviewing many literatures on compost organic fertilizer and seaweeds, In the present review, compost is described as an excellent soil amendment and a biocontrol agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. compost is an ideal organic fertilizer for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment.

4 OBJECTIVES OF THE STUDY

Objectives will guide the research in understanding the performance and practical implications of composting seaweed waste.

Main Research objectives-
Performances of composting seaweed wastes.

Research objectives for a study on the performance of composting seaweed waste include-

1. Assessing the effectiveness of different composting methods for seaweed waste.
2. Determining the optimal composting conditions- temperature, moisture, C/N ration, for seaweed waste decomposition.
3. Analyzing the potential use of seaweed based compost in Betel leaf cultivation.

5 REVIEW OF LITERATURE

Some the of key references reviewed to understand the importance and significance of seaweed wastes are summarized below

Durlave Roy (2018) study abstract titled -A Plant needs organic fertilizer to grow in a Balanced Way -National Conference Paper on Agricultural and Food Mechanization (NCAFM) 2018. Review of the literature up to that point -Chemical fertilizers are not working without organic fertilizers.

Ahmed N. and Thompson S. (2019) study was conducted on the blue dimensions of aquaculture:a global synthesis, Sci. Total Environ. 652 (2019) 851–861. Review of key literature- topic related to aquaculture and its environmental aspects. The rapid development of aquaculture has been considered the blue revolution, which is an approach to increasing global fish production in order to contribute to human nutrition and food security. The use of blue water (ie, surface and groundwater) in aquaculture also makes a significant contribution to global fish production.

BBS, Population Density and Vulnerability (2015) reported a challenge for Sustainable Development of Bangladesh. Statistics and Informatics Division, Ministry of Planning, Government of Bangladesh, Dhaka, Popul. Monogr. 7 (2015) 146 pp. Review of key literature- Sustainable development in Bangladesh is a critical and multifaceted challenge, with numerous factors at play.

Chowdhury S.R. (2014) a policy guide for Maritime Province Map of Bangladesh, Instituteof Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 2014. Review of key literature - historical maritime borders, Bay of Bengal, Exclusive economic zone, coastal vulnerabilities, maritime infrastructure.

Chung I.K. Oak et al. (2013) a case study was conducted Installing kelp forests/seaweed beds for mitigation and adaptation against global warming:Korean project overview, ICES J. Mar. Sci. 70 (2013) 1038–1044. Review of the literature up to that point- Carbon sequestration, Erosion control, Biodiversity enhancement. Local economic benefits, challenges concern,Policy and regulation, International collaboration.

Cotas J. et al. (2020) conducted a comprehensive review of the nutraceutical and therapeutic applications of red seaweeds(Rhodophyta), Life 10 (3) (2020) 1–19.

Review of key literature- Red seaweeds , scientifically known as Rhodophyta, have gained significant attention in recent years due to their rich bioactive compounds and potential therapeutic uses.

Deepak G. and Panpatte et al. (2019) The book entitled Soil Fertility Management for Sustainable Development addresses the important aspects of soil fertility management, with the help of reputed national and international scientists working in the field of soil fertility management. Review of key literature- Importance of soil fertility,Traditional practices,Chemical fertilizer Vs. Organic approaches, Soil testing and precision agriculture, Cover crops and conservation agriculture, Microbial communities, Sustainable practices for developing regions, Climate change impacts,Policy and education, Long term studies.

.**Durlave Roy (2018)** thesis on productivity improvement techniques at northern agro services ltd : A case study DOI: 10.13140/RG.2.2.32087.80800. Fertilizer savings are all there. Review of key literature- agriculture-related company like Northern Agro Services Ltd- Process optimization, Employee training and development,Goal setting and monitoring,Technology adoption, Resource allocation, Inventory management, Comunnication and collaboration , Quality control, Health and safety measures, Customer feedback, Data driven decision making, Employee empowerment.

Durlave Roy (2014) Poster on feed the soil to feed the plant, https://www.researchgate.net/publication/301518013_feed_the_soil_to_feed_the_plant. Fertilizer savings are all there. Review of the literature up to that point- Soil health and plant nutrition, Organic Matter and microorganisms, Crop rotation and cover crops, Compost and mulching, Soil testing and nutrient management, Regenerative Agriculture, Environmental benefits.

Deb A and Haque M.E (2011) study was conducted that Sufferings start from the mother's womb: vulnerabilities and livelihood war of the small-scale fishers of Bangladesh, Sustainability 3 (2011) 2500–2527. Review of the literature up to that point- Historical context, Livelihood challenges, Gender dynamics, Government policies and interventions, Community resilience and adaptation.

Duarte C.M et al. (2017) study was conducted that Can seaweed farming play role in climate change mitigation and adaptation? Front. Mar. Sci. 4 (2017) 100. useful paper. Review of the literature up to that point – Carbon sequestration, Ocean acidification mitigation, Blue carbon,Biofuel production, Biomass production, Coastal protection, Aquaculture synergy . Seaweed aquaculture, the fastest-growing component of global food production, offers a slate of opportunities to mitigate, and adapt to climate change. Seaweed farms release carbon that maybe buried in sediments or exported to the deep sea, therefore acting as a CO2 sink. The crop can also be used, in total or in part, for biofuel production, with a potential CO2 mitigation capacity, in terms of avoided emissions from fossil fuels.

Mamun Abdullah Al et al. (2020) conducted an experiment on Habitat structure and diversity patterns of seaweeds in the coastal waters of Saint Martins Island, Bay of Bengal, Bangladesh. useful paper. Review of the literature up to that point- Biodiversity in saint martins island, Seaweed diversity, Habitat types, Environmental factors, Seasonal variations, Human impact, Conservation efforts.

Marino M.et al. (2019) Livelihood aspects of seaweed farming in RoteIsland, Indonesia, Mar. Policy 107 (2019), 103600. useful paper.Review of the literature up to that point- Economic impact, Livelihood diversification, Sustainability challenges, Community involvement, Gender dynanics, Environmental impact,Market access. Findings of this study highlight farmers dependence seaweed farming activities in southwest Rote.

Shahadat Hossain M. et al. (2021) study was conducted that Seaweeds farming for Sustainabledevelopment blue economy in Bangladesh. Useful paper. Review of the literature up to that point- Blue economy and sustainable development, Seaweed species in Bangladesh,Environmental and economic benefits , Challenges and constraints, Research and Development initiatives, Policy and regulatory framework, case studies and success stories, future prospects. Findings- Seaweeds are marine plants of the millennium contributing significantly to the society, economy and environment. Over 15,000 species of seaweeds are found globally, of which 34 species are suitable for farming, 145 species for human consumption and 101 for extracting hydrocolloids.

Seaweeds farming areas in the world cover 48 million km2 across 132 countries, although 44 of them are active in production.

E. Nabti et al. (2017) conducted an experiment on Impact of seaweeds on agricultural crop production as biofertilizer. Very useful paper. Review of the literature up to that point- Nutrient composition, Organic Matter, Algal extracts,Disease resistance,Stress tolerance, Microbial activity, Environmental benefits, Crop specific effects.

Elhafid Nabti et al. (2016) study was conducted that Impact of seaweeds on agricultural cropproduction as bio-fertilizer.Very related to my research. Review of the literature up to that point- Nutrient composition, Organic Matter, Algal extracts, Disease resistance, Stress tolerance, Microbial activity, Environmental benefits, Crop specific effects. Seaweeds or marine macroalgae are rich in diverse compounds like lipids, proteins, carbohydrates, phytohormones, amino acids, osmoprotectants, antimicrobial compounds and minerals. Their potential for agricultural applications is used since antiquity, but recent demands of organic farming and organic food stimulated much the application of organic treatments like seaweed extracts in agriculture.

Raghunandan B. et al. (2019) conducted an experiment on Perspectives of Seaweed as Organic Fertilizer in Agriculture.Useful article. . Review of the literature up to that point- Nutrient content, Biostimulant properties, Soil health, Environmental sustainability, Crop specific effects, Economic feasibility, Regulatory considerations, Challenges and limitations.

Paul G.C. (2008) conducted an experiment on efficacy of northern organic fertilizer on sustainable sugarcane production in Bangladesh. Very useful paper. Review of the literature up to that point-Organic fertilizers in sugarcane production, northern organic fertilizer, Nutrient management, Sustainability impact,economic viability, Challenges and recommendations,Case studies.Findings- A field study was conducted to evaluate the efficacy of northern organic fertiliser on sugarcane yield and economic return at Ishurdi (High Ganges River Flood Plain) and Thakurgaon (Old Himalayan Piedmont Plain) sites in Bangladesh. Results revealed that the combined use of northern organic fertiliser@ 750 kg per hectare and 75 per cent recommended inorganic fertilisers gave higher average sugarcane yield of 72.33 tons.

Durlave Roy (2018) Poster on A Plant needs organic fertilizer for it to grow in a balanced way.PSP6 Symposium 6th Symposium on Phosphorus in Soils and Plants 2018 Leuven (Belgium). Review of the literature up to that point -Chemical fertilizers are not working without organic fertilizers.

Durlave Roy (2018) Poster on Production Strategy – plants needs organic fertilizer to grow in a balanced way, www.ishs.org/news/hortiasia2018-international-horticulture-forum. Review of the literature up to that point -Chemical fertilizers are not working without organic fertilizers.

Elizabeth J. et al. published an article (2021) study was conducted on Ensuring the Sustainable Future ofthe Rapidly Expanding Global Seaweed Aquaculture Industry – A Vision. Very useful article.Review of the literature up to that point – Introduction to seaweed aquaculture, Rapid expansion of seaweed aquaculture, Environmental impacts, Sustainability challenges, Regulatory frameworks, Best practices and innovations,Economic and social implications, Technological advancements, Market trends and consumer demand, Research and collaboration, Case studies, Future vision for sustainability.

Fernandez P.A. ,Leal P.P. ,Henríquez L.A. , study was conducted co-culture in marine farms: macroalgaecan act as chemical refuge for shell-forming molluscs under an ocean acidification scenario, Phycologia 58 (2019) 542–551.Very useful article. Review of the literature up to that point -the literature suggests that macroalgae may offer a degree of protection to shell forming molluscs under ocean acidification scenarios by creating localized areas with higher PH levels.

Froehlich H.E. et al. (2019) study was conducted that Blue growth potential to mitigate climate change through seaweed offsetting, Curr. Biol. 29 (2019)3087–3093. Related to my research. Review of the literature up to that point -Carbon sequestration , Coastal protection, Nutrient uptake, Bioenergy production, Blue economy opportunities. Carbon offsetting—receiving credit for reducing, avoiding, or sequestering carbon—has become part of the portfolio of solutions to mitigate carbon emissions, and thus climate change, through policy and voluntary markets, primarily by land-based re- or afforestation and preservation.

Garland M. and Axon S. et al. (2019) reported that The blue economy: identifying geographic concepts and sensitivities, Geogr. Compass 13 (2019), Commercial seaweed market analysis by product (brown seaweed, red seaweed, green seaweed), by form (liquid, powdered, flakes), by application (agriculture, animal feed, human consumption) and segment forecasts to 2024. R eview of the literature up to that point – The blue economy is a complex and multifaceted concept with numerous geographic concepts and sensitivities. It encompasses a wide range of activities, including fisheries, aquaculture, tourism, shipping and renewable energy production.

Sumedha, Chinnari et al. (2016) conducted an experiment on Seaweeds – Promising Organic Fertilizers. The review of literature and findings highlights the potential of seaweeds as organic fertilizers and their role in sustainable agriculture.

Sarker M.N.(1992) Studies on the red sea weeds in Bangladesh. In: Regional workshop on the taxonomy, ecology and processing of commercially important red sea weeds, held at Kasetsart University in Bangkok, Thailand, Organized by FAO/NACA andFrance Govt. Address the findings of this research, seaweeds are marine plants of the millennium contributing significantly to the society, economy and environment. Over 15,000 species of seaweeds are found globally, of which 34 species are suitable for farming, 145 species for human consumption and 101 for extracting hydrocolloids. Seaweeds farming areas in the world cover 48 million km2 across 132 countries, although 44 of them are active in production. Global production of seaweeds is ~32.9 million tonnes (wet weight) per annum valued at US$ 11.8 billion, which is expected to rise US$ 22.13 billion by 2024. Along the coast of Bangladesh, 32 seaweeds species are abundant, 14 species are commercially important and four species namely Gracilaria tenuistipitata, Ulva intestinalis, Ulva lactuca and Hypnea musciformis are farmed, but in small amount. The principles of ‘blue economy’ or ‘ocean economy’ reflects economic development and ocean health as compatible propositions that focuses on ocean resources for increasing food security, improving nutrition and health, alleviating poverty, creating new jobs, generating alternative energy, lifting seaborne trade and industrial profiles by protecting ecosystem health and biodiversity. The blue economy voices low carbon with resource efficiency, which offers diversified opportunities for sustainable, clean and equitable progress in traditional and emerging sectors. In Bangladesh, approximately 300 households are engaged in seaweeds farming, producing 390 tonnes (wet weight) in 2020 with potential applications

in food, feed, cosmetics and pharmaceuticals sectors. By the year 2050, seaweeds production in Bangladesh could be increased to 50 million tonnes from ~5,000 km2 shallow coastal waters. The increased production can contribute about 25% of food to the coastal community, 5 million tonnes of plant protein, 1.5 million tonnes of oil and 125 million megawatt-hours of bioenergy. Moreover, the removal of nitrogen and phosphorous can be 1 million ton and 0.1 million tonnes, respectively, and carbon sequestration from the environment is 15 million tonnes. Potential direct and indirect employment of 100,000 jobs could be created. Overall, the benefits of seaweeds farming could reflect on 26 targets of 8 SDGs and fairly contribute to the blue economy development in Bangladesh.

Scieszka S. and Klewick E. (2019) Algae in food: a general review, Crit. Rev.Food Sci. Nutr.59 (21)3538–3547. Algae are common all over the Earth. Due to their rich chemical composition and content of bioactive substances they have been used in many fields of industry. Their gelling, thickening and stabilizing properties have led to the development of such products as agar, alginate and carrageenan. Moreover, algae are used in the food industry as food supplements and an addition to functional food. Algae are also added to meat products, such as pasty, steaks, frankfurters and sausages, as well as to fish, fish products, and oils, to improve their quality. Cereal-based products, such as pasta, flour and bread, are another group of products enriched with algae. Due to their properties algae may also be used for construction of fermented functional food. Fermented products containing algae are, most of all, dairy products, such as cheese, cream, milk deserts, yoghurt, cottage cheese, and processed cheese. Combination of fermented products offering a high content of lactic acid bacteria with algae possessing biologically active metabolites of natural origin allows not only to compose products with a high content of nutrients, but also to create a brand new segment of fermented food.

Shahneaz A., Salma U. (2015) Reported prospects and challenges of Blue Economy in Bangladesh. Daily Observer, 28 January. The concept of Blue Economy has opened a new horizon for economic development of the coastal countries through utilizing sea and marine resources at national and international level. The concept has become a buzzword for sustainable development particularly in drafting the post-2015 development goals. Estimates suggest some 30 million Bangladeshi directly depend on oceanic economic activities like fisheries and commercial transportation. Coastal and Island developing

countries have remained at the forefront of this Blue Economy advocacy, recognizing that the oceans have a major role to play in humanity's future.

SID, Annual Report (2018-19) Reported statistics and Informatics Division (SID), Ministry of Planning, Government of Bangladesh, Dhaka, p. 131.

Sondak C.F.A. et al. (2017) study was conducted that Carbon dioxide mitigation potential ofseaweed aquaculture beds (SABs), J. Appl. Phycol. 29 (2363–2373).

Suresh B. and Ravishankar G.A.(2020) reported critical reviews in Biotechnology. Phytoremediation - a novel andpromising approach for environmental clean-up, Crit. Rev. Biotechnol. 24 (2–3) (2004)97–124.Technogym, Discover the millennia-old food of the future, edible seaweeds.htt ps://www.technogym.com/int/newsroom/edible-seaweeds-benefits-food-future/ Accessed on April 1.

World Bank (2018) Resettlement Policy Framework**.** Approved Bangladesh Sustainable Coastal and Marine FisheriesProject (BSCMFP).

Mohidul I. et al. (2017) conducted an experiment on Seaweed Hypnea sp. culture inCoxs Bazar coast, Bangladesh.The findings of this research is the culture of a red seaweed Hypnea sp. in three locations of Cox's Bazar coast, Saint Martin Island, Inani and Bakkhali with net method of 4 × 4 m coir rope net was evaluated. Seaweed was partially harvested at 15 days interval during December 2015 to January 2016. Daily growth rate of cultured Hypnea sp. was significantly higher (3.21 ± 0.01% day-1) in Saint Martin while Inani had the lowest (0.41 ± 0.06% day-1). Biomass yield of Hypnea sp. (3.81 ± 0.04 kg fresh wt.m−2) gained highest in Saint Martin than in Bakkhali (3.34 ± 0.10) and Inani (2.70 ± 0.02). Growth rate of seaweeds had a significant correlation with NO3-N ($p < 0.05$) but not with PO4-P. Culture of seaweed along those sites added a new dimension of prospect and possibility of seaweed mariculture in Bangladesh coast.

Haque K. et al. (2010) a survey was conducted to know the collection , identification and biochemical analysis of different seaweeds from Saint Martin's. Island . Bangladesh. Findings- five species of marine a1gae were collected from Saint Martin's island, identified and biochemical analyses were carried out in BCSIR Laboratories, Chittagong.

Biochemical composition were analysed to evaluate its food value and also to find out variation in composition during the period of investigation. The protein content of Sargassum coriifolium was 16.07%, whereas in Padina ltenuis that was estimated at 8.32%.

Hasselstrom L. et al. (2018) a case study was conducted from the west coast of Sweden, the impact of seaweed cultivation on ecosystem services - a case study from the west coast of Sweden, Mar. Pollut. Bull. 133 (2018) 53– 64. The paper presents a holistic qualitative assessment of ecosystem services affected by seaweed cultivation on the Swedish west coast.

Hossain M.S. et al. (2020) Seaweeds for Blue Economy in Bangladesh, Food and Agriculture Organization of the United Nations, 2020, p. 87 pp. Points to consider-being an ocean-based country, Bangladesh has immense potential to be an advanced country by the year 2041.

Regional workshop (2019) on underutilized fish and marine genetic resources and their amelioration colombo, Srilanka. Here some key points to consider – underutilized species, biodiversity, food security,research and conservation, amelioration strategies, challenges.

Virtual Marine (2020) socio-ecological systems symposium. Here some key poins to consider-background and objectives. managing for sustainable use of the earth's marine and coastal systems.

Valderrama D. (2012) Social and economic dimensions of seaweed farming: aglobal review, in: Proceedings of the The 16th Biennial Conference of the International Institute of Fisheries Economics & Trade (IIFET), July 16–20, Dar es Salaam,

Tanzania. Proceedings, 2012, pp. 1–11. This paper summarizes the findings of a recent FAO review on the social and economic dimensions of seaweed farming.

IRR (1998) Participatory Methods in Community-Based Coastal ResourceManagement, International Institute of Rural Reconstruction, Silang, Cavite, Philippines. Points to consider-field workers from government, non-government, community-based and even research organizations are increasingly applying participatory and community-based approaches (developed primarily in terrestrial settings) to work in the coastal zone

Jard G. et al.(2013) macroalgae screening: composition and methane potential for potential alternative sources of energy and products, Bioresour. Technol. 144 (2013)492–498. Study was conducted, macroalgae are biomass resources that represent a valuable feedstock to be used entirely for human consumption or for food additives after some extractions (mainly colloids) and/or for energy production. In order to better develop the algal sector, it is important to determine the capacity of macroalgae to produce these added-values molecules for food and/or for energy industries on the basis of their biochemical characteristics.

Krause-Jensen D. et al. (2015) Macroalgae contribute to nested mosaics ofpH variability in a subarctic fjord, Biogeosciences 12 (2015) 4895–4911. Findings -effects of ocean acidification oncalcifiers and non-calcifying phototrophs occupying coastal habitats cannot be derived from extrapolation of current and forecasted offshore conditions but they require an under-standing of the regimes of pH . To increase knowledge of the natural variability in pH in the Arctic coastal zone and specifically to test the influenceof benthic vegetated habitats.

Nor A.M.et al. (2019) A value chain analysis of Malaysia"s seaweed industry, J. Appl. Phycol. (2019), https://doi.org/10.1007/s10811-019. Findings- A global shortfall in protein supply from capture fisheries has motivated the Malaysian government to revise its aquaculture strategy, focusing on three commodities: seaweed, fish and marine shrimp. However, the performance of the Malaysian aquaculture sector, particularly seaweed production, is poorly documented.

Obura D.O. (2020) Getting to 2030 - scaling effort to ambition through a narrative model of the SDGs, Mar. Policy 117 (2020), 103973. Findings-The Sustainable Development Goals express a narrative about the relationships between people and nature. This paper builds a narrative from an ocean perspective– through the lens of a coral reef seascape, and the blue economy. The ocean, intimately connected with the land, freshwater flows and climate provides a vast array of benefits to humanity.

Rockstrom J. and Sukhdev P. (2017) reported How Food Connects All the SDGs - Stockholm Resilience Centre (https://www.stockholmresilience.org/research/research-news/2016–06-14-how-food-connects-all-the-sdgs.html〉. (Accessed 20 July 2020)

Rafiqul Haider M. et al. (2013) Indigenous management practices of betel leaf (piper betle) by the khasia community of Bangladesh. Findings- The Khasia community, living within reserve forests of Sylhet division mostly in moulvibazar district. Traditionally they grow betel-leaf on trees which is different from plain land betel-leaf cultivation. Tree based betel-leaf cultivation is a productive and sustainable agroforestry system. Average farm size is about 1.21 hectares per family.

Rebours C. et al. (2014) Seaweeds: an opportunity for wealth andsustainable livelihood for coastal communities, J. Appl. Phycol. 26 (2014) 1939–1951. Findings- The European, Canadian, and Latin American seaweed industries rely on the sustainable harvesting of natural resources. As several countries wish to increase their activity, the harvest should be managed according to integrated and participatory governance regimes to ensure production within a long-term perspective.

UN (2017) reported Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313), Annex. Available at https://unstats.un.org/sdgs/indicators/indicators-list〉(Accessed on 2020–07-07).

UNDESA (2014) reported Blue Economy Concept Paper, United Nations Department of Economic and Social Affairs, New York, 2014.

Wei N. et.al. (2013) successful blue economy examples with an emphasison international perspectives, Front. Mar. Sci. 2019 (2019) 1–14, https://doi.org/ 10.3389/fmars.2019.00261.Findings- Careful definition and illustrative case studies are fundamental work in developing a Blue Economy. As blue research expands with the world increasingly understanding its importance, policy makers and research institutions worldwide concerned with ocean and coastal regions are demanding further and improved analysis of the Blue Economy.

Winder GM and Dix A. (eds) (2016) Trading Environments: Frontiers, Commercial Knowledge and Environmental Transformation, 1750–1990. London: Routledge, in he Environment and Society Series, series editors Heike Egner and Bernhard Glaeser, 2016. Findings- this volume examines dynamic interactions between the calculative and speculative practices of commerce and the fruitfulness, variability, materiality, liveliness

and risks of nature. It does so in diverse environments caught up in new trading relationships forged on and through frontiers for agriculture, forestry, mining and fishing.

Winder G.M. and Heron R.L (2017) Assembling a blue economy moment? Geographic engagement with globalizing biological-economic relations in multi-use marine environments, Dialog. Hum. Geogr. 7 (1) (2017) 3–26. In the 2010s, the 'Blue Economy' has been widely advocated by a spectrum of interests as a strategy to save the world's oceans and water. This article explores what the Blue Economy moment is and how geographers can engage with it.

World Bank and UNDESA (2017) reported The Potential of the Blue Economy: Increasing Longterm Benefits of the Sustainable Use of MarineResources for Small Island Developing States and Coastal Least Developed Countries, United Nations Department of Economic andSocial Affairs and World Bank, Washington DC, 2017.

World Bank Group (2016) reported Seaweed Aquaculture for Food Security, Income Generation and Environmental Health in Tropical Developing Countries, World Bank Group: Environmental and Natural Resources, 2016, pp. 1–16.

WWF (2020) reported **p**rinciples for a Sustainable Blue Economy, Worldwide Fund for Nature(WWF) Baltic Ecoregion Programme. (Accessed 20 July 2020), 2014, (https://wwf.ocean.panda.or)

Xi Xiao X. et al. (2017) reported Nutrient removal from Chinese coastal waters by large-scale seaweed aquaculture, Sci. Rep. 7 (2017) 46613. Findings - China is facing intense coastal eutrophication. Large-scale seaweed aquaculture in China is popular, now accounting for over 2/3's of global production. Here, we estimate the nutrient removal capability of large-scale Chinese seaweed farms to determine its significance in mitigating eutrophication.

6 MATERIALS AND METHODS

7 Location of the study Area

A field study was conducted at three sites at Khasia farmers of Sreemangal khasia betel leaf cultivation community area of Sreemangal, Bangladesh.

Duration- Six months.

Design of the experiment –

T_1 = Farmers practice (control)
T_2 = Seaweed wastes mixed organic compost fertilizer 25g per support tree.
T_3 = Seaweed wastes mixed organic compost fertilizer 50g per support tree

Figure 02- MAP- Habiganj- Sreemangal- Moulvibazar, Bangladesh

Seaweed support tree **Organic Fertilizer** **Betel Leaf** **Betel Leaf with**

Figure 03: Images from the site

The present study proceeds to examine the following research questions:

1. Main research question-The Science of Seaweeds explores how analysis of the future trend and performances of composting seaweeds wastes ?

2. How do the environmental settings of the rich Khasia betel leaf farmers of Sreema ngal provide bases for evolving various seaweed based compost organic fertilizer farming in different parts of the community?
3. In what ways do the traditional values and indigenous knowledge of the farmers contribute towards diversity and sustainability of the community seaweed based compost organic fertilizer farming?

4. How far and in what ways the seaweed based compost organic fertilizer farming in community areas are getting modified overtime and changing socio-economic context?
5. Is seaweed based compost organic fertilizer agriculture currently prevalent in the community sustainable? If not, what are the probable measures to be adopted to make the seaweed based compost organic fertilizer farming economically more viable and ecologically more acceptable?
6. What kinds of difficulties are encountered by the farmers during their cultivation ofcrops through seaweed based compost organic fertilizer farming?

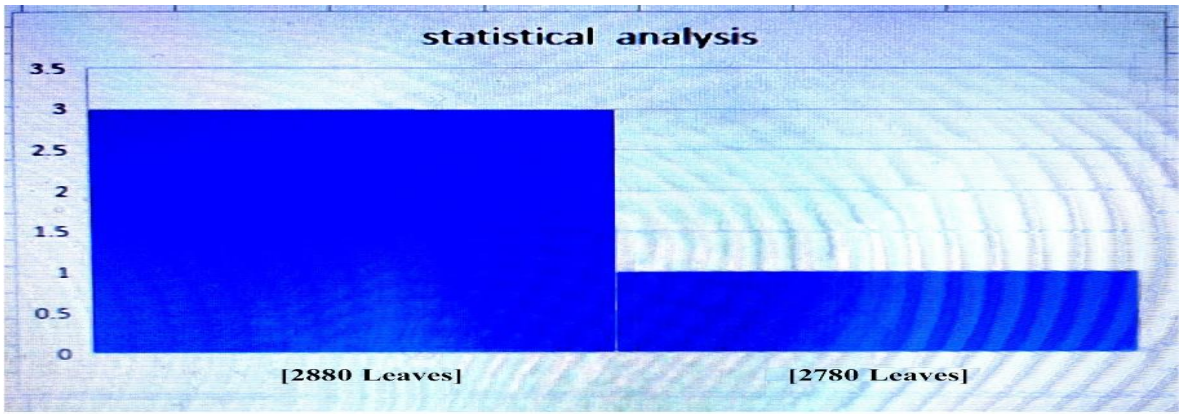
8 RESULTS

A step by step guide for betel leaf farming (Pan), planting, plant care, harvesting procedure along with economics and profit of betel leaf cultivation**.** Sample rich Khasia farmers of Sreemangal khasia betel leaf cultivation community area map selected for meticulous study.
After the field work primary and secondary data collected from different areas. The highest betel leaf yield was obtained from seaweed wastes mixed with compost organic fertilizer applied to plants. Table 1. (2880 leaf) showed highest betel leaf production. This study suggests that seaweed wastes mixed with organic fertilizer are suitable for betel leaf cultivation.

TABLE 1. Yield of betel leaf as influenced by seaweed wastes based organic fertilizer

Treatments	Description	Betel Leaf Plucking per day
T_1	Farmers practice (control)	2780
T_2	Seaweed wastes mixed organic compost fertilizer 25g per support tree	2780
T_3	Seaweed wastes mixed organic compost fertilizer 50g per support tree .	2880

Table 2. Statistical Analysis (Bar Graph)



9 CONCLUSION

Khasia community people in Sreemangal Upazila, Bangladesh are used to cultivating betel leaf as their main livelihood. It is their only living means. Their families live on sale of several Kuri (20 kanta or 2880 pieces) of betel leaves daily. Marine red algae from the Bangladesh Bay of Bengal Hypnea Sp have been used as organic materials due to the presence of a number of plant growth-stimulating compounds. The effect of various seaweed species on plant growth and development with an emphasis on the use of this renewable bio-resource in sustainable agriculture of northern fertilizers raw materials system. Organically made fertilizers play an important role in increasing crop yield and the quality of crops promises improvements considering climate adaptation. Seaweed wastes compost was put in evaluation trials at Sreemangal, Bangladesh to evaluate its efficacy and find out the optimum dose for profitable Betel leaf production. This part of the study is directed toward the analysis of the future trend and performances of composting seaweed wastes. The science of seaweeds explores, how analysis of the future trend and performances of composting seaweed wastes. A field study was conducted at three treatments at Khasia farmers of Sreemangal Khasia betel leaf cultivation community area of Bangladesh. Seaweed wastes mixed with compost organic fertilizer dose of 25g and 50g per support tree . The highest betel leaf yield was obtained from seaweed wastes mixed with compost organic fertilizer applied to plants. Table 1. (2880 leaf). The use of seaweed based compost organic fertilizer had a positive effect of betel leaf yield. This study suggests that seaweed wastes mixed with organic fertilizer are suitable for betel leaf cultivation. Area-based conservation is a key tool for delivering the Sustainable Development Goal of responsible production and consumption and climate action.

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10 REFERENCES

Durlave Roy (2018) A plant needs organic fertilizer to grow in a balanced way -National Conference Paper on Agricultural and Food Mechanization (NCAFM) 2018 Pullman Kuching, Sarawak 18 April 2018, Conference: NCAFM 2018 Kuching, Malaysia

Ahmed, N., & Thompson, S. (2019). The blue dimensions of aquaculture: A global synthesis. *Science of the Total Environment*, *652*, 851-861.

BBS, Population Density and Vulnerability: A Challenge for Sustainable Development of Bangladesh. Statistics and Informatics Division, Ministry of planning, government of Bangladesh, Dhaka, Popul.Monogr.7 (2015)146pp.

Chowdhury S.R., Maritime Province Map of Bangladesh, Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh, 2014.

Chung, I. K., Oak, J. H., Lee, J. A., Shin, J. A., Kim, J. G., & Park, K. S. (2013). Installing kelp forests/seaweed beds for mitigation and adaptation against global warming: Korean Project Overview. *ICES Journal of Marine Science*, *70*(5), 1038-1044.

Cotas, J., Leandro, A., Pacheco, D., Gonçalves, A. M., & Pereira, L. (2020). A comprehensive review of the nutraceutical and therapeutic applications of red seaweeds (Rhodophyta). *Life*, *10*(3), 19.

Panpatte, D. G., & Jhala, Y. K. (Eds.). (2019). *Soil fertility management for sustainable development*. Springer.

Durlave Roy,2018. Thesis Productivity improvement techniques at northern agro services ltd : A case study DOI:10.13140/RG.2.2.32087.80800

Durlave Roy,2014, Poster feed the soil to feed the plant, DOI:10.13140/RG.2.2.28732.36483

Deb, A. K., & Haque, C. E. (2011). 'Sufferings start from the mothers' womb': vulnerabilities and livelihood war of the small-scale fishers of Bangladesh. *Sustainability*, *3*(12), 2500-2527.

Duarte, C. M., Wu, J., Xiao, X., Bruhn, A., & Krause-Jensen, D. (2017). Can seaweed farming play a role in climate change mitigation and adaptation?. *Frontiers in Marine Science*, *4*, 100.

Nabti, E., Jha, B., & Hartmann, A. (2017). Impact of seaweeds on agricultural crop production as biofertilizer. *International Journal of Environmental Science and Technology*, *14*, 1119-1134.

Cottier-Cook, E. J., Nagabhatla, N., Asri, A., Beveridge, M., Bianchi, P., Bolton, J., ... & Yarish, C. (2021). Ensuring the sustainable future of the rapidly expanding global seaweed aquaculture industry–a vision.

Fernández, P. A., Leal, P. P., & Henríquez, L. A. (2019). Co-culture in marine farms: macroalgae can act as chemical refuge for shell-forming molluscs under an ocean acidification scenario. *Phycologia*, *58*(5), 542-551.

Froehlich H.E., Afflerbach J.C.,Frazier M.,Halpern B.S., Blue growth potential to mitigate climate change through seaweed offsetting, Curr. Biol. 29 (2019)3087–3093.

Garland, M., Axon, S., Graziano, M., Morrissey, J., & Heidkamp, C. P. (2019). The blue economy: Identifying geographic concepts and sensitivities. *Geography Compass*, *13*(7), e12445.

Haque, K. F., Chy, S. Y., Akter, S., Wahab, M. A., & Nath, K. K. (2009). Collection, identification and biochemical analyses of different sea weeds from Saint Martin s island. *Bangladesh Journal of Agricultural Research*, *34*(1), 59-65.

Hasselström, L., Visch, W., Gröndahl, F., Nylund, G. M., & Pavia, H. (2018). The impact of seaweed cultivation on ecosystem services-a case study from the west coast of Sweden. *Marine Pollution Bulletin*, *133*, 53-64.

Hossain, M. S., Chowdhury, M. S. N., & Alamgir, M. (2020). *Seaweeds for blue economy in Bangladesh* (pp. 87-pp). Food and Agriculture Organization of the United Nations.

Ira, G. C. (1998). Participatory Methods in Community based Coastal Resource Management. 1. *Philippines: Silang, Cavite*.

Jard, G., Marfaing, H., Carrère, H., Delgenès, J. P., Steyer, J. P., & Dumas, C. (2013). French Brittany macroalgae screening: composition and methane potential for potential alternative sources of energy and products. *Bioresource technology*, *144*, 492-498.

Krause-Jensen, D., Duarte, C. M., Hendriks, I. E., Meire, L., Blicher, M. E., Marbà, N., & Sejr, M. K. (2015). Macroalgae contribute to nested mosaics of pH variability in a subarctic fjord. *Biogeosciences*, *12*(16), 4895-4911.

Mariño, M., Breckwoldt, A., Teichberg, M., Kase, A., & Reuter, H. (2019). Livelihood aspects of seaweed farming in Rote Island, Indonesia. *Marine Policy*, *107*, 103600.

Islam, M. M., Khan, M. S. K., Hasan, J., Mallick, D., & Hoq, M. E. (2017). Seaweed Hypnea sp. culture in Cox s Bazar coast, Bangladesh. *Bangladesh Journal of Zoology*, *45*(1), 37-46.

Munoz R. and Guieysse B.(2006), Seaweeds remove organic pollutants,heavy metals and pathogens.

Al, M. A., Akhtar, A., Rahman, M. F., Kamal, A. H. M., Karim, N. U., & Hassan, M. L. (2020). Habitat structure and diversity patterns of seaweeds in the coastal waters of Saint Martin's Island, Bay of Bengal, Bangladesh. *Regional Studies in Marine Science*, *33*, 100959.

Hossain, M. S., Chowdhury, M. S. N., & Alamgir, M. (2020). *Seaweeds for blue economy in Bangladesh* (pp. 87-pp). Food and Agriculture Organization of the United Nations.

Nor, A. M., Gray, T. S., Caldwell, G. S., & Stead, S. M. (2020). A value chain analysis of Malaysia's seaweed industry. *Journal of Applied Phycology*, *32*, 2161-2171.

Obura, D. O. (2020). Getting to 2030-Scaling effort to ambition through a narrative model of the SDGs. *Marine Policy*, *117*, 103973.

Paul, G. C., Bokhtiar, S. M., Alam, K. M., Haque, A., & Hossain, G. M. A. (2008). Efficacy of Northern Organic Fertiliser on Sustainable Sugarcane Production in Bangladesh. *PLANTER*, *84*(982), 11.

Pauli, G. A. (2010). *The blue economy: 10 years, 100 innovations, 100 million jobs*. Paradigm publications.

Poster- A Plant needs organic fertilizer for it to grow in a balanced way -Durlave Roy PSP6 Symposium 6th Symposium on Phosphorus in Soils and Plants 2018

Poster- Production Strategy – plants needs organic fertilizer to grow in a balanced way -Durlave Roy, www.ishs.org/news/hortiasia2018-international-horticulture-forum.

Raghunandan, B. L., Vyas, R. V., Patel, H. K., & Jhala, Y. K. (2019). Perspectives of seaweed as organic fertilizer in agriculture. *Soil fertility management for sustainable development*, 267-289.

Rockström, J., & Sukhdev, P. (2016). How food connects all the SDGs. *Stockholm resilience centre*, *14*.

Haider, M. R., Khair, A., Rahman, M. M., & Alam, M. K. (2013). Indigenous management practices of betel-leaf (Piper betle L.) cultivation by the Khasia community in Bangladesh.

Rebours, C., Marinho-Soriano, E., Zertuche-González, J. A., Hayashi, L., Vásquez, J. A., Kradolfer, P., ... & Robledo, D. (2014). Seaweeds: an opportunity for wealth and sustainable livelihood for coastal communities. *Journal of applied phycology*, *26*, 1939-1951.

Regional workshop(2019) on underutilized fish and marine genetic resources andtheiramelioration colombo,srilanka.

Sarker, M. N. (1992). Studies on the red sea weeds in Bangladesh. In *A paper presented at the Regional Workshop on the Taxonomy, Ecology and Processing of Commercially Important Red Sea Weeds*.

Ścieszka, S., & Klewicka, E. (2019). Algae in food: A general review. *Critical reviews in food science and nutrition*, *59*(21), 3538-3547.

Shahneaz, A., & Salma, U. (2015). Prospects and challenges of Blue Economy in Bangladesh. *The Daily Observer*, *28*.

SID, Annual Report 2018-19. Statistics and Informatics Division (SID), Ministry of Planning, Government of Bangladesh, Dhaka, 2019, p. 131.

Sondak, C. F., Ang, P. O., Beardall, J., Bellgrove, A., Boo, S. M., Gerung, G. S., ... & Chung, I. K. (2017). Erratum to: Carbon dioxide mitigation potential of seaweed aquaculture beds (SABs)(Journal of Applied Phycology,(2017), 29, 5,(2363-2373), 10.1007/s10811-016-1022-1).

Suresh, B., & Ravishankar, G. A. (2004). Phytoremediation—a novel and promising approach for environmental clean-up. *Critical reviews in biotechnology*, *24*(2-3), 97-124.

UN, Transforming our world: the 2030 Agenda for Sustainable Development, A/ RES/70/L1, Available at: 〈http://www.un.org/en/development/desa/population/ migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf〉(Accessed on 2020–07-07), 2015.

United Nations Statistical Commission. (2018). Annex: global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. New York: UN Statistical Commission; 2017.

UNDESA, Blue Economy Concept Paper, United Nations Department of Economic and Social Affairs, New York, 2014.

United Nations Economic Commission for Africa. (2016). Africa's blue economy: A policy handbook.

United Nations, The 2019 Revision of World Population Prospects (WPP).Population Division, Department of Economic and Social Affairs,United Nations Secretariat, New York, 2019. The global human population is expected to reach 10.9 billion by 2100 [UN(2019)] that will increase pressureon the food production sectors to meet the additional demand of food and nutrition in a changing environmental condition.

Valderrama, D. (2012). Social and economic dimensions of seaweed farming: a global review.

Virtual Marine socio-ecological systems symposium 2021

Wei, N., Quarterman, J., & Jin, Y. S. (2013). Marine macroalgae: an untapped resource for producing fuels and chemicals. *Trends in biotechnology*, *31*(2), 70-77.

Wenhai, L., Cusack, C., Baker, M., Tao, W., Mingbao, C., Paige, K., ... & Yufeng, Y. (2019). Successful blue economy examples with an emphasis on international perspectives. *Frontiers in Marine Science*, *6*, 261.

Winder GM and Dix A. (eds), Trading Environments: Frontiers, Commercial Knowledge and Environmental Transformation, 1750–1990. London: Routledge, in the Environment and Society Series, series editors Heike Egner and Bernhard Glaeser, 2016.

World Bank Approved Bangladesh Sustainable Coastal and Marine Fisheries Project (BSCMFP) 2018

WB, U. (2017). The potential of the blue economy: increasing long-term benefits of the sustainable use of marine resources for Small Island developing states and coastal least developed countries. *World Bank—WB, and United Nations Department of Economic and Social Affairs—UNDESA. World Bank, Washington, DC*.

World Bank Group, Seaweed Aquaculture for Food Security, Income Generation and Environmental Health in Tropical Developing Countries, World Bank Group: Environmental and Natural Resources, 2016, pp. 1–16.

WWF, Principles for a Sustainable Blue Economy, Worldwide Fund for Nature (WWF) Baltic Ecoregion Programme. (Accessed 20 July 2020), 2014, 〈https://wwf.ocean.panda.org〉.

.www.fisheriesjournal.com/archives/2019/vol7issue5/PartF/7-5-57-856.pdf

www.facebook.com/Seaweed-Aquaculture-Biotechnology-1775850036069633

www.facebook.com/FAOBangladesh/videos/266483602245563 www.norternfertilizer.com

www.fisheries.gov.bd

www.tbsnews.net/features/panorama/seaweed-has-great-potential-no-investors-257548

Xiao, X., Agusti, S., Lin, F., Li, K., Pan, Y., Yu, Y., ... & Duarte, C. M. (2017). Nutrient removal from Chinese coastal waters by large-scale seaweed aquaculture. *Scientific reports*, *7*(1), 46613.

Zafar, M. (2005). Seaweed culture in Bangladesh holds

Design Posters

Envisioning Smart Villages: A Path to Progress with the Local Marketplace

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Abstract

In India, agriculture provides a means of subsistence while the expert handiwork of regional artisans protects the legacy of village customs. Farmers in India struggle with agricultural waste, unfair pricing, reliance on middlemen, and unpredictability of the market. Similar to this, the advancement of artisans working in handicrafts, clay work, weaving, carpentry, and traditional arts is hampered by inadequate support, restricted market access, networking gaps, a lack of an online presence, and shifting market demands. As a result, these difficulties make it difficult for villages to achieve economic stability, which forces a closer look at the relevant problems. Also, 70% of customers in India choose online shopping for their greater convenience, accessibility, and market

1.1 Aim

In addition to ensuring proper pricing, global visibility via an online marketplace, and raising awareness for the expansion of village economies globally, the goal is to stop local traditional craftsmanship and a variety of agricultural produce from being wasted among villagers.

1.2 Objective

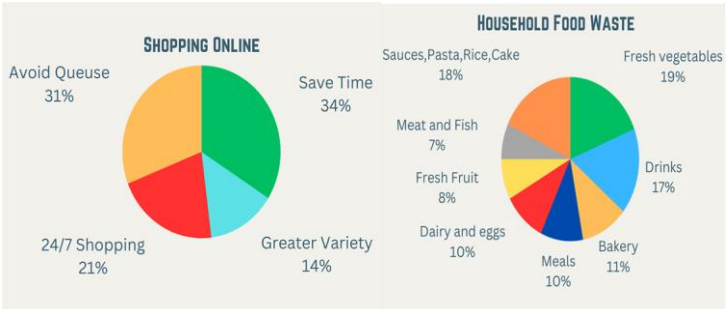
- Support farmers, artisans, craftsmen to showcase their local products in front of global audience.
- By creating an online presence, help villagers to reach new markets and increase their customer base.
- By introducing fair pricing, try to reduce waste, save time and support the steady expansion of rural economics.

2.My Model

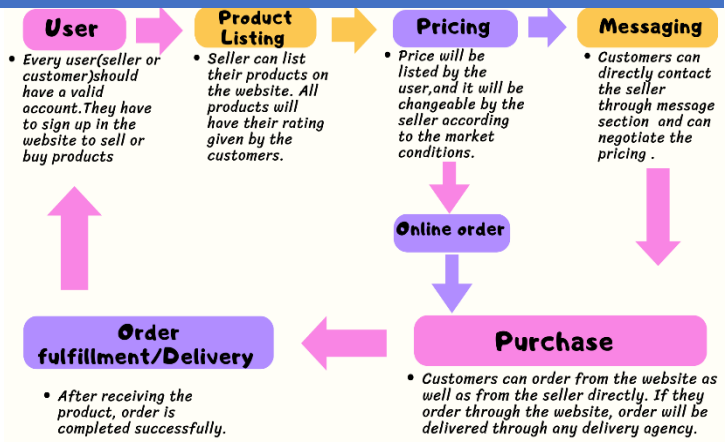
In the envisioned scenario, a customised website provides users with unique accounts for frictionless communication. Sellers are able to display their products and set prices in sections divided by categories like agriculture, crafts, and handloom weaving. Direct communication between buyers and sellers is made possible by a special messaging feature, mimicking traditional markets and promoting open negotiations. Transactions allow for both local and remote purchases because they transcend physical proximity. This dynamic ecosystem combines market traditions and digital innovation to close the gap between rural producers and global consumers, foster economic empowerment, and maintain regional market specificities. Customer can also rate the products of seller depending on its quality.

1.Introduction

India is a nation renowned for its many different cultures, which include many different traditional practises. Each state cultivates unique seed varieties, dons distinctive traditional garb, and creates intricate handloom weavings like the eri, muga silk, and traditional arts of Assam. However, the lack of a strong online platform and market makes it difficult for these priceless traditions to reach their full potential. Despite agricultural efforts, waste still happens and is blamed on inadequate pricing mechanisms. Even though government and NGO interventions are in progress, they have not yet had the desired impact.



3. Model Implementation



The model runs smoothly users sign up, vendors list goods with prices, and messaging option enables open communication. Both in-person and online orders are accepted to serve both nearby and distant customers. Smooth transactions are made possible by secure payments, combining tradition and technology to boost the economies of farmers and rural artisans.

4. Conclusion

This project emerges as a lifeline for farmers, artisans, and villagers in harmony with tradition. Due to the online presence of products, it moves economic development, efficiency improvements, and waste reduction forward all at once. With the help of this project, rural prosperity and the revitalization of Smart Villages will be sparked.

5. References

- https://www.statista.com/forecasts/823371/online-vs-offline-purchases-by-category-in-inda
- https://www.pngfind.com/mpng/iwJwTi_this-is-because-fuel-is-wasted-for-the/
- https://collegedunia.com/news/e-482-charts-show-show-the-reasons-given-for-shopping-online-and-in-store-ielts-writing-task-1

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