Proceedings of The 5th International Conference on Smart Villages and Rural Development COSVARD 2022

12-13 December 2022
Hybrid Mode

Conference Chairs & Editors:

A/Prof Hemanta Doloi (Chair)
Prof Atul Bora (Co-Chair)

The University of Melbourne
Victoria 3010, Australia

Smart Villages Lab
Culture • Construction • Capacity • Community

5th International Conference on Smart Villages and Rural Development (COSVARD 2022) hosted by the Smart Villages Lab (SVL) of the Faculty of Architecture, Building and Planning of the University of Melbourne.

Date: 12-13 December 2022
Venue: Webinar

Publication Data
This proceedings contains the double-blind peer-reviewed papers presented at the COSVARD 2022 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 12-13 December 2022.

Publication title
Proceedings of the 5th International Conference on Smart Villages and Rural Development (COSVARD 2022)

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Conference Chairs and Editors
Associate Prof Hemanta Doloi (Chair), Editor-in-Chief, Smart Villages Lab, The University of Melbourne.
Prof Atul Bora (Co-Chair), Co-Editor, Assam Engineering College, Jalukbari, Guwahati, Assam.

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Smart Villages Lab
Faculty of Architecture, Building and Planning
The University of Melbourne

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20 December 2022

Preface

A very warm welcome from the conference Convenor and the Chair to all the attendees and stakeholders of COSVARD 2022 conference.

Having had success in the past four COSVARD conferences and with the hiatus of COVID-19 pandemic for last two consecutive years, successful hosting of COSVARD 2022 on a hybrid mode is yet again great testament towards the commitment in our Smart Villages mission collectively. With almost no restrictions in place for COVID-19 pandemic, our local organising partner was able to showcase the very fine inaugural session at Assam Engineering College (AEC) on a face-to-face mode. However, allowing the flexibility for wider participation and building on the premise of general acceptance of the online mode, bulk of the proceedings were conducted as Webinar. It is pleasing the see that COSVARD 2022 was yet a great success once again with over 900 enthusiastic attendees participated from over nine countries.

COSVARD 2022 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 of COSVARD for building necessary capacities and mobilising required effort for reducing the urban-rural divide is pivotal. With now five 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. In smart village creation, data-driven and context specific solutions are at the center of intervention planning and management. 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 narrow the gap between urban and rural communities. 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 2022 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' and 'Rural Enterprises and Rural Entrepreneurship. A "Smart Villages Poster Competition" was again a part of COSVARD 2022 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.

Finally, 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.

The research papers received from broad audience across all five themes were accepted for COSVARD 2022 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 12 final papers and one design poster were included in the conference proceedings. Ten selected keynotes were presented by ten 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 (Dean, 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 Nayan Sharma, Indian Institute of Technology Roorkee (IIT Roorkee), Indian Institute of Technology Delhi (IIT Delhi), Prof Mark Burry, Director Smart Cities Research Institute from Swinburne University of Technology, Prof Atul Bora, Principal Assam Engineering College, Assam; Dr Arvind Phukan, President of the Core Professional Group for the Brahmaputra (CPGB), USA, Prof Kshama Puntambekar, Department of Urban and Regional Planning, School of Planning and Architecture, Bhopal, Dr Samir Baruah, Ex-

Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India and Mr Siddharth Narasimhan & Adithya VS from TVASTA Group Chennai India.

Last but not least, I sincerely appreciate the support, 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 2022 would not have been possible.

With warm regards

Associate Professor Hemanta Doloi
Convenor and Chair (COSVARD 2022)
Director (Smart Villages Lab)

5th International Conference on Smart Villages and Rural Development (COSVARD 2022)

THE UNIVERSITY OF MELBOURNE

Smart Villages Lab

Smart Villages Program
Faculty of Architecture, Building andPlanning
Smartvillageslab.msd.unimelb.edu.au

Hybrid Mode
12-13 December 2022

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 2022**
Time: Dec 12, 2022 02:30 PM Canberra, Melbourne, Sydney
9:00am (Indian Standard Time, IST)

Registration Link:
https://unimelb.zoom.us/webinar/register/WN_v3t8Q0V5TBuJvafISIYpCg

(Or Scan the QR to visit the link)

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

Webinar ID: **849 5975 6522**
Password: **cosvard22**

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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 in Hybrid Mode on *Dec 12, 2022 02:30 PM Canberra, Melbourne, Sydney, 9:00am (Indian Standard Time, IST). For registration visit:*
https://unimelb.zoom.us/webinar/register/WN_v3t8Q0V5TBuJvafISIYpCg

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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: "Body of Knowledge for developing Smart Villages and Rural Infrastructure?"

2. **Prof V.K. Vijay,** *National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)*
   Theme: "Unnat Bharat Abhiyan : Transforming Higher Education and villages for Atmnirbhar Bharat"

3. **Prof Nayan Sharma,** *IIT Roorkee, India*
   Theme: "Distinguished Professor (Visiting), Shiv Nadar University, Institution of Eminence India, Delhi-NCR"

4. **Dr Aravind Phukan** *(Past Director District Rotary, USA)*
   Theme: "Mitigate the flood and erosion problems of the Brahmaputra River on the Majuli Island"

5. **Prof Mark Burry,** *AO, Director (Smart Cities Research Institute), Swinburne University of Technology, Victoria, Australia*
   Theme: "Artificial intelligence (AI) and the Smart Village: a Challenge or an Opportunity?"

6. **Prof Atul Bora,** *Principal (Assam Engineering College)*
   Theme: "A Roadmap from Sustainable Building to Human Settlements to Sustainable World"

7. **Professor George Ofori**, *Dean, School of the Built Environment and Architecture, London South Bank University, London, UK*
   Theme: "Building a Body of Knowledge in Project Management in Developing Countries"

8. **Prof Koshy Varghese** *(IIT Madras)*
   Theme: "3D printing for built environment"

9. **Prof Kshama Puntambekar,** *Ph.D, Department of Urban and Regional Planning, School of Planning and Architecture, Bhopal*
   Theme: "Strategic planning for livelihood opportunities in hill districts - A case of Senapati"

10. **Dr Samir Baruah,** *Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India*
    Theme: "Banking Support for Rural Entrepreneurs"

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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
- Velyne Katharpi, University of Melbourne, Australia
- A/Prof Sean Jin, Western Sydney University, Australia
- Dr Sasanka Borah, Assam Engineering College, India
- 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 (TBA)
Day 1 - Monday 12th December 2022

2:30pm (AEDT#) – 5:00pm (AEDT) : 9:00am (IST*) – 11:30am (IST)

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

Anchored by: Mr Kaustav Pallav Baruah (Ex Student, Assam Engineering College)	
2:30pm (AEDT) **9:00am (IST)**	**Inviting Guests to Dias, Lighting of Lamp and Felicitation of Guests**
2.45pm (AEDT) **9:15am (IST)**	Welcome and Introduction **A/Prof Hemanta Doloi (Chair)**
3.00pm (AEDT) **9:30am (IST)**	Inaugural Speech **[Prof Atul Bora (Co-Chair)** (Principal, Assam Engineering College)
Time adjustments may be required subject to the attendance of the Honourable Minister for Education, the Chief Secretary or other ministerial delegates from the Government of Assam, India (TBA)	
3:15 pm (AEDT) **9:45am (IST)**	**[Prof Mark Burry, AO, Swinburne University of Technology, Victoria, Australia]**
3:30 pm (AEDT) **10:00am (IST)**	**[Prof P K Sikdar Profer Dean, IIT Bombay, India]**
3:45 pm (AEDT) **10:15am (IST)**	**[Er Bhaskar Jyoti Phukan, Managing Director, NRL, India]**
4:00pm (AEDT) **10:30am (IST)**	**[Er Pankaj Kumar Goswami, Director, Operations, OIL, India]**
4:15pm (AEDT) **10:45am (IST)**	**[Prof Robert Crawford, The University of Melbourne]**
4:30pm (AEDT) **11:00am (IST)**	**[Dr Gao Shang, The University of Melbourne]**
4:45pm (AEDT) **11:15am (IST)**	**[Dr Samir Baruah, Ex- Banker, Mentor & Advisor, Laghu Udyog Bharti, NE]**
5:00 pm (AEDT) **11:30am (IST)**	Vote of Thanks **[to be advised]**
(High Tea - Break)	
Technical Session starts at 6:30pm (AEDT) **1:00pm (IST)**	

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6:30pm (AEDT) **1:00pm (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: Body of Knowledge for developing Smart Villages and Rural Infrastructure?** **Chair: A/Prof Hemanta Doloi**	
7:30pm (AEDT) **2:00pm (IST)**	**Session 1: Sustainability and Resilience**	
	Chair: Prof Robert Crawford	**Authors**
Paper 5	Sustainable projects using green energy in India	Pranjal Kumar PHUKAN *Assam, India*
Paper 4	Madonie Smart Villages Technological Sustainable Design for Sicilian Inner Rural Areas	Luisa LOMBARDO *University of Palermo, Italy*
Paper 6	Design Thinking of A Model Village For Sustainable Agriculture Growth	Sadia Tabassum SUROVI *Chittagong University of Engineering & Technology, Bangladesh*
8.30pm (AEDT) **3:00pm (IST)**	**Break**	
8:40pm (AEDT) **3:10pm (IST)**	**Session 2: Rural Housing**	
	Chair: Dr Sally Donovan [UoM]	**Authors**
Paper 8	Assessing Relevance and Challenges for Implementing SMART Interventions for Rural Vulnerability of Indian Villages	Vaidehi PATHAK and Sameer DESHKAR *VNIT, Nagpur, India*
Paper 7	Towards a new prediction model for energy-related occupant behaviour in domestic environments	Dorsa FATOUREHCHI, Masa NOGUCHI and Hemanta DOLOI *The University of Melbourne, Australia*
Paper 16	Culture and Built Environment Relationship in Social Housing of Manipur	Dwijomala HANJABAM and Sachin YADAV *Mizorum University, India*
9:40 pm (AEDT) **4:10pm (IST)**	**Break**	

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Technical Session
Day 1 - Monday 12th December 2022

9.45pm (AEDT) **4:15pm (IST)**	**Keynote 2: Dr Arvind Phukan** *[Dr Arvind Phukan, Past Rotary District Governor Arvind Phukan Ph.D,.D.I.C.,P.E.,D.Sc. (Honorary), President/Founder, Core Professional Group for the Brahmaputra (CPGB), Former Professor of Civil Engineering, University of Alaska, Anchorage, USA, CEO/Founder , Phukan Inc., Consulting Engineering Company, Anchorage, Alaska (USA)* **Topic: Mitigate the flood and erosion problems of the Brahmaputra River on the Majuli Island** **Chair: A/Prof Hemanta Doloi**	
10.45pm(AEDT) **5:15pm (IST)**	**Session 3: Infrastructure-I**	
	Chair: Prof P K Sikdar, Former Dean IIT Bombay	**Authors**
Paper 11	Sailing the wave of modernization: Traditional Boats Incorporated in New Inter-island Freight Transport System in Indonesia	Mohamad NAROTAMA, Joewono SOEMARDJITO, Kuncoro Harto WIDODO, Dewanti DEWANTI, Hengki PURWOTO & Dwi Ardianta KURNIAWAN
Paper 3	Usefulness of data analytics in Smart Villages development	Hemanta DOLOI *Smart Villages Lab* *The University of Melbourne, Australia*
Paper 13	Role of GIS in Study of smart village	Ankita Prakash SRIVASTAVA and Robbin DWIVEDI *Sushant University, India*
11.45pm(AEDT) **6:15pm (IST)**	**End of Day 1**	

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Technical Session
Day 2 - Tuesday 13th December 2022

2:30pm (AEDT) 9:00am (IST)	**Keynote 3: Prof V.K. Vijay** *National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)* Topic: Unnat Bharat Abhiyan : Transforming Higher Education and villages for Atmnirbhar Bharat **Chair: A/Prof Hemanta Doloi**	
3.30pm (AEDT) 10:00am (IST)	**Keynote 4: Prof Nayan Sharma, IIT Roorkee, India** *Distinguished Professor (Visiting), Shiv Nadar University, Institution of Eminence India, Delhi-NCR* *Adjunct Professor, CTRANS, Indian Institute of Technology Roorkee, INDIA Chief Advisor, Innovante Water Solutions Pvt. Ltd.* *Former Honorary Professor of River Science, University of Nottingham, UK* *Former Visiting Professor, Ecole Polytechnique Fédérale de Lausanne (EPFL), SWITZERLAND* **Topic: Chronic Flood Devastation in Assam and Permanent Remedies** **Chair: A/Prof Hemanta Doloi**	
4.30pm (AEDT) 11:00am (IST)	**Break**	
4.45pm (AEDT) 11:15am (IST)	**Session 4: Infrastructure-II**	
	Chair: Er Pankaj Kumar Goswami, Director Operations [OIL]	**Authors**
Paper 15	Integration of occupants' sentiments for maximizing positive experience in household design	Sajal CHOWDHURY, Masa NOGUCHI and Hemanta DOLOI *The University of Melbourne, Australia*
Paper 12	Development of local lead commodities to reduce empty back load on sea toll program in Indonesia	Kuncoro Harto WIDODO, Dwi Ardianta KURNIAWAN, Joewono SOEMARDJITO & Sarah Auliya FURJATULLAH *Universitas Gadjah Mada (UGM), Indonesia*
Paper 10	A review of construction issues leading to construction project underperformance in Tanzania	Abdullatif S ABDALLAH and Hemanta DOLOI *Smart Villages Lab* *The University of Melbourne, Australia*
5.45pm (AEDT) 12:15pm (IST)	**Break**	
	Chair: Mr Bhaskar Phukan, Director Technical, NRL	
6.00pm (AEDT) 12:30pm (IST)	**Keynote 5: Prof Mark Burry, AO** *Director (Smart Cities Research Institute)* *Swinburne University of Technology, Victoria, Australia* **Topic: Artificial intelligence (AI) and the Smart Village: a Challenge or an Opportunity?**	
6:45pm (AEDT) 1:15pm (IST)	**Keynote 6: Prof Atul Bora,** *Principal (Assam Engineering College)* **Topic: To be advised**	
7:30pm (AEDT) 2:00pm (IST)	**Break**	

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Technical Session
Day 2 - Tuesday 13th December 2022

	Chair: Prof Shyamanta M. Hazarika, IIT Guwahati
7:45pm(AEDT) **2:15pm (IST)**	**Keynote 7: Professor George Ofori** *Dean, School of the Built Environment and Architecture* *London South Bank University, London, UK* **Topic: Building a Body of Knowledge in Project Management in Developing Countries**
8.30pm(AEDT) **3:00pm (IST)**	**Keynote 8: Prof Koshy Varghese** *(IIT Madras)*, **Siddharth Narasimhan & Adithya VS (Tvasta) - Topic: 3D printing for built environment**
9:15pm (AEDT) 3:45pm (IST)	**Break**
	Chair: Prof Jayanta Pathak, AEC Guwahati
9.30pm (AEDT) **4:00pm (IST)**	**Keynote 9: Prof Kshama Puntambekar, Ph.D** *Department of Urban and Regional Planning* *School of Planning and Architecture, Bhopal* **Topic: Strategic planning for livelihood opportunities in hill districts - A case of Senapati**
10.15pm (AEDT) **4:45pm (IST)**	**Keynote 10: Dr Samir Baruah** *Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India* **Topic: Banking Support for Rural Entrepreneurs**
11.00pm (AEDT) **5:30pm (IST)**	**Awards announcements** **A/Prof Hemanta Doloi**
11:10pm (AEDT) **5:40pm (IST)**	*Closing remarks* **A/Prof Hemanta Doloi and Prof Atul Bora**
End of Conference	

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12-13 December 2022

For Registration

Follow the link below:

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Committees and Partners

Organising Committee

Dr Hemanta Doloi (Chair), The University of Melbourne
Dr Atul Bora AEC (Co-Chair), Assam Engineering College
A/Prof Robert Crawford, The University of Melbourne
Dr Hannah Robertson, The University of Melbourne

Local Organising Committee:

Dr Atul Bora, Assam Engineering College
Prof Jayanta Pathak , Assam Engineering College
A/Prof Bipul Talukdar, Assam Engineering College
Dr Sasanka Borah, Assam Engineering College
Dr Pradip Baishya, Assam Engineering College
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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***: "Body of Knowledge for developing Smart Villages and Rural Infrastructure?"*
2. Prof V.K. Vijay, National Coordinator, IREDA Chair Professor, Country-Head (Unnat Bharat Abhiyan) (IIT Delhi)
    - **Theme***: "Unnat Bharat Abhiyan : Transforming Higher Education and villages for Atmnirbhar Bharat"*
3. Prof Nayan Sharma, IIT Roorkee, India
    - **Theme***: "Distinguished Professor (Visiting), Shiv Nadar University, Institution of Eminence India, Delhi-NCR"*
4. Dr Aravind Phukan (Past Director District Rotary, USA)
    - **Theme***: "Mitigate the flood and erosion problems of the Brahmaputra River on the Majuli Island"*
5. Prof Mark Burry, AO, Director (Smart Cities Research Institute), Swinburne University of Technology, Victoria, Australia
    - **Theme***: "Artificial intelligence (AI) and the Smart Village: a Challenge or an Opportunity?"*
6. Prof Atul Bora, Principal (Assam Engineering College)
    - **Theme***: "A Roadmap from Sustainable Building to Human Settlements to Sustainable World"*
7. Professor George Ofori, Dean, School of the Built Environment and Architecture, London South Bank University, London, UK
    - **Theme***: "Building a Body of Knowledge in Project Management in Developing Countries"*
8. Mr Siddharth Narasimhan & Adithya VS from TVASTA Group Chennai India. from TVASTA Group Chennai India
    - **Theme***: Affordable Housing Through 3D Printing*
9. Prof Kshama Puntambekar, Department of Urban and Regional Planning, School of Planning and Architecture, Bhopal
    - **Theme***: "Strategic planning for livelihood opportunities in hill districts - A case of Senapati"*
10. Dr Samir Baruah, Ex-Banker, Mentor & Advisor, Laghu Udyug Bharti, North East India, Social Entrepreneurs, India
    - **Theme***: "Banking Support for Rural Entrepreneurs"*

Prizes

Research Papers

1st Prize

DWIJOMALA HANJABAM AND SACHIN YADAV, “Culture and built environment relationship in Social Housing of Manipur”, Mizoram University, India, India

2nd Prize

MOHAMAD NAROTAMA, JOEWONO SOEMARDJITO, KUNCORO HARTO WIDODO, DEWANTI DEWANTI AND DWI ADRIANTA KURNIAWAN, “Sailing the wave of modernization: Traditional Boats Incorporated in New Inter-island Freight Transport System in Indonesia”, Universitas Gadjah Mada, Indonesia.

3rd Prize

LUISA LAMBARDO, “Madonie Smart Villages – Circular Economy and Re-use for Sicilian Inner Rural Areas”, University of Palermo, Italy.

4th Prize - 1

SADIA TABASSUM SUROVI, “Design Thinking of a Model Village for Sustainable Agriculture Growth”, Chittagong University of Engineering & Technology, Bangladesh

4th Prize - 2

ANKITA PRAKASH SRIVASTAVA AND ROBBIN DWIVEDI, “Role of GIS in Study of smart village”, Sushant University, India

Research Papers

MADONIE SMART VILLAGES

CIRCULAR ECONOMY AND RE-USE FOR SICILIAN INNER RURAL AREAS

Luisa Lombardo
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Abstract: *The EU is promoting the enhancement of marginal rural areas. In the Mediterranean area, in Sicily, there is the "Madonie" District, an inner rural area with 21 municipalities suffering of depopulation and lack of work despite to their natural and architectural potentials. The pandemic situation has pointed out the necessity of a better life quality that could be guarantee with the creation of smart villages, collaborating urban centers. The purpose of the research is to enhance these territories with technological sustainable design to enable urbanization and digital innovation and to their development. Rehabilitation must be guaranteed using technologically eco-efficient strategies and functional and innovative solutions to compare "Madonie District" municipalities with Italian and European smart villages. The research focuses on improving circular economy such as Industry 5.0 and Society 5.0 where economy takes benefits based on implementing digitalization and useful services to these weakest areas that could operate in close union. The goal of the research is to revitalize an area that has great potentials, but that has not yet implemented a smart network system. The collaboration between public and private Institutions leads to the realization of the proposed projects and the creation of guidelines/best practices are useful to create, devise and concretize a program of technological development in this area. This system can help exploiting the endemic resources from architectural, social, circular economy and cultural heritage point of view. In order to achieve the goals of sustainable development, the process of digitization and technological innovation is articulated through meticulous analysis and investigation of places, evaluation of problems encountered, and interpretation of solutions to be implemented. The final research protocol and the identification of best practices are useful to create a programme of development and social renewal. Stakeholders, investors and local companies guarantee the survival of rural communities and prepare them for Renaissance. These actions favour local culture combining tradition and technological and digital innovation. The scalability of this research represents a sustainable development and a "modus operandi" that can be implemented and transposed in other similar contexts.*

Keywords: *Sicilian inner rural areas, Industry 5.0, Technological and digital innovation, Smart village, Manufactoring sector.*

1 Introduction

In the centre of Sicily, in the Mediterranean Sea, there is the “Madonie” district composed by 21 municipalities characterised by their beautiful landscape and unmodified territory. It is part of the UNESCO Geopark[1] and it is the fourth Sicilian Park by size with its 39.941 hectares. It is located not so far from the principal city of the region, Palermo, and there are specific flora and fauna specialities, also the manufacturing sector is the core of economy with agriculture one and where the constructive heritage has not changed in the last years. Unfortunately, despite its specific peculiarities, that make it special and unique all over the world, it is suffering of depopulation and lack of work. The project of smart villages[2] wants to give a new impetus to the inner rural economy, to the cultural and social activities of these areas through the regeneration of its territories. The meaning of smart village includes a network of villages strictly collaborating each other in the development and restoration of existing housing structures and buildings, embracing circular economy[3], privileging the short chain in compliance with green and eco-sustainable environmental policies.

Major challenges are affecting rural areas and it is increasingly being recognised the need to enable rural communities to make the best of the new opportunities offered by digital transformation. New links between urban and rural areas and new value chains, but above all the transition to a circular and low-carbon economy. Being a smart village, in this sense, could be a possibility to give another life to these territories. Circular economy means sustainable resources, products as a service, sharing platforms, life cycle extension, recovery and recycling and also reuse [1]. A paradigm shift at the distribution level: from products to services. Thanks to the development of digital technologies, supply and demand can be brought together in a new way, that is, a company does not sell the product to the consumer, but the corresponding service. Best green practices in agriculture, in the Madonie’s area, have the aim of providing rural communities with new opportunities for the circular economy through coordinating interests of academics, researchers, stakeholders and policymakers operating in the field of biotechnology and bioenergy [2]. In an inner area like this, the concept of being smart is a necessary procedure in order to put marginalized area back again in the centre of human life. Almost all of our agricultural products - which make our country an excellence worldwide - come from inland areas, as well as manufacturing and industrial crafts.

Agriculture, most of all in the Madonie area, is a fertile ground for the circular economy: from the primary sector there are urban wastes, livestock, food and crop waste, a renewable mine for the recovery of elements that play a central role for the soil such as phosphorus, nitrogen and potassium, but also biogas and soil improvers. Using agricultural waste is possible: reduce CO_2 emissions caused by the production of mineral fertilizers and produce soil improvers and fuels from renewable sources. Italy is in pole position in the European rankings of the total index of circularity, considering the degree

[1] Madonie UNESCO Geopark: https://www.parcodellemadonie.it/
[2] Smart villages for EU: https://enrd.ec.europa.eu/enrd-thematic-work/smart-and-competitive-rural-areas/smart-villages_it
[3] Circular economy and EU: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en#:~:text=The%20EU's%20transition%20to%20a,entire%20life%20cycle%20of%20products.

of efficient use of resources, use of second raw materials and innovation in the categories production, consumption and waste management. In Italy, industry is also the major contributor for European economy that in the 2009-2019 has represented the 20% of the GDP. Manufacturing sector represents the 14,5% of the value of the European economy. Italy is second in the world, after USA and third after China and USA for purchasing power. In the Madonie's district are widespread agriculture and industry sectors, more than service and tourism ones developed especially in the coastal area. in the Madonie's municipalities the number of agriculture factories is the highest of Sicily and it produces the 60-70% of Sicilian products. One of the specialities that makes this territory very special is the presence of slow food presidia, food that can be found and that grow only in this area, but the recruitment is not so easy due to the type of companies and family labour. Endemic species are protected in order to save the extinction of native breeds but also to pass on production techniques and crafts from generation to generation. They are counted among the principals Scillato's apricot, the dark bee from Castelbuono and Caltavuturo, Polizzi Generosa's bean, Madonie's manna, Polizzi Generosa's pepper and Madonie's provola cheese. Inner specialities born seventy years ago and that are being disappearing due to the lack of workers.

The other important contribute is given by industry, most of all in municipalities with an area dedicated to productive settlements, where local products are transformed from raw material to finished product both for food products and building ones. The Madonie area, in this sense, could be considered a production machine able to self-manage and self-produce. That is why being a smart village in producing through circular economy could represent an important step to improve the Madonie district and make a virtuous model scalable in other place with the same features but it is important to underline that, without a thought in creating a network of smart villages strictly in collaboration it is impossible to reach the goal [3].

2 Methodology

In Italy, the NRRP[4], the National Recovery and Resilience Plan, from this year, is giving lots of funds to these inner rural areas. Funds could be used to improve these territories in agriculture, which is widespread, but also in factories, for new technologies to produce products and to recovery old buildings and to create new companies in order to make Madonie's production at the centre of the economy of Sicily. The NRRP in recent months has given opportunities for small municipalities and especially villages, by March 15, 2022, to submit their application to start territorial regeneration projects: with a series of targeted investments and interventions, the government wanted to focus on the revitalization of small towns, boosting tourism and culture, as well as the economy. The total investment of 1,020 million euros has been divided into two lines of intervention: "Line A," which concerns "pilot projects" for the cultural, social and economic regeneration of villages at risk of abandonment or already depopulated, with a budget of 420 million euros, and "Line B," dedicated mainly to local projects with a budget of 580 million euros. That's why, in these area, inner rural areas are presenting lots of projects to obtain funds and create new labour possibilities. The cultural and social regeneration of the historic villages has been pursued as part of the interventions of the NRRP through the instrument of the Special Public and Private Partnership with nine lines of intervention and a reform for a total of

[4] https://italiadomani.gov.it/it/home.html

resources to be invested, by 2026, of 4.28 billion euros, equal to 1,82% of the total resources of the NRRP of 235,12 billion euros. From 9 April it is also possible to send intervention projects for the protection and enhancement of rural architecture. The notice has a financial endowment of 6,5 million euros destined to finance 43 participations for a maximum contribution for everyone of 150 thousand euros. The objective of this further strategy is the enhancement of the beauty of the rural landscape through the recovery of buildings, structures and rural works (tholos, land houses, farms, stables and mills) typical of the popular and religious tradition of Sicilian rural communities. The funding will have to be aimed at the implementation of interventions that have as their object the conservation and functional recovery, the maintenance of the rural landscape, the creation of spaces for small social services, cultural, environmental and tourist (excluding the receptive use), for environmental education and knowledge of the territory [4].

The growth of the agri-food system of the Madonita dairy production district identifies several interventions that, within the dairy chain, eliminate the criticalities present at local level and above all enhance production in a perspective of "recovery" of added value which, to date, represents a deficit in the local economic system. The enhancement of the product must take place through interventions that refer not only to the local supply chain but that create synergies or consolidated recoveries of efficiency that, in a global market logic, are the minimum conditions for competitiveness. The possibility of implementing projects to enhance the dairy sector at a wider territorial level (inter-provincial/sub-regional or regional) could allow the coordination of larger-scale interventions with positive effects related to both the quality and efficiency of the product and the supply chain: technological innovation, the transfer of “know-how”, the achievement of economies of scale, the concentration of supply or sales agreements with the distribution chains, all of which require the achievement of appropriate "critical masses" in terms of production levels or the number of actors involved [5].

Madonie is a compact area from every point of view, but the abandonment phenomenon is not only related to the population, but include also rural architecture spread in the area. Forms of rural architecture, represent the ideal continuity of the natural context in which they are located, both for the materials with which they are built, as for their environmental location and the sustainability criteria of an architecture without architects and daughter of the material culture of a specific geographical area. In all territory they are ancient and sometimes abandoned. Improvement solutions in terms of resource and energy consumption such as the possibility of introducing shared plants for the production or even the reuse of ancient and historic buildings with the consequent recovery and restoration of degraded and vulnerable areas, interventions for the use and maintenance of the landscape, organization and articulation of territorial structures to support the uses of natural and cultural resources, with the recovery of agricultural systems to support the quality and differentiation of the supply of goods and services [6]. Enhancement of craft activities and small local entrepreneurships based on models of compatible development, management of interventions, reuse of materials, recovery of traditional crafts and technologies and creation of new activities that, in enhancing local specificities, are able to make compatible and use technological development for the preservation and protection of natural values implementing also circular economy [7].

However, Madonie’s municipalities has lot of examples of smart strategies that could be pilot projects to improve all the 21 municipalities of the district [8][9]. From Bompietro, a

small village of the Madonie Park, there is the Bompietro's dairy. Born in 2004, it was abandoned for years and a new direction was led by a judge that decided, in 2014, to restore it and give a new identity to the ancient building but also to the specifical products of the Madonie district. An idea of a 43 years old entrepreneur from Palermo, Giovanni Messina, that transforms milk into "ricotta" and cheese. The company of which he is sole administrator was born from the ashes of a pre-existing factory and today is a dairy with low environmental impact that gave rise to an awakening and a repopulation of the territory. A company with five employees, all hired between Bompietro and the neighboring municipalities of Castellana Sicula and Blufi, and a collaborator in Palermo, a growing turnover of about 350 thousand euros and a production of over 150 kilos of cheese per day, with a more widespread distribution in Sicily, Palermo, Ragusa, Catania, Messina and Madonie, (where it is applied to all madonie people a 15% discount on the price), and then in Rome, L'Aquila, Pisa and Pistoia and abroad in Austria. Bompietro's dairy is a typical example of rehabilitation of an ancient dairy and of giving value to territory through the production of cheese with goat's milk, the exportation in Europe of Madonie local products and a pay of the 20% more to the farmers. A mixed use of circular economy and use of new technology to produce better and more and not to waste materials.

Figure 1: Bompietro's diary, Bompietro, Madonie (PA) @Luisa Lombardo

Another important company is the Castagna's ancient mill-pasta factory, closed for years, located in the district "Ponte", is due to two of the wealthiest families of Petralia Sottana, the Pucci and the Calascibetta, although present in many other economic sectors of the countryside, in the early twentieth century: an important pasta factory for processing pasta and its derivatives. The first structure consisting of an imposing stone building, still existing, and enlarged in the following year, was inaugurated the 20 July 1905. It was an excellent investment and immediately production at an industrial level became particularly active. It was one of the most modern companies in Italy also due to the technicians and engineers who designed the operating chains and a thermo-dryingpatented mechanic to have electricity, it was probably the only one in the whole area. During the XX Century the Castagna's family undertook a work of modernization of the building and of the plants equipping the pasta factory with modern pasta production lines with continuous high temperature cycle. After 50 years of great success, it began a slow and inexorable decline that led in 2007 to the stop of production and the closure of a company that in addition to

having made the history of Petralia Sottana represented together with its induced one of the few working realities of our country. In recent days, next to the signs “FOR SALE” appeared another sign with the inscription “SOLD”. Therefore, after many years from the closure, the ancient Pastificio Castagna (and even before Pucci-Calascibetta) has found a buyer, whose names at the time have not been disclosed, perhaps the most interesting news is that the new owners are willing to resume the activity of pasta factory and mill, as has always been. With fallout, hopefully, also in the field of employment. It seems that the new owner wants to make again this mill-past factory great in order to produce traditional products using new technology and reuse this building as in the past including new producing techniques like the model of circular economy.

Figure 2: Castagna’s ancient mill-pasta factory, Petralia Sottana, Madonie (PA); @Luisa Lombardo

Verbumcaudo is an ancient fief of the Madonie disctrict, in the heart of Sicily. Confiscated from the Mafia it returned to the community thanks to the investigations of Giovanni Falcone, today it is cultivated by a cooperative of young Madonites. A place of development, of economic and social growth, of hope for neighboring communities: a farm and fields cultivated between the area of Nisseso valley and the Madonie territory, which until 1983 belonged to the Greco brothers, boss regents of the Ciaculli’s family. Today the community has reclaimed it through eleven young people who had the courage to give a new story to the abandoned fields starting from the work of the land, from organic crops and excellence, thus constituting the Cooperative Social Verbumcaudo. The stories of the girls and boys of the cooperative are stories of "remaining", all young people who are choosing to invest in the Sicilian hinterland: they are engineers, geologists, nature guides, agronomists, accountants and qualified agricultural workers. Verbumcaudo is a symbol of redemption and represents all the tenacity of a generation that has decided to fight with obstinacy for the right to remain in their land and work with dignity. The cooperative Verbumcaudo is sprouting where the Mafia once dominated and, thanks to a new project supported by lot of foundations, will continue to make fertile and productive the land that preserve all the hope of a territory and of the people who live there, of the many associations and cooperatives, and workers who have decided not to give in to oblivion but to cultivate communities and sow the future. Cooperative is made up of 11 members

has been entrusted with the feud Verbumcaudo, an organic farm that extends over 151 hectares, cultivated with ancient Sicilian wheat, lentils, chickpeas, hemp, dried tomato, including 8 hectares of olive grove and 5 hectares of experimental vineyard, where more than thirty species of native Sicilian vines in danger of extinction have been replanted. There are also significant rural blocks that are being used and recovered for agriculture use. Another example of reuse, improving new technology and use of waste products from agriculture, tout court, another example of circular economy.

Figure 3: Verbumcaudo's fief, Polizzi Generosa, Madonie (PA); @Luisa Lombardo

The Barreca company's history begins with transhumance. The cows, harvested from the 'mannira', were whipped and milked to make pieces of cheese and ricotta to be consumed fresh and seasoned. A family member looked to the future with the idea of a change and the company's current appearance is beginning to emerge. Innovations, adaptations, more profitable farming systems. And for us who have observed this passage with the eyes of childhood, memories become nostalgic suggestions that feed the passion and authenticity of the present. It is located between Geraci Siculo and Gangi and lead by the third family's generation. In recent years it has changed the production introducing also technology for monitoring animals' life and for changing the traditional way of productivity but also an example of using traditional architecture of the place without using or creating new buildings.

Figure a: Barreca company, Geraci Siculo, Madonie (PA); @Luisa Lombardo

Local production, in the Madonie area, has had its spearhead also with Dolce & Gabbana company. Domenico Dolce was born in 1958 in Polizzi Generosa, one of the municipalities of Madonie. His Sicilian roots started with his little tailoring company in Polizzi Generosa, then the success gained was launched first in Milan and after all over the world. Even if they became very important and known in the fashion industry he decided, as well, to promote Sicily all over the world using not only Sicilian plots on clothes but also organizing events and catwalks showing the Sicilian beauty to everyone. Their contribute to Sicily is also linked to his generosity in fact, sometimes, he decided to donate for restoration of ancient and important buildings and to promote the enhancement of Sicily through his products but also through their website and their fashion products participating in some important campaigns for the enhancement of Polizzi Generosa, for example the one of the FAI – Fondo Ambiente Italiano[5] that allowed municipality to gain 25.000 euros fot the restoration of the most important church of the town.

Fiasconaro's company is the last example of a virtuous regenerative process, starts in '50 in Castelbuono, a little municipality of Madonie's district promoting Sicilian pastry ad products. Starting with the "panettone" they decided to interpretate in a Sicilian way the traditional Italian northern sweet. A big success that, in few years, has become very important not only for Sicily, but also all over the world. For its way of promoting Sicilian product, the owner was also nominated Knight of Labour from Mattarella, the Italian President of the Republic, for his special social and civil conduct. Now the company resells all over the world, gives work and continues to guarantee new jobs promoting new technological systems to produce keeping on mind tradition and innovation.

These are some few important examples of giving value to the territory introducing circular economy through technology, recovery and reuse, but also including society, university, local people, tradition and innovation, promoting natural resources [10].

3 Discussion of case studies

The cases analyzed were chosen "ad hoc" because they represent valid virtuous strategies of not only innovative technological strategies implemented to the tradition for the production of local products, but at the same time, a way to develop circular economy in those small places where innovation has not yet found a place. In particular:
- **Bompietro's diary company**: it represents a mixed use of circular economy and use of new technology to produce better and more local products and not to waste materials; a viable road possible to move, combined, architecture and local economy.;
- **Castagna's ancient mill-pasta factory**: it's the rehabilitation of a structure attached to its historic business in an innovative way by combining tradition and innovation and bringing back the ancient knowledge and flavors of the Madonie area; the choice brings, at the same time, new job opportunities, especially workers who are familiar with local flavors and past traditions regarding production and raw materials.;
- **Verbumcaudo fief**: not only the recovery of a lost space by generating new economic and productive processes, but also the redemption of an asset that was once the property of the Mafia and now the property of an area that wants to be reborn like a phoenix from its ashes; a perfect combination of tradition, innovation and legality;

[5] FAI – Fondo per l'Ambiente Italiano, no-profit organization: https://fondoambiente.it/

- **Barreca company**: the story of a family that has improved performance in the production of local products by approaching technology and implementing technological innovation in innovative ways for both production and export beyond the borders of Sicily;
- **Fiasconaro's company**: a story written starting in 1953 that from a small ice cream shop in the main square of the town built over time a thriving business in the field of pastry and catering, making a qualitative leap that transformed the Fiasconaro brand into a reality known outside the borders of the Island.

These examples are to emphasize that despite the vast and still technologically backward area, nevertheless there are glimmers of light represented by these few case studies present that if properly taken as examples to follow could lead the great territory of the Madonie to be the leader of not only Sicilian but also Italian excellence in the world.

4 Results and Conclusions

The reality of the Madonie district, full of virtuous examples of giving value to the territory, unfortunately, has to be compared with the rest of companies that have not implemented yet a smart approach to the production system. The goal to be reach is to convert old traditional factory into a new model of smart factory. Rethinking this new model is important to involve all the 21 municipalities and create a smart model in a large scale that includes sustainability, restoration and recovery and most of all the principles of circular economy. This could be led by implementing human-centric, sustainability and resilience.

Industry 5.0 helps to put human needs and interests at the centre of the production process and this is no longer being realized by asking ourselves what we could do with technology, but by asking ourselves what technology could do for us. Instead of reflecting on how the worker can adapt his skills to the continuous evolution of technology, the reflection focuses on how to use technology to adapt the production process to the needs of the operator. The concept of sustainability referred to here is that of environmental sustainability. The recycling of materials used in production, the use of renewable energy, the reduction of emissions of pollutants into the atmosphere, are actions that make sustainable production over time. It is here that we can see the strong link between Industry 5.0 and Industry 4.0, because enabling technologies such as AI and additive manufacturing can play a key role in reducing waste and optimizing resource use. Resilience is "the ability to adapt and reorganize quickly during shocks and unpredictable events, minimizing the negative impact". The approach underlying the Industry 5.0 model places man and his needs at the heart of the innovation process. Technology is used to support human activities and to create an inclusive work environment. The worker is no longer replaced by the robot, but by the integration of technology and human capabilities. The aim is to create safe working environments in which the well-being of workers is guaranteed at 360 degrees.

As for workers, Industry 5.0 provides countless benefits to companies that observe its principles and apply its tools. From the ability to attract and retain talents, to energy savings, to greater resilience. The investments needed to start a process of transition to Industry 5.0 could be considerable, especially for those companies that have not yet made the transition to Industry 4.0. Like any epochal change, Industry 5.0 requires courage, resourcefulness and careful planning of investments, but the risks that companies could face if they ignored current trends would be much greater.

Technology 5.0 is strictly linked to Society 5.0 with the concept of baukultur for the first time used with the Davos' Declaration in 2016 and by the Japanese Government. Social

and environmental sustainability means mobility, pollution and inequality's reduction, social innovation and new model of business. Positive changes in the life and new model of business with nature and technology: IoT, Big Data and artificial intelligence. Improving life's quality and cooperation between public and private and civil society just to have a super smart society that includes manufacturing power, hi-tech, robotics, environmental commitment, energy, automated and intelligent control, partnership and participatory innovation. Industry 5.0 and digital technology are drivers for entrepreneurship, competitiveness and new professionalism. The European Commission has underlined this concept in order to pay attention to stakeholders and shareholders' values. The concept guarantees worker's wellbeing at the centre of production process, the use of new technologies to provide prosperity and growth but also respecting limits of production of the planet. Industries have to adapt, evolve and embrace green and digital transition to be competitive and being engines of prosperity. Involving experts, academics and professionals with proven experience could be the key to obtain a good strategy but also to identify the areas of interventions, instruments and also priority objectives that are not the same for everyone, but specific for each of them.

The circular economy, with its mix of tradition and innovation, can be a fundamental opportunity for the relaunch of our Country and therefore of the inner areas. It is pragmatic and at the same time perspective, for a reversal of the linear economy that has so far dominated our lives. It is necessary to integrate the planned and existing strategies, developing a tool for coordinating and monitoring the implementation measures already planned, which must be placed in the National Strategy for Sustainable Development [11]. Internal Areas must focus on the circular economy to create jobs, development and widespread well-being, respecting the territory and the environment and, at the same time, they represent the driving force behind the regenerative aspects of the social and economic fabric to have a network of smart villages.

A pilot project like this on smart small municipalities and the case studies presented show the potential contribution that smart municipalities can make in a range of policy issues; However, much will depend on the outcome of the current strategic planning exercise and how Member States respond to the Commission's recommendations. Other variables that will determine the future success of smart small municipalities include the impact of key strategic factors, such as climate change, and the need to address a range of economic, social and environmental issues, such as the ageing of the population. Finally, some factors will also play a decisive role further, such as the provision of adequate digital infrastructure and digital training, active citizenship at local level and a positive attitude on the part of key actors at national, regional and local level.

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Sustainable Projects with ESG compliance by Green Energy in India

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Abstract: *Agreeing to the Environmental Protection Agency (EPA), green energy provides the highest environmental value and contains power produced by solar, wind, geothermal, biogas, low-impact hydroelectric, and certain eligible biomass sources. Even though renewable energy incorporates the same sources as green energy, this energy further generally includes technologies and products which can have a significant impact on both the local and global environment. Renewable Energy Sources (RES) are a key pillar to realizing sustainable development, which is the core reason why energy projects are being carried out not only in developed countries but also in many developing countries. Since the technical and financial risk remains a major obstacle to financing renewable energy projects, numerous tools are available to decrease risks on investment into clean energy projects. Renewables are the world's fastest-growing energy resource, with wind and solar being the most noticeable sources, while hydro, biomass and geothermal are gaining ground. Sustainability emboldens businesses to emphasis on their decision-making on the environmental, social, and human impacts in the long-term, rather than on short-term gains, and is becoming a top priority. Overseas environmental, social and governance (ESG) funds can play a vivacious role in development of the Indian renewal energy sector. ESG resources are collections of equities or bonds for which environmental, social, and governance factors are combined into the investment process. India has an advantage in tapping into foreign ESG funds owing to its flawless renewal energy targets and growing power demand. Indian corporates are also setting targets to grow into carbon neutral and pouring ESG linked funds to meet the targets.*

Keywords: *Renewable energy, Green energy, Environment impacts, Energy projects, ESG*

1. Introduction:

The first step in any path to the future is wiser use of the energy resources, also referred to as conservation. This would include elimination of obvious waste, higher energy conversion efficiency, substitution for lower energy intensity products and processes, recycling and more energy-modest lifestyles (Parikh J 2009).

Renewable energy deployment in India is to surge economic growth, energy security, energy access and climate change because sustainable development is possible with renewable energy and providing citizens with reasonable, reliable, viable and modern-day energy. India is one of the world's most attractive renewable energy markets owing to resilient government backing and an improving economy.

Colossal global investments in renewables technology, such as developing PV module competence in solar, dropping the balance of plant costs, and refining wind turbine technology, mainly large rotor diameters and developed hub heights, have resulted in a substantial reduction in the cost of green energy. Whereas the price of wind energy has decreased by 30-40%, the cost of Concentrating Solar Power (CSP) has lessened by 47 percent. The paramount and substantial reduction in recent years has been in the cost of solar photovoltaic (SPV) electricity, which has been reduced by 82%. Rendering to the International Renewable Energy Agency (IRENA), new renewable power production projects are presently less expensive than sustaining countless standing coal facilities.

The World Economic Forum's (WEF) Energy Transition Index (ETI) calculates the performance of each country's energy arrangements across three dimensions, including economic development and growth, environmental sustainability, energy security and access indicators, and their proclivity to transition to secure, sustainable, affordable, all-encompassing energy systems, and it includes 115 countries, with India ranking 87th.

On the lately concluded COP 26 (Conference of the Parties), India vowed to surge its non-fossil energy capacity to 500 GW by 2030 and meet 50% of its total energy necessities from renewable energy by 2030 and would decrease its emissions amount by close to 45% by 2030 as well as cut one billion tonnes of carbon emissions by 2030. The key objective for installing renewable energy in India is to advance economic growth, improve energy security, increase access to energy and lessen climate change. By way of confirming access to reasonable, dependable, sustainable and up-to-date energy for citizens, sustainable development is conceivable by use of sustainable energy. Favourable situation have pushed India among the top leaders in the world’s most attractive renewable energy markets like robust government support and the progressively apt economic condition. Apart from that, government has diligently taken care of policies, programs and an open-minded atmosphere to appeal foreign investments in order to rise up in the renewable energy marketplace at a fast degree. The aforementioned is foreseen that the renewable energy sector can generate a huge number of jobs over the ensuing years (Kumar. J, C.R., Majid, M.A 2020:1).

India with 1.368 billion inhabitants is ranked second and its yearly growth rate is 1.18% and embodies nearly 17.74% of the world’s population. Renewables arisen to be the second most significant source of inherent power production by exceeding gas and then oil. India will have the demand for renewables and will have an annual increase of 12% with incredible growth of 256 Mtoe in 2040 from 17 Mtoe in 2016.

1.1 Tables and Figures:

Fig 1: Projected primary energy consumption of India (including renewable energy) from 2016 to 2040

Table 1: Renewable energy for sustainable development in India

	Level (Mtoe)												
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
Total	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%
Oil (Mb/d)	58	75	106	122	155	212	251	308	359	419	485	5.1%	3.5%
Gas (Bcf/d)	11	17	24	32	54	45	57	72	89	106	128	5.6%	4.5%
Coal	110	140	164	211	290	412	485	593	710	824	955	5.2%	3.6%
Nuclear	1	2	4	4	5	9	11	16	27	35	44	7.1%	7.0%
Hydro	15	17	17	22	25	29	36	43	47	50	52	2.6%	2.5%
Renewables	0	0	1	2	7	17	41	86	133	191	255	35.1%	12.0%

Above table excerpted from Kumar. J, C.R., Majid, M.A. Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. Energ Sustain Soc 10, 2 (2020)

Rendering to the International Renewable Energy Agency (IRENA) report, a quarter of India's energy demand can be happened by way of renewable energy and it possibly will actually surge stake of renewable power generation to over one-third by 2030.

Mentioning to Energy, Sustainability and Society's 2020 report, projected prospects of wind power in India during 1995 (BSK Naidu 1996) was found to be 20,000 MW (20 GW), solar energy was 5×10^{15} kWh/pa, bioenergy was 17,000 MW, bagasse cogeneration was 8000 MW and small hydropower was 10,000 MW. It was observed that in 2006 that estimation on renewal potential was as 85,000 MW with wind 4500 MW, solar 35 MW, biomass/ bioenergy 25,000 MW and small hydropower of 15,000 MW (Ashwani Kumar, Kapil Kumar, Naresh Kaushik, Satyawati Sharma, Saroj Mishra 1996). According to the annual report of the Ministry of New and Renewable Energy (MNRE) for 2017–2018, the estimated potential of wind power was 302.251 GW (at 100-m mast height), of small hydropower 19.749 GW, biomass power 17.536 GW, bagasse cogeneration 5 GW, waste to energy (WTE) 2.554 GW, and solar 748.990 GW.

Future-Ready concept is unceasingly influencing Indian business policy for minimizing the risk and exploiting the opportunities that a number of future developments and external factors have to deal with. It supports industries to sketch out applicable extenuation, variation and transformational programmes in contrast to the probable risks and forestalling the future and increasing competences to influence the prospects to make business risk resistant and future-ready. Company's Group Sustainability Department can use its operational guidance built on the risk map established throughout their businesses to chart the current status and to develop a tactic best fit to alleviate the risks.

RECAI (Renewable Energy Country Attractiveness Index) reported for 40 countries and the report are centred on the appeal of renewable energy investment and placement opportunities. The index is based on macro vitals like economic steadiness, investment climate, energy necessities viz. security and supply, clean energy gap and reasonability. Moreover, also contains policy enablement such as political constancy and support for renewables. Technology capabilities like natural resources, power take-off attractiveness, potential care, and technology maturity and prediction growth are in use into deliberation for ranking where India has moved to the fourth position of the RECAI-2018.

Environment, Social and Governance (ESG)

Nearly each and every characteristic of businesses starting from products and services to manufacturing processes, supply chain, research and development and further sales activities is affected by climate change risks and prospects. Trades need to contemplate on the influence on product development and manufacturing as this can aid businesses to progress innovative energy-efficient products and services to lessen GHG emissions. Enterprises can ponder on carbon prices (carbon credit prices) in the short term, and variations to stakeholder and consumer behavior as the primary likely threats to identify the progress of energy-efficient eco-friendly products and services as developing prospects.

Sustainable development is founded on the three pillars of economic, environmental and social impacts. While the first two pillars are discussed extensively, it is very important to address the social pillar, without which sustainable development cannot succeed. Quoting from the by Chikkatur et al.: ‘‘Thus, there is a great need for moving towards a philosophy of ‘‘planning with people’’ that empowers project-affected people and allows them to influence decision-making, rather than ‘‘planning of people’’ or ‘‘planning for people’’ (ParikhJ, Energy and its sustainable development for India, 2009).

ESG investing contains three elements like environmental, social, and corporate governance which contains a number of norms which that may possibly be deliberated, either one by socially accountable investors or by companies targeting to embrace ESG-friendly functioning standpoint. As mentioned in Corporate Finance Institute website resources, environmental conditions contain a company’s usage of renewable energy sources, its waste management program, by what method it handles likely complications of air or water pollution getting out from its processes, deforestation concerns, its approach and engagements about climate variation concerns. Added conceivable environmental issues comprise raw material obtaining and whether it monitors biodiversity put into practise on land it possesses or controls.

As an emerging economy, India has made strides toward achieving the social, economic, and environmental goals outlined in the Sustainable Development Goals. In this regard, India made its first Nationally Determined Contribution (NDC) to the Paris Agreement in 2015. Indian Prime Minister Narendra Modi delivered a statement at the 26th Conference of the Parties (COP 26) in Glasgow in November 2021, setting an ambitious target of reducing emissions by 2030. The NITI Aayog SDG India Index & Dashboard for India has been raised to 66 from 60 in 2019-20 and 57 in 2018-19. (Rusen Kumar 2022).

In order to support commitments sourcing renewable energy for 100% of all their worksites, India can institute and implement augmented regional action plans, comprising of solar power generation capacity installation, renewable energy certificate obtaining, power purchasing pacts and green assessment. Similarly, trades can ensure a plan to carry on

growing the usage of renewable energy in regions where renewable energy can be fortified. Innumerable metrics such as GHG emissions, GHG emissions intensity and energy expenditure and savings could be used by trades to quantify and define risks and occasions related to climate change. Explicitly, industries can use the internally focussed carbon price to monitor the decision-making method in terms of energy-efficient facilities, power generation, carbon credit clearance and renewable energy project venture.

Solar energy

Renewable energy has started doing progressively significant part for intensification of grid power, providing energy availability, plummeting intake of fossil fuels and assisting pursue its low carbon development path. India had submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC, charting the country's post-2020 climate actions which were built on its goal of installing 175 Gigawatts (GW) of renewable power capacity by 2022. Moreover, India has set an objective to upsurge the country's share of non-fossil-based installed electric capacity to 40 percent by 2030. The INDC likewise pledges to reduce India's GHG emissions intensity per unit GDP by 33 to 35 percent below 2005 levels by 2030 and to make an added carbon sink of 2.5 to 3 billion tonnes of carbon dioxide through additional tree covers.

Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy implemented "Grid Connected Rooftop and Small Solar Power Plants Programme" which is providing subsidy up to 30% of benchmark cost for the general category states and up to 70 % of benchmark cost for special category states, i.e. North Eastern States including Sikkim, Uttarakhand, Himachal Pradesh, Jammu & Kashmir and Lakshadweep, Andaman & Nicobar Islands for installation of grid connected rooftop solar power plants in building of residential, institutional and social sector. For Government sector achievement linked incentives up to 25% of the benchmark cost in general category States/UTs and 60 % of the benchmark cost for special category States/UTs has being provided. (MNRE Annual report 2018-19)

As per the MNRE report, under the National Solar Mission, the objective of grid-connected solar power projects has been updated from 20 GW by the year 2021–2022 to 100 GW by the year 2021–2022. The "Made in India" inventiveness to sponsor domestic manufacturing reinforced this great height in solar installation capacity. At this time, India has the fifth highest solar installed capacity worldwide. By 31st of December 2018, solar energy had accomplished 25,212.26 MW against the target of 2022 and an added 22.8 GW of capacity has been proposed out for implementation.

India has added a highest 10 Gigawatts (GW) of solar energy to its increasing installed capacity in 2021 which has been the highest 12-month capacity addition with almost a 200% year-on-year growth. With this, India has at this instant exceeded 50 GW of cumulative installed solar capacity as on 28 February 2022 (Bharath Jairaj, Niharika Tagotra 2022). Producing clean renewable electricity is critical for India where nearly 300 million people which is approximately a quarter of its population who lives starved of access to electricity. Currently, India is one of the lowest per capita users of electricity in the world; even after people are connected to the electricity grid, and they face recurrent disruptions. Complement to that the anticipated economic growth and the growth in population, the demand for energy in India is estimated to double by 2040 (World Bank Group 2016).

Wind energy

In the early 1980's, the Department of Non-conventional Energy Sources (DNES) came into existence with the aim to reduce the dependence of primary energy sources like coal, oil etc. in view of the India's energy security. The DNES became Ministry of Non-conventional Energy Sources (MNES) in the year 1992 and now from 2006, the Ministry was renamed as Ministry of New & Renewable Energy (MNRE). The growth of Renewable Energy in India is enormous and Wind Energy proves to be the most effective solution to the problem of depleting fossil fuels, importing of coal, greenhouse gas emission, environmental pollution etc. Wind energy as a renewable, non-polluting and affordable source directly avoids dependency of fuel and transport, can lead to green and clean electricity.

Wind power generation capacity in India has meaningfully augmented and as on May 2022, the total installed wind power capacity was 40.71 GW, the fourth largest installed wind power capacity in the world (Wikipedia). National Institute of Wind Energy (NIWE) has a directive to carry out wind resource valuations across India. At first, it assessed wind potential of 49,130 MW at 50m above ground level. NIWE modified its calculations and projected that the installable wind potential capacity is around 102,788 MW at 80m above ground level and subsequently has selected advanced modelling techniques and reconsidered this study as per the guidance and directives of MNRE and valued the wind power potential at 100m height as 302,251 MW. Specified on the 2% land availability for all states except for Himalayan states, North-eastern states and Andaman & Nicobar Islands, NIWE has arrived the estimations.

At that time of the success of onshore wind power programme, Indian government has decided to boost the development of offshore wind in the country due to the presence of 7500 km long coastline. The MNRE has acknowledged medium- and long-term target for off-shore wind power capacity additions, which are 5 GW by 2022 and 30 GW by 2030. Concern ministry came out with the National Off-Shore Wind Policy in October, 2015 to take benefit of offshore wind power potential in the Indian Exclusive Economic Zone (EEZ) along the Indian coastline. National Institute of Wind Energy (NIWE) during the phase of piloting offshore wind potential studies and preliminary studies has shown decent potential on the coasts of Tamilnadu and Gujarat (Indian Wind Energy Association report).

In the wind sector, approximately 70-80% indigenisation has been realised through domestic manufacturing, and major global players in this field have their presence in India, with over 43 different models of wind turbines manufactured by more than 15 different companies through joint ventures under registered production, affiliates of foreign companies, and domestic companies with their own technology. India exports wind turbines and components to the United States, Europe, Australia, Brazil, and other Asian countries, with strong domestic manufacturing companies accounting for 70-80% of domestic production.

India's energy storage mission will arrange for an opportunity for globally competitive battery manufacturing capacity with the aim of increasing the battery manufacturing know-how and scaling up its national production capacity thereby it can make a considerable economic contribution in this vital sector. The mission aims to identify the cumulative battery requirements, total market size, imports, and domestic manufacturing with an economic opportunity from battery manufacturing given by the National Institution for Transforming India (NITI Aayog).

Other renewal sources

Geothermal energy is the intrinsic heat existing within the earth and is found in rocks and fluid that occupied cracks and pores in the earth's crust which can be used for a multiplicity of purposes. This energy is a vast, underutilised heat and power reserve and is environmentally friendly, reliable and locally produced. India's geothermal potential is rational; and prospective geothermal provinces can make 10,600MW of electricity and the soil range having rocks are in age from over 4500 million years to the present day and are spread across various geographical divisions. Archean, Proterozoic, coastland continental Palaeozoic, Mesozoic, Tertiary, and Quaternary rocks are among them. The Geological Survey of India has stated that there are over 300 hot spring locations.

India has massive hydro prospects of approximately 84,000 MW at 60% load factor which can be economically made for usage. Nearly 49 large hydropower projects are under construction in India that will get completed by the year 2022 with a collective capacity of 15,006 MW and an additional potential of 6,740 MW of installed capacity from small, mini and micro hydel arrangements have been considered with identification of pumped storing schemes with an cumulative installed capacity of 94,000 MW. The country has already established almost 6,800 MW pumped storage capacities with identification of 15,384 MW capacities for small units with 5,718 sites (Lekha Chandran 2015).

According to a report by the Climate Policy Initiative, total investment needed for India to meet its renewable energy targets by 2022 is $189.15 billion, 27% of which is required to be invested in wind, 37% for utility-scale solar projects, 32% for solar rooftop projects, and 4% for biomass and small hydropower projects (Vivek Sen, Kuldeep Sharma, and Gireesh Shrimali 2016). According to data from the Department for Promotion of Industry and Internal Trade, cumulative FDI inflows in the power sector from 2000 to 2020 were around $15 billion, which is around 3% of total FDI inflows (Department for Promotion of Industry and Internal Trade, India). The government allowed 100% of FDI under the automatic route to the power sector in 2012, easing the approval process (Reserve Bank of India) This included investment in the generation and transmission of electricity through hydroelectric dams, fossil fuel–based thermal power plants, renewable energy generation and distribution, distribution of electricity to households, industrial commercial users, and power trading. There has been an increase in penetration of nonconventional sources of energy in the Indian market, which have seen rising FDI participation.

Green investment banks are government-backed organisations that "crowd in" private investment in low-carbon assets, provide debt for projects with existing capital reserves, and raise funds through bond issuance and asset-backed securities. Green bonds can be issued by governments through private or public banks, the World Bank, or regional development banks to attract both domestic and international investors, thereby broadening the investor base and incentivizing private players interested in cleaner energy. Indian green bonds are in high demand abroad. With many countries aiming for a green recovery from the Covid-19 pandemic's recession, central banks may inject liquidity into the markets, including through the issuance of green bonds (Pravakar Sahoo 2021).

Conclusion

Nevertheless, the experience from many countries indicates otherwise: it shows grid networks are capable of accommodating a high share of renewable energy through

improvements in power system operations and reforms in regulatory frameworks and markets. In India, the Central Electricity Authority (CEA) estimates the share of renewable energy in power grid networks would reach around 17.5 per cent by 2022, based on the 160-GW capacity in solar and wind.3 Grid integration is far easier at these penetration levels of 15-20 per cent. The International Energy Agency's (IEA) study of best practices in managing RE integration indicates that gradual technical and economic grid management measures are sufficient for reliable and cost-effective operation of power systems in a high renewable scenario. India's grid is well positioned to efficiently integrate the level of RE share projected for 2022. The planned transmission capacity in the country is adequate. India already has a vast 83 GW of inter-regional transmission capacity which provides grid operators with a wide balancing area. To balance variable renewable energy, the reserve capacity needs to be appropriately utilised. It can be broken down into various sub-categories such as primary, secondary, slow tertiary, fast tertiary etc., depending on their response time; these have to be identified in advance, kept available and deployed in real time. India's Intended Nationally Determined Contribution (INDC) goals talk about increasing the share of non-fossil-based power capacity to 40 per cent by 2030.28 Further, the draft National Energy Policy (NEP) published by the Niti Aayog projects that 597-710 GW of renewable energy capacity is likely to be operational in the country by 2040.29 This would amount to a 50-56 per cent share in installed capacity and 29-36 per cent share in generation.

Despite India's significant assurances to increase renewable and clean energy investments, progress in the clean energy sector remains insufficient. Off taker risk due to a lack of infrastructure, financial intermediaries, and investor misunderstanding has dampened private investment in the sector. As a result, the government must encourage investment in green energy sources and implement appropriate formal changes to move India's energy mix toward renewables.

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DESIGN THINKING OF A MODEL VILLAGE FOR SUSTAINABLE AGRICULTURE GROWTH

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Abstract: Since the dawn of civilization, agriculture has been the most important industry in the world and plays a vital role in the world's economy, especially the economy of developing countries like Bangladesh. The suitable climate and fertile land favor agricultural growth here. But despite having these opportunities, the agricultural sector of Bangladesh is declining day by day. This decline is engendering numerous problems like- poverty serge, drop-down of GDP, food crisis, obstructed rural development, and rural-to-urban migration- hence impeding the growth of the nation. In Bangladesh, the rural areas are the powerhouse of the agriculture industry. But unfortunately, these areas lack development in every sector; which consequently affects the growth of agriculture. This study aims to investigate the scope of architectural interventions to assist the agriculture industry of Bangladesh at the village scale and take concern about rural development as well. The primary aim of the study is to develop the economic and social conditions of small and marginal farmers by ensuring proper facilities and infrastructure at the root level. In this paper, the problems regarding the agriculture sector in rural areas were studied thoroughly to get a strong grip on the context. Then the scopes of architectural interventions were identified through literature and ethnographic study to prepare a tentative design solution for a selected site. Relevant case studies have been explored to get a guideline for the design solution. And finally, an idea of the village model has been developed in an existing setting to present the possible design recommendations.

Keywords: *agriculture industry, architectural intervention, agro-village, sustainable rural development, rural infrastructural development.*

1 Introduction

Agriculture is the earliest industry in the history of mankind. The development of agriculture enabled the human population to grow many times larger than could be sustained by hunting and gathering. This transformed mankind from a nomad-hunting community to a permanent community. Thus, civilization began. In the current world, agriculture plays a pivotal role in the world's economy. The agricultural industry is still one of the biggest sources of employment. About 60% of people rely directly on agriculture as a livelihood (zavatta,2014). 38% percent of the world's land area is occupied by agriculture (FAO,2020).

Agriculture plays a crucial role in the economy of developing countries and provides the main source of food, income, and employment to their rural populations. Being a developing and predominantly agrarian country, agriculture is the most important sector in Bangladesh. But this sector is facing challenges and declining day by day which is hampering food production as well as rural development.

In Bangladesh, villages are the unit of agricultural production. So, to ensure the growth of this sector, villages should be the primary concern. Most of the villagers are farmers who are the backbone of this sector. The development of their social and economic condition is vital for the overall development of the agriculture sector. Besides, infrastructural development in rural areas regarding this industry can play an important role here. This paper aims to contribute to these areas by necessary architectural interventions to boost the growth of this industry. Therefore, the study first explores the background of agriculture and related study about the relationship between infrastructural development and agriculture productivity. Then after completing the problem analysis, the scope of architectural interventions was identified and later tentative design solutions were proposed accordingly for a selected site area. The outcome of this study aims to provide a conceptual design thinking of a model village that will assist the growth of agriculture at the micro-level. Also, the design thinking procedures can facilitate the making of a prototype of model villages in a different context.

1.1 Background

Bangladesh has an area of about 50,000 square miles of which about 60 percent of the total land area is cultivated land (world bank,2018). Agriculture plays a dominant role in the growth and stability of the economy of Bangladesh. 65% of the total population lives in rural areas and derives their livelihood from the agricultural sector (world bank,2016). About 41 percent of the labor force is still employed in Agriculture (YAS,2017).

During the recent decade, the overall Gross Domestic Product (GDP) of Bangladesh has shown a considerably increasing trend. But the growth in agricultural GDP slightly declined, with an average growth of about 3.4% from 1997 to 2014. Being an agricultural country, there is barely any alternative to this industry to ensure the economic growth of Bangladesh. Food security, employment opportunities, etc are directly linked to the development of the agriculture sector. So, Government has been trying to develop this sector. (RED, B.,2017)

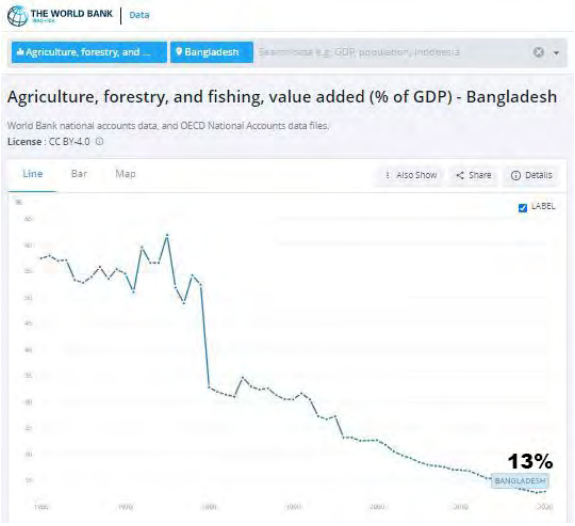


Figure 1: GDP percentage of agriculture industry

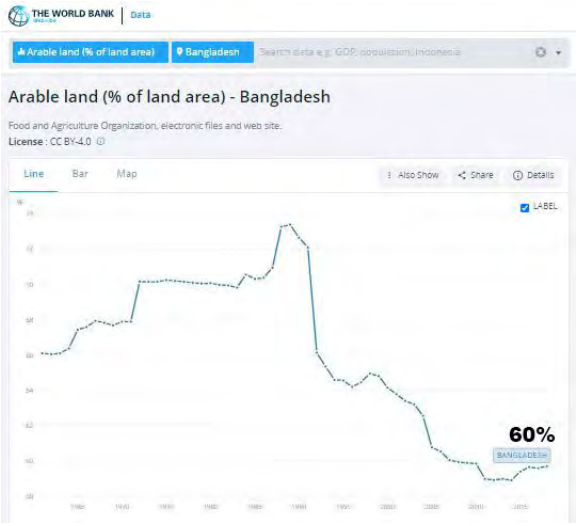


Figure 2: Arable land percentage

Gilberto M. Llanto in his "The impact of infrastructure on agricultural productivity" paper has discussed the link between rural infrastructure and agriculture productivity and validates the hypothesis that shortages in rural infrastructure like energy, transportation, or related infrastructure have a bad impact on crop productivity. Rural infrastructure increases agricultural productivity and thus reduces food prices which benefit both urban and rural inhabitants who are net food customers. Moreover, infrastructural development induces growth in rural areas. (Llanto, G. M. 2012).

Dr. Amrit Patel in his study "Infrastructure for Agriculture & Rural Development in India Need for A Comprehensive Program & Adequate Investment" has explored different types of agriculture infrastructure as follows:

- Input-based infrastructure: Seed, Fertilizer, Pesticides, Farm equipment, machinery, etc.
- Resource-based infrastructure: Water/irrigation, Farm power/energy
- Physical infrastructure: Road connectivity, Transport, storage, processing, preservation, etc.
- Institutional infrastructure: Agricultural research, extension & education technology, information & communication services, financial services, marketing, etc.

Dr. Amit Patel also stated that better infrastructure leads to the expansion of markets, economies of scale, and improvement in market operations. The study primarily recognizes that infrastructural investment has a great impact on the rural economy, especially on smallholders. (Patel, 2014)

Mohammad Anwar Hossain and Md. Nazmul Hossain has investigated infrastructural constraints in the agro-marketing system in their paper "Some Observations over Supply Chain: With Reference to Vegetables Market of Bangladesh". It was stated that most

vegetable markets lack basic support facilities such as warehouses, cold storage facilities, potable water, drainage, or vehicle access for loading and unloading. (Hossain, M. A., & Hossain, M. N. 2013)

Though the opportunities for market systems are rising, there is still no visible strategic action to develop this sector. The market for food grains, vegetables, fruits, and spices is not sufficient compared to the growing demand (FAO & WHO). The farmers were not able to store their products during the peak season for future use and marketing which could be helpful to the uniform distribution of horticultural crops throughout the year. This is a major cause of food loss. Besides, the shortage of quality inputs, high prices, and uncertain sales make the farmers less interested in vegetable production. (Rahman,2018)

1.1 The rationale of the study

The performance of the agricultural sector has a great impact on the macroeconomic situation of the country (statistics, 2017). This sector is the major contributor to sustained food, nutrition, and livelihood security of its large population to achieve self-sufficiency in food production, reduce rural poverty and foster sustainable economic development (SPARS, 2017) Thus, the overall development of the economy is dependent on this sector. So, it is very important to take immediate action in all possible ways for the growth of the agriculture sector in Bangladesh. The first part of this study traces the existing problems in this sector to find the appropriate areas for necessary interventions. Though this paper mainly focuses on the architectural intervention areas, the problem analysis of this paper can encourage others to seek solutions from the perspective of different backgrounds too- to mitigate the existing problems in the agriculture sector.

1.2 Aim and objective

This study aims to facilitate the agriculture industry with necessary architectural interventions. To attain this aim- the required objectives are as follows-

- Find out the scope of architectural intervention through detailed problem analysis.
- Develop tentative design recommendations accordingly to achieve a model village for sustainable agricultural growth.

1.3 Scope and limitation

Possible scopes of the research are-

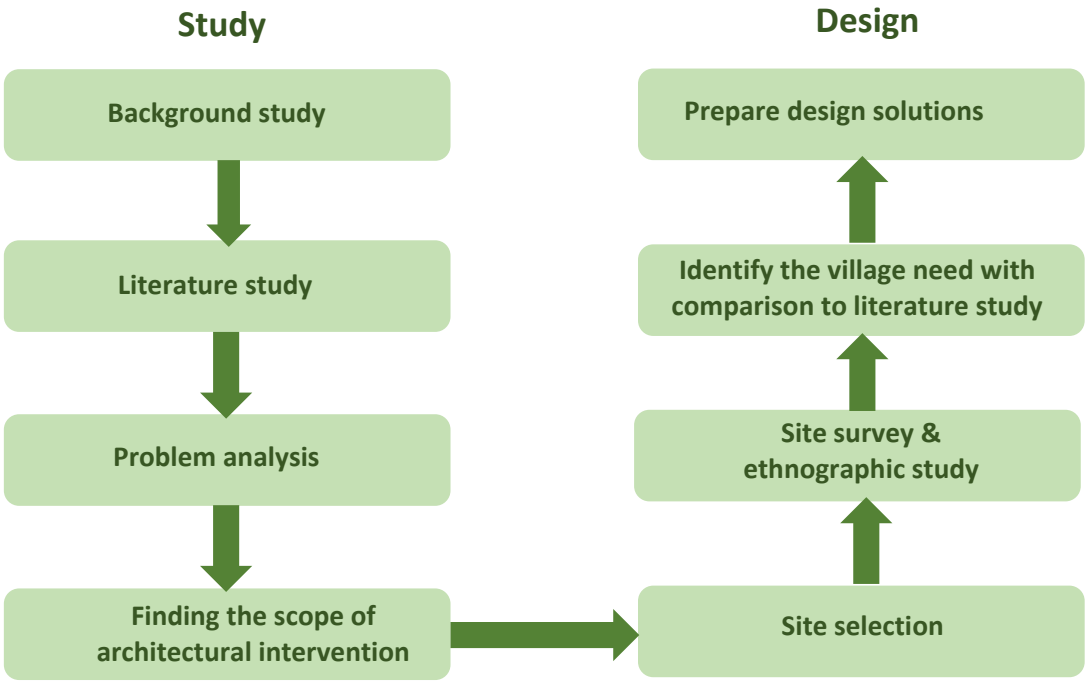
- Identifying the scope of architectural intervention in the agriculture sector.
- Thinking about the role of an architect in the agriculture industry and rural development.
- Proposing a tentative architectural design solution in the context of a particular village.

The study has the following limitation-

- Though different particular crops are cultivated in different regions of Bangladesh, the study investigates the problem analysis from a general point of view and mainly works on the rice and vegetable industry problems regardless of a particular crop.

- While working on the design solutions, this study does not include the rural settlement planning and horizontal expansion of household issues.

1.4 Methodology



1.5 Problem analysis

This study investigates the existing problem in every step of the agro-food supply chain. There are a lot of problems at every step of this chain. The problems start from the production of crops. Gradual loss of arable land at a significant rate is declining production to the highest extent. The shifting rate of agricultural land to non-agricultural use is said to be about 1% per year (Planning Commission, 2009), which is alarming concerning the total crop production and food security in Bangladesh (Rahman and Hasan, 2003). The horizontal expansion of rural households is largely responsible for the problem. (Ahmed, Z., & Marzuk, A.,2013)

Land cover type	1976		2000		2010	
	Area (ha)	% of total	Area (ha)	% of total	Area (ha)	% of total
Agricultural land	13,303,654	91.83	12,742,274	87.69	12,176,904	83.53
Non-agricultural land	1,183,605	8.17	1,788,307	12.31	2,400,867	16.47
Total	14,487,259	100.0	14,530,581	100.0	14,577,771	100.0

Figure 3: Change in land usage over time

After harvesting, some crops need further post-harvesting procedures which require adequate space to run different activities. But the ever-expanding dwelling units also create a shortage of these types of space. (Ahmed, Z., & Marzuk, A.,2013). As a result, sometimes the farmers are compelled to use the pitched highway road for drying the paddy which is too risky and creates an obstruction to vehicles running across the road. Due to these drawbacks of paddy processing, farmers are bound to sell the paddy to the mill owner at a very low rate. And thus lost the opportunity of a good amount of profit.

Figure 4: post harvesting activities of paddy on road

Moreover, some agro-products like vegetables and fish need further processing for distribution and export purposes. These are the concern of the agro-processing industry which remains closely integrated with the agricultural sector. (Mahmood, 2019)
Despite having a huge demand, the agro-processing industry is not well developed, especially in rural areas. The lack of cold storage, mills, warehouses for storage, and equipment, such as scales and packing machines, has led to difficulties in this industry (Raihan, 2022)

After processing, either the products go directly to the market or are required to be stored. Products like vegetables and fish require cold storage to keep them fresh for a certain period. But unfortunately, the numbers of storage are not sufficient compared to the demand. (The Financial Express, 2021)

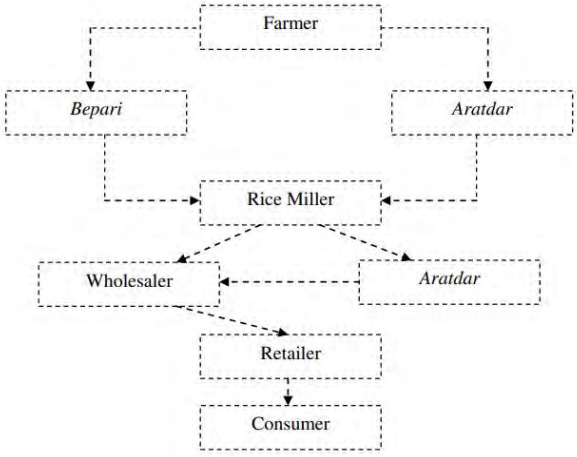


Figure 6: Market system of rice
(Rahman, M. M. R., & Neena, S. B.,2018)

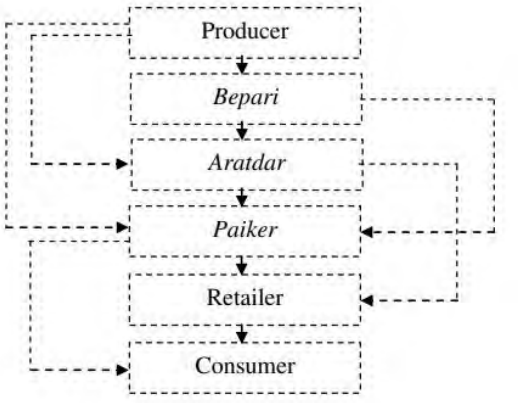


Figure 5: Market system of vegetable
(Rahman, M. M. R., & Neena, S. B.,2018)

The next step of the supply chain: trading - is not properly accessible by the marginal farmers. In most cases, they remain hostage in the hands of 3rd party vendors. (Jamaluddin, 2017). The market for agricultural products is controlled by syndicates that are formed by big businessmen. They buy the crops produced by the farmers at a very cheap price and later sell them at higher prices to earn huge profits. They also control the trade of agricultural inputs in such a way that the farmers are greatly exploited. (BASF, 2020). So, it becomes tough for the farmers to get a fair price for their products. The absence of proper market infrastructure is creating this problem. (Rahman, M. M. R., & Neena, S. B.,2018)

The next step: distribution- mainly suffers from poor transport system and road network. lack of transportation facilities, higher transaction costs, multiple market intermediaries, lack of awareness, and several other socio-economic problems facing ago product supply chain management in Bangladesh. (GAZI, M. A. I.,2020)

1.6 Identifying the areas of architectural intervention

Architectural intervention generally means a physical intervention that, as a result of a project, proposes an architectural space generated based on human intervention. The fact that the architectural object incorporates the infrastructural nature into its own implies the precondition that this object becomes an integral part of an infrastructural system of higher order. (Pinto, 2013)
In this study, the architectural intervention primarily focuses on necessary building infrastructure or planning development to strengthen the agriculture industry. After investigating the problem analysis thoroughly, certain problems were identified which can be solved by building infrastructure development or planning.

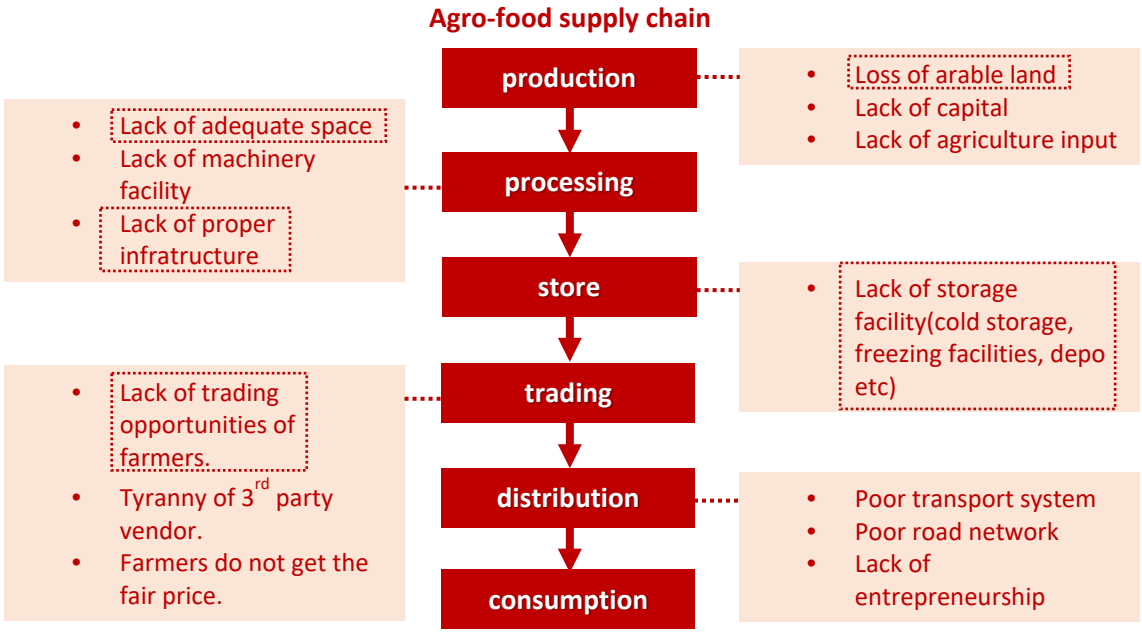


Figure 7: Problem analysis diagram (finding out the areas of architectural intervention)

1.7 Case study: Dumuria Village Super Market

There is an urgent need of transforming the food market system to make better food sourcing and supply systems. This village supermarket concept has emerged to answer that demand. It will offer a new marketplace and food business hub that will improve inward and outward market linkage among producers and traders. This marketplace aims to build a direct connection between the producers and the end market. By doing so, it will contribute in both ways -production and meeting the demand; and ensure safe and sustainable food from consumers at the local level and export markets.

The village supermarket idea considers the environment and resource efficiency factors from planning to the construction process. It includes cold storage units, and freezing and ice facilities that will mitigate post-harvest food losses. Smart agro-market functionalities along with digital automated trading and auctioning facilities will make transparent trading of products. The main challenge of this project will be to show that this model is replicable and investment-worthy. The initiators of this project are expecting that this model will be easily replicable in other developing countries where market transformation through building robust infrastructure will help the farmers. (Solidaridad, 2018)

Figure 9: Dumuria Village Super Market

Figure 8: Market space view 1

Figure 11: Market space view 2

Figure 10: Market space view 3

2 Site Analysis

An existing village of Hathazari Upazilla, Chattrogram has been chosen for the project site. According to Chattrogram DAP, Structure plan 1995 has identified Hathazari Thana as one of the future agriculture expansion areas. The selected village “Charia” is 4km away from Hathazari Thana. Around 10,000 people live in that village and the majority of them are farmers. The village has around 500 acres of arable land which is shrinking gradually due to household expansion. The village has lost around 100 acres of arable land from the time of 2004-2020. The mostly harvested crop in the village is rice. The farmers also produce vegetables in different seasons. There are several ponds for fish cultivation and washing purpose. Cattle rearing is also common for economically solvent farmers.
The village is situated alongside Chittagong-khagrachori Road and also a railway station in the heart of the village. The railway transport connects the rural areas of Hathazari thana with the main town.

Figure 12: Site location map

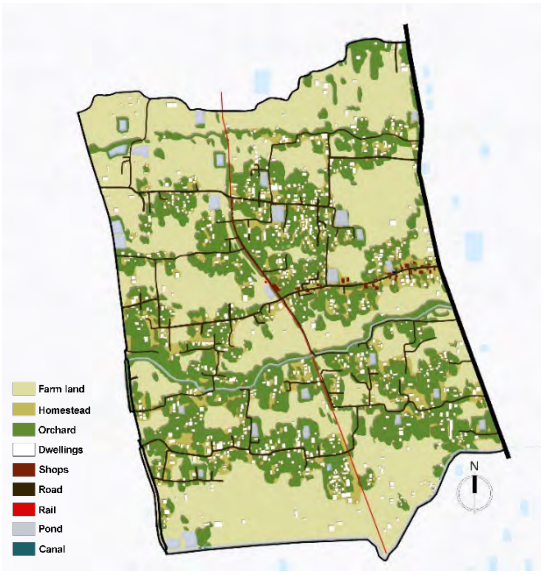


Figure 13: Existing village map

Figure 15: Homestead expansion (2004-2020)

Figure 16: Farm land in 2004 (600 acres)

Figure 14: Farm land in 2020 (500 acres)

2.1 The need of the village:

In Charia village, most of the farmers are smallholders. They mainly cultivate rice in their fields. Vegetables are also produced by farmers. Some of the solvent farmers have a dwelling with a large courtyard while most of the poor farmers do not have adequate open space in their houses. This scarcity of open space hinders the post-harvesting activities of paddy. These small farmers sometimes use the pitched highway for paddy drying or sell their paddy to rice mills at a cheaper price.

Figure 18: Existing condition 1

Figure 17: Existing condition 2

There is no Bazar in the village. Villagers go to the Hathazari main road to buy utensils. Farmers also go to that market to sell their produce. They only can reach out to local customers. Though there is a good demand for fresh vegetables in the town, they do not have a distribution network to town. So, third-party vendors buy the crops and vegetables from the farmers at a very cheap price. There is no cold storage for potatoes or other vegetables. Moreover, the village doesn't have any community gathering space or basic facilities for the social development of the villagers.

3 Detail Design Recommendations

3.1 Programs:

1."Chatal" space: post-harvesting workspace facility

2. Warehouse facility & Market.

3. Community Centre

3.2 Post-harvesting facility for paddy:

As the households in the village keep growing, it is quite impossible to provide each household with paddy processing space. Rather, a common shared space by a group of households can be an efficient solution. In the proposed model, there will be a common shared ground for drying paddy and other processing steps along with a granary and working shed for farmers. A group of 12-15 farming families can share this space for post-harvest processing of their products. Moreover, this small group can also pool their other resource like- cropland, capital, and other services. And that can act as the foundation of cooperative farming.

To set up a prototype model for post harvesting facility, a village cluster was chosen. It was "Shikdar Para" which has around 30 families and most of them do not have adequate space in their houses for post-harvesting work. So, a common vacant space was selected and facilitated with this facility financed by mutual funding. This kind of space is locally called "Chatal". The primary function of this space is to dry paddy, so it includes an empty

plain surface with a proper drainage facility to reduce harvest loss. Along with this, there are working sheds and granaries in the common “Chatal” space. This facility will ensure the farmers won’t have to sell their paddy for a very low price. They can run the post-harvesting procedures of paddy, and sell the rice at a good price.
Moreover, this “Chatal” space will serve as a meeting place for the villagers and also encourage them in multiple cooperative activities. This “Chatal” will be a place for spending leisure time.

Figure 19: Existing Mapping of Shikdar para

Figure 20: Proposed plan of Shikdar para

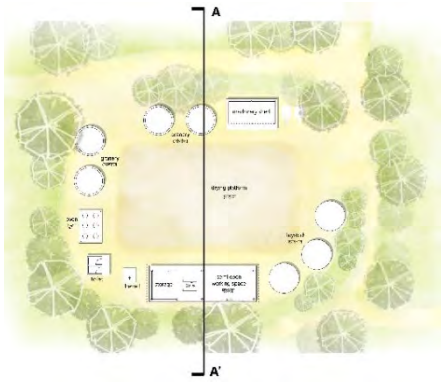


Figure 21: "Chatal" plan

Figure 22: "Chatal" section

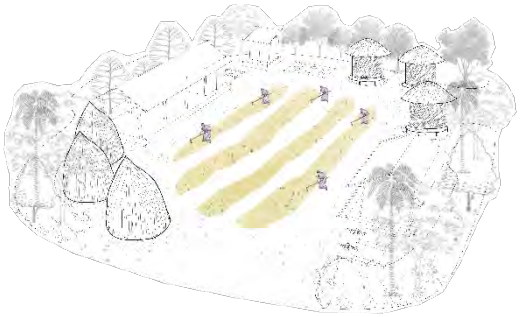


Figure 23: "Chatal" activity 1

Figure 24: "Chatal" activity 2

3.3 Marketspace & warehouse facilities:

There will be a central market space and storage facilities for the village. The location for these facilities is chosen beside the main road- which goes through the middle of the village. This location will allow the products to be easily delivered through roadways and railways.

The warehouse includes- A horti cold storage of 300 metric tons capacity and a fish cold storage of 100 metric tons has been proposed in the central portion of the village. Along with the cold storage, the Horti processing zone and fish processing zone are also provided to create the opportunity of exporting food to a remote place. 2 rice depo and a milk processing and storage facility have also been provided. The storage capacity for different items is determined according to the gross production of the village. The cold storage of vegetables and fish will allow the marginal farmers to get a fair price and free them from the syndicate of 3rd party vendors. And the processing space of vegetables & fish will give the opportunity of exporting products to remote places, thus ensuring more profit for the farmers.

A well-organized marketing facility is a crying need for the rural farmer as they usually do not get fair prices for their product. A market space has been developed along with the warehouse to facilitate the income of the poor farmers. 30 wholesale shop (art) has been provided for vegetables and fish. In addition to the “Arot”s, there is also a zone for the dry market, grocery, and agro-input shops. A tea/food stall has also been provided. There are also open spaces and temporary shed spaces for small sellers.

Figure 25: Warehouse & market plan

Figure 26: Market space view

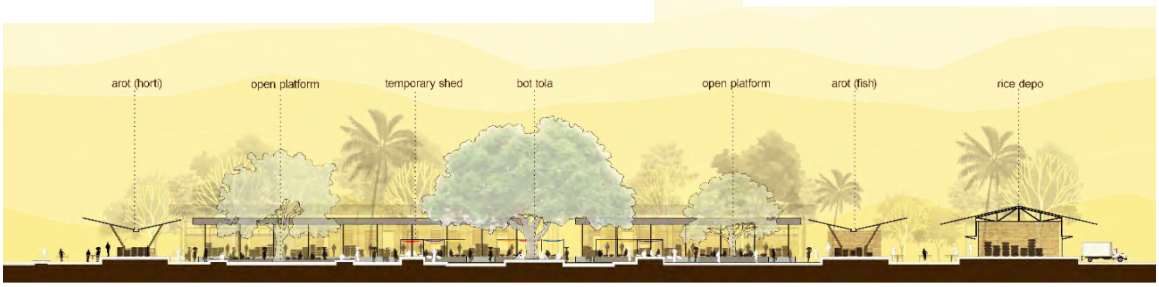


Figure 27: Market space section

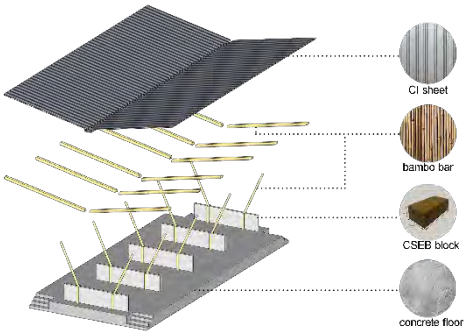


Figure 28: "Arot" structural detail

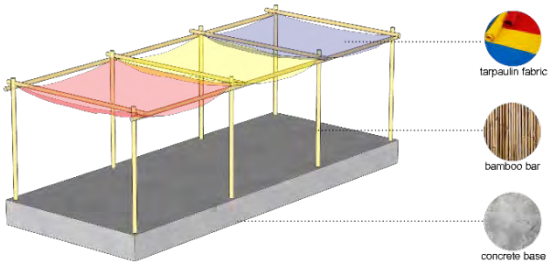


Figure 29: "Temporary shed" structural detail

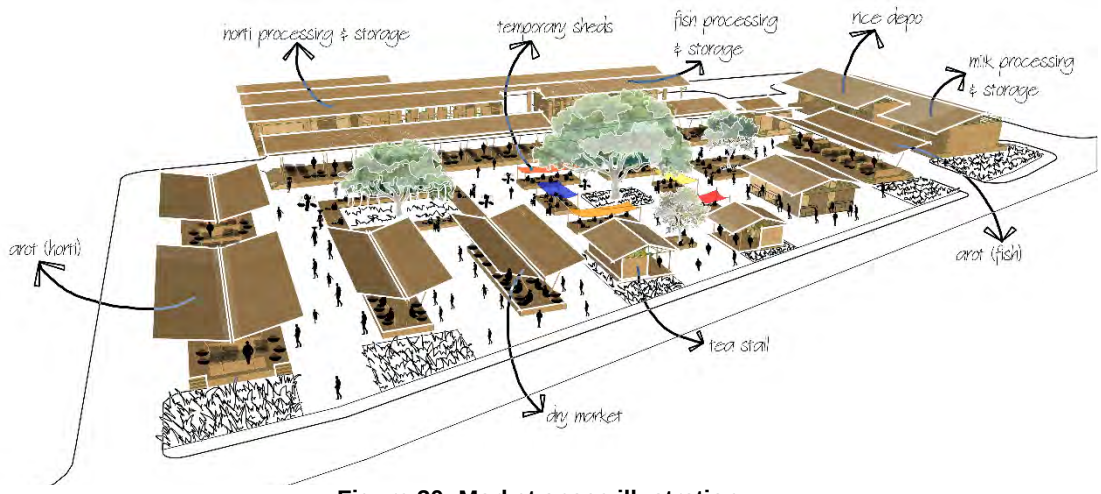


Figure 30: Market space illustration

3.4 Community Center:

Though a community center is not directly linked with agricultural development, it plays an important factor in the social development of rural inhabitants. So, the proposed program for the village model includes a community canter as well. The community hall of the center will serve different seminars, training, and community gathering purpose. Along with these, an office room and banking facility has been provided. On the first floor, a library and e-learning center have been added to ensure the educational welfare of the villagers.

Figure 32: Library space

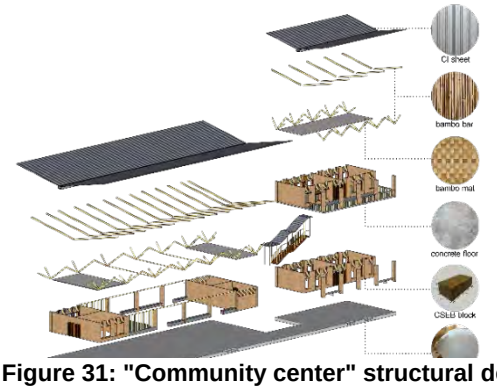


Figure 31: "Community center" structural detail

Figure 33: "Community center" elevation

Figure 34: "Community center" entry space

Figure 35: Community hall

Figure 36: Proposed masterplan

The first stage of the proposed master plan consists of the amenity facilities such as a warehouse, market & community hall for the whole village, and a village cluster with shared paddy processing space. In the later stages, this village cluster will work as a prototype for other clusters of the village. And, in the future, this village can be a role model for other villages to develop the farmers' economic conditions. And, thus these model villages will work as a micro-unit to develop the agriculture industry of Bangladesh.

4 Possible Source of Funding:

Farmers of "Shikdar Para" can build the common "Chatal" space by forming a strong cooperative. "**Comprehensive Village Development Program**" (CVDP) can be beneficial in this regard. This program was initiated by the Government of Bangladesh and the vision of this program is- One Village One Organization". In this project, the members of the society do not receive direct credit. Instead of that, they generate their fund from their contribution and invest jointly in different profitable sectors. Families of 15-16 farmers can form a cooperative group and receive guidance through the CVDP program. Hence, the cooperative group can pool their production and resources. This cooperative approach is aligned with the concept of economies of scale and can also be related as a form of economic synergy, where "two or more agents working together to produce a result not obtained by any of the agents. They can arrange the proper land for the "Chatal" through mutual discussion among the cooperative's members. Moreover, the simple and basic structures of "Sheds" can be easily constructed with locally available materials and labor. However, for materials that can't be arranged from the surroundings for instance- the CI sheet; the cooperative can arrange its fund to buy those.

The central village amenities can be funded through various programs of the Local Government Engineering Department (LGED). One of them is- the "**Bangladesh Agriculture Infrastructure Development Program**" (BAIDP) under which LGED has the plan to develop market centers and collection centers in rural areas. (oldweb.lged.gov.bd)

particulars	rate	quantity	total
CI sheet (3' wide)	8000 tk/bundle	7.5 bundle	60,000 tk
Bamboo (local resource)	400 tk/unit	50	20,000 tk
Soil (local resource)	-	-	-
Lumpsum	-	-	20,000 tk
			1,00,000 tk

Table 1: Cost estimation for "Chatal" space

Organization	Program	Activities
Local Government Engineering Department (LGED)	Bangladesh Agriculture Infrastructure Development Program (BAIDP)	develop market centers and collection centers.
USAID	Feed the future	increase agriculture-led growth, strengthen resilience and engage the private sector.
Government of Bangladesh	Comprehensive Village Development Program	enhances village cooperation models.

Table 2: Possible funding sources for the project.

5 Future Scope of the project

The primary focus of the study was on how building infrastructure and space design in rural areas can contribute to the development of the agriculture industry. It didn't include rural settlement planning which could be an essential part to save arable lands. So, further development of this study can include rural settlement planning and deal with the horizontal expansion of household issues. The problem analysis regarding the agriculture industry has taken concern about the rice and vegetable crop industry in general. So, in the future, a more focused study can be generated for a particular region that has a particular major crop for formulating a more effective village model.

6 Conclusion

As the agricultural sector is the most important for our national growth, necessary measures should be taken immediately to develop the overall condition. And people from all sorts of our country, regardless of their background, should come forward and be a part of this development. The purpose of the project was to analyze the problems from an architectural point of view and develop solutions through architectural interventions. A tentative design model in an existing village has been developed to present the viability of the solutions. In the design development process, the vernacular style of architecture has been given importance. The lifestyle of villagers was studied to develop an acceptable design for them. Some decisions regarding the design model were made concerning the selected site location. So, modification of this design model might be needed to be adjusted to the site forces of a different location.

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Towards a new prediction model for energy-related occupant behaviour in domestic environments

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Abstract: *Climate change has significantly increased global concern regarding the critical role of human activities on carbon dioxide (CO_2) emissions through energy use in buildings. According to International Energy Agency (IEA), with 19% contributions, residential buildings have a considerable share of the total CO_2 emissions among other types of buildings. Therefore, many researchers endeavoured to investigate how to predict occupants' energy use through different occupant behaviour models. Although such models have helped researchers to consider the occupants' energy-related behaviour for the energy calculation of buildings, several gaps remain between the predicted energy obtained from the occupant behaviour models in pre-design stage and the actual energy consumption of occupied buildings. This issue stems from the stochastic nature of occupants' interaction with buildings' systems to control their living environment based on their different physical and psychological needs for comfort. This can result in various unpredictable responses of occupants to existing domestic environments based on their perceived discomfort, which may not be included in behaviour models. To address the issues of existing frameworks, there is a need to control occupants' behaviour to achieve more accurate energy-related predictions. This might be achieved by proposing a new framework to enable the occupants to learn the opportunities within their living environment to achieve more energy-saving behaviour by providing feedback based on their existing energy-related behaviours. Therefore, this study's primary objective is to explore one of the most comprehensive frameworks representing energy-related occupant behaviour. Afterwards, a new energy-related feedback prediction model is proposed to address the current gap in behaviour prediction. This framework may not only guide energy predictions for researchers and designers but also could guide occupants' energy-related behaviour, which could help them achieve energy-saving behaviour.*

Keywords: *predictive model, energy use, domestic environments, occupant behaviour, discomfort.*

1 Introduction

The Intergovernmental Panel on Climate Change has highlighted the significant impact of human activities on climate change and global warming in various reports (Change 1990 & 2014). Although several resources are known to contribute to this issue through CO_2 emissions, energy has a large share of 73% of the overall emissions (Bouckaert et al., 2021). The IEA analysis showed that the most critical sectors responsible for CO_2 from energy consumption are industry, transportation, and buildings, amongst which buildings account for 17.5% of total emissions. However, with 19% contributions, residential buildings have a considerable share among other types of buildings (Fig. 1). According to IEA EBC Annex 66 results (2014-2017), occupants' behaviour plays a crucial role in the operational energy use in buildings.

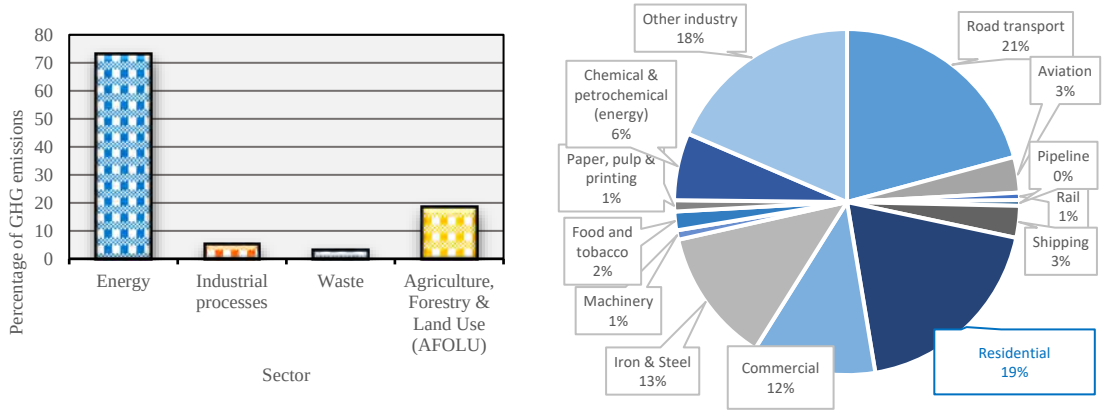

Figure 1. Greenhouse gas emissions (%) from buildings due to energy use on a global scale (World Resources Institute 2020)

To address this issue, many designers started to implement energy efficiency in their design process by proposing buildings with high energy performance. Although this strategy contributed to reducing energy use in those buildings, the significant amount of consumed energy was mainly due to the occupants rather than the efficient systems installed in the building. According to de Dear and Brager (1998), occupants are active recipients of their living environment. Thus, they could play a significant role in energy use by interacting with the buildings' lighting, heating, and cooling systems. Therefore, a performance gap still exists between the energy used in an occupied building and the energy predicted in the pre-design phase of the building. This has resulted in consideration of occupant behaviour in the design and operational phase of the building.

Regarding this interaction between humans and buildings, an extensive literature has focused on the approach to account for occupants' behaviour in evaluating buildings' energy performance (Gaetani et al. 2016). For instance, researchers aimed to understand how occupants control their indoor environment to achieve thermal, visual, and acoustic comfort. As a result, they proposed various frameworks and behaviour models to implement energy-related occupant behaviour during their occupancy time in the building and proposed occupant behaviour models for energy prediction in the buildings.

Although such models have helped researchers to consider the occupant-centric decision-making approach within the design and operation process (Azar et al. 2020), several gaps remain to be addressed. Due to the stochastic nature of the occupant behaviour, such models might face limitations regarding recognising their real interaction with the systems,

affecting the quality of their estimates (Hong et al. 2017). This issue is more prevalent in residential buildings where the controllability of the indoor environment is more flexible than the commercial environments. This might increase the expectation leading to the frequent control of their living environment based on their preference, thus consuming more energy (Andargie et al. 2019), creating habitual reactions to their discomfort over time. Since, as indicated by the availability of controllable systems could result in higher expectations and spoiled occupants to consume more energy when feeling discomfort (De Vecchi et al. 2017). Therefore, this can lead to various unpredictable responses of occupants to existing domestic environments based on their perceived discomfort, which might not be included in behaviour models. Moreover, researchers proposed various behaviour models based on different contextual results and variables. As a result, a more comprehensive method to understand the complexity of human behaviour was developed for researchers to integrate it into their studies. To address the limitation created by the diverse nature of the occupant behaviour, a more comprehensive framework was developed by (Hong et al. 2015) to consider the complex nature of the interaction between occupants and building systems. Therefore, they introduced the Drivers-Needs-Actions-Systems (DNAS) framework for building energy-related behaviour modelling. This framework provided a very clear understanding of the key aspects of the daily interaction of occupants with their building systems.

It is worth mentioning that although it is necessary to comprehensively understand the crucial aspects of the occupant behaviour, additional steps might be needed to encourage occupants for more energy-saving behaviour, encouraging behavioural change in occupants. Several studies have shown that it may not be possible to achieve complete accuracy in terms of prediction models due to incidental behaviour of occupants (Sepehr et al. 2018). Therefore, behavioural changes may further contribute to achieving a more predictable future in terms of energy use in residential buildings. This might be achieved by reflecting on their current behaviour through various feedback based on the opportunities available for the occupants in the buildings. In this research first DNAS framework is explored to understand the concept of this model. Afterwards, a new energy-related feedback prediction model is proposed to address the current gaps in behaviour prediction. This framework may not only guide energy predictions for researchers and designers but also could provide guidance for occupants' energy-related behaviour, which could help them achieve energy-saving behaviour.

2 Drivers-Needs-Actions-Systems (DNAS) framework for energy-related occupant behaviour in buildings

Several techniques and approaches are proposed to examine the total energy use in buildings considering occupant behaviour in residential and commercial buildings. These models aim to predict the effects of user behaviour on buildings' energy consumption. Although most models included variables to account for cultural and contextual variations in different countries, the variability of the occupants' behaviour requires further investigation.

To consider the incidental behaviour of occupants, the DNAS framework was developed for researchers to standardise the representation of energy-related occupant behaviour at the international level (Turner and Hong 2013). In this framework, they defined the behavioural impact of the building users in four main aspects "drivers, needs, actions and systems" (Fig. 2). The ***drivers*** are the contextual and physical environment parameters which act as stimuli for occupants to achieve their subjective and objective needs in their inside world. The aspect of ***needs*** represents the users' physical and non-physical needs

which must be addressed to achieve more satisfactory results in their living environment. ***Actions*** define the users' interaction with the building systems to achieve thermal, visual, and acoustic comfort. ***Systems*** are the equipment in the buildings through which the users achieve their comfort within their environment.

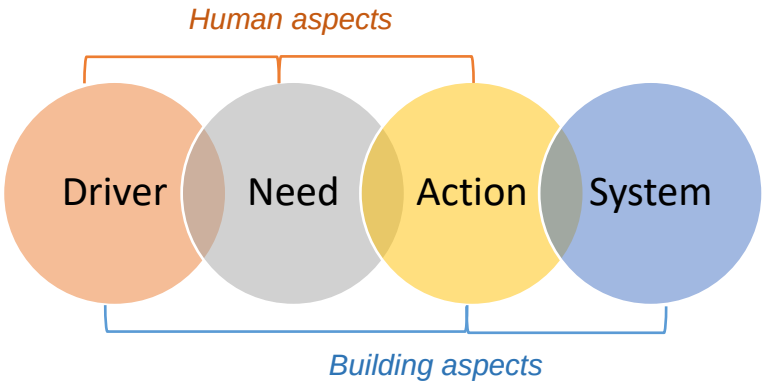

Figure 2. Key aspects of the DNAS framework

This framework helped researchers create scenarios for occupants' interaction with building systems when they felt discomfort in their environment. According to this framework, the occupants are stimulated based on their current contextual environment, and they take actions depending on their needs at that specific time. Therefore, to eliminate the discomfort, they control the systems of the buildings accordingly. For example, when the temperature of the office where the users work increases and the occupants' comfort is affected, they may open the operable windows of the buildings based on the needs from their environment. As a result, the driver is the room's temperature, the need is their thermal comfort, the action is to open the windows, and the systems are the operable windows. Although this framework provides a comprehensive framework to understand the scenario of the human-building interaction, the sequence of the occurred phases might be changed in practice, which is discussed in the following sections.

2.1 The hierarchy of human-building interaction

In this framework, the action component can be occupants' self-adjustments (e.g., clothing), opening or closing a window, or turning on or off the cooling systems. Moreover, it has been pointed out that the actions can also include discomfort reports of the occupants to the building manager or leaving the room. Based on this scenario, it can be inferred that the actions may change into reporting their discomfort depending on the restrictions they faced in the process of the human-building interaction. Therefore, the controllability level of the systems could eventually prevent their actions, altering them to inactions. Thus, although this scenario can be applied in offices where the occupants may have restrictions in controlling their surrounding environment, such scenarios could be changed from constraints to opportunities in residential buildings. According to de Dear (1998), occupants have a more active role in controlling their living environments. This can stem from the availability of opportunities in their buildings to interact with the cooling, lighting, and heating systems based on their preferences, which has resulted in higher expectations and energy consumption. As a result, considering the domestic environment of occupants, the actions component can be affected by the available systems in their

house. In other words, without understanding the available systems of the built environment, the occupants may not take action based on their needs. Therefore, the sequence of the components in DNAS framework could be changed from actions-systems to systems-actions (Fig. 3). For instance, depending on the availability of the windows in a room, a person might change their actions from turning on the artificial lights to pulling off the window curtains (depending on the constraints) in the room to increase daylight. Therefore, the actions have the potential to be changed based on the capacity of buildings to create comfortable environments.

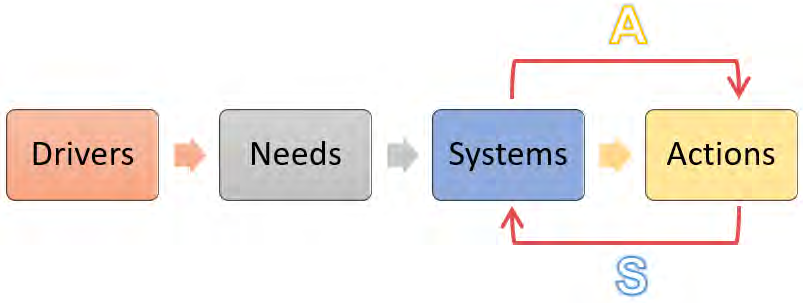

Figure 3. The change in the sequence from action-system to system-action in the context of the domestic environment

Since the availability of control systems could lead to diverse activities in the domestic environment, the amount of energy used may increase. For instance, depending on the tolerance of the occupants, they may choose an option that is more accessible or takes less time to achieve comfort. As a result, although pulling off the curtains could be an option for the users to change their environment, they may choose to turn on the artificial lights instead. This can be related to occupants' limited tolerance range in mixed-mode buildings than in naturally ventilated buildings (Kim et al. 2019). Therefore, there is a need to create opportunities to reduce occupants' energy consumption based on the relationships between key components of this model.

2.2 The relationship between DNAS components

The increase in the controllability features of the residential buildings necessitates solutions for behavioural modifications in occupants, which could play a crucial role in reducing energy consumption in residential settings.

To create behavioural change in the occupants, several interventions are proposed to develop a mechanism to change occupants' energy-related behaviour. In such a mechanism, the occupants' behaviour is considered recurring activities that could create habituation of behaviour during their everyday interaction with the domestic environment. Although the occupant behaviour can be stochastic in nature, the reaction to a specific thermal, visual, and acoustic discomfort can be turned into habitual interaction with their buildings' cooling, lighting, and heating systems. In this regard, occupants' behaviour can be defined as recurring activities in a process loop rather than a hierarchical activity in a linear process.

In the DNAS framework, a linear relationship between the key components of energy-related behaviour exists; however, based on the recurring nature of the behaviour, they are iteratively interacting with each other. Therefore, there is a need to create opportunities

to reduce occupants' energy consumption by revisiting the linear process defined in the DNAS model (Fig. 4).

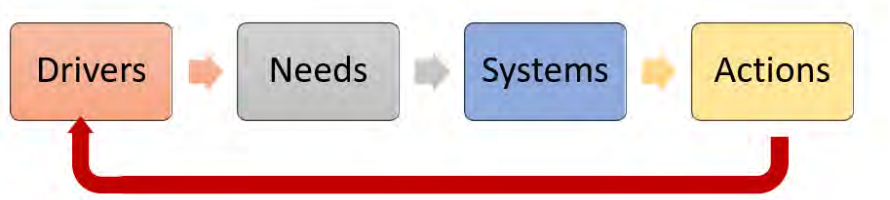

Figure 4. From linear to process loop approach in the energy-related behaviour framework

This process loop may not provide an opportunity for occupants to revisit their energy-related behaviour. Not only is there a need for researchers to understand the key components of human energy-related behaviour, but also occupants should gain knowledge to be encouraged for behaviour change. Therefore, without understanding their actions, occupants cannot judge whether they can change their energy-related behaviour and whether there are any other alternative actions that they can choose amongst other available actions.

2.3 Reflection as a key component of the energy-related behaviour model

Knowledge can create opportunities for occupants to discover the capacity and the available options within their living environment to achieve better solutions and comfortable conditions. To do so, the reflection can be defined as a component to connect the other components in the model (Fig. 5). This can create opportunities for occupants to learn extra strategies to exercise to achieve energy savings within their existing living environment.

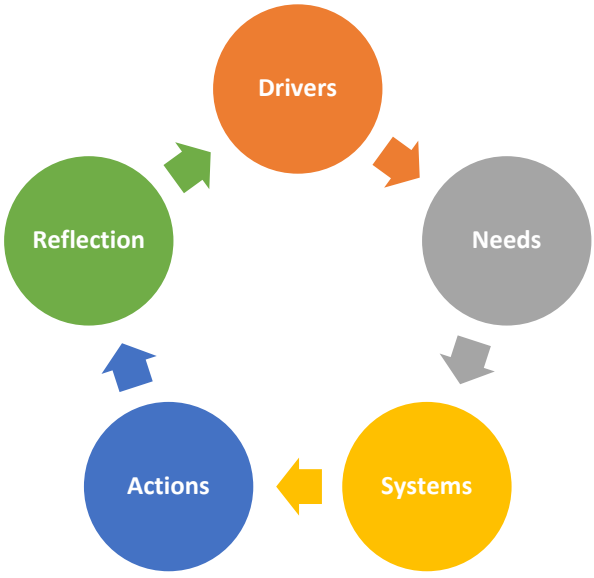

Figure 5. The inclusion of reflection in the energy-related behaviour model

According to DNAS framework, the driver component covers five aspects: building, occupant, environment, system, and time. As stated, this component represents

stimulating factors that provoke occupants to implement energy-related actions, such as indoor air temperature, time of day, and season. However, a driver, such as high air temperature, may not necessarily drive occupants to take action. Therefore, according to the definition by Nicol and Humphreys (2002), "*if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort*". Therefore, according to this definition, it is discomfort that acts as a driver for taking action. Thus, in the new proposed model, the definition of driver as a stimulating factor can be replaced by "stimuli", which could potentially impact occupants' comfort.

The need component in DNAS framework is defined as the physical, physiological, and psychological requirement of occupants to achieve satisfaction. However, prior to occupants' needs, contradictory of information should occur, which may be in contrast with the current activities being implemented by the occupants. For instance, if the occupant is sleeping, the stimuli such as high temperature may create needs, but this need could depend on the level of discomfort caused for the occupant. Therefore, the actions can be affected by the occupant's perceived discomfort. As a result, the needs component can be replaced by the component of "perceived discomfort". The level of discomfort depends on the physiological, physical, and psychological needs of the occupants.

After adding the component of "reflection", the models could create a chance for occupants to change their activities based on the options available to them (Fig. 6). Therefore, the systems component can be replaced by the "options" component because as occupants gain knowledge regarding the availability of different options, they might have the opportunity to change their actions accordingly.

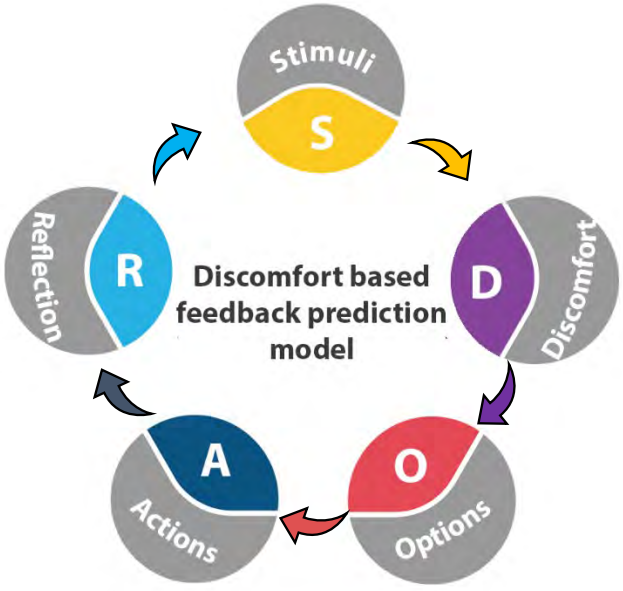

Figure 6. The discomfort-based feedback model proposed for residential buildings

3 Conclusion

This research endeavoured to propose a more practical energy-related occupant prediction model based on exploring a standard energy-related occupant behaviour

framework, namely DNAS model. This paper intended to address the limitations of the model in the context of residential buildings where the occupants have more control in their living environment and thus more interaction with the building systems. Therefore, the main aim of the new discomfort-based feedback prediction model is to include discomfort levels while knowledge in the process of human-building interaction.
This model could not only help the researchers and architects to consider the key aspects related to occupants' actions within their residential buildings, but also highlights the importance of education in the process of human-building interaction by embedding the reflection component in the process loop of the new model. Through the proposed model a behaviour change may be possible by helping occupants to recognise the constraints and opportunities available in their buildings while providing feedbacks based on their existing energy-related behaviours as swell as the potential energy saving behaviour within their living environment.

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SMART VILLAGE APPROACH: AN EFFECTIVE STRATEGY FOR REDUCING RURAL VULNERABILITY

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Abstract: *Every crisis has the potential to reconsider the design of human settlements and their structures to make them more resilient to future shocks. Rural regions consist of various settlement patterns, infrastructure, and livelihoods, and they are closely intertwined with urban areas. It is important in a country like India, a culturally diverse and geographically expansive nation, with a huge segment of the population, around 2/3rd, residing in rural areas, where most of them are vulnerable to risk scenarios. For the 21st-century village, the Information & Communication Technology (ICT) and Science & Technology (S&T) revolution act as a catalyst to increase security, gender equality, climate resilience, and participatory democracy while providing clean water, sanitation, nutrition, as well as efficient job opportunities. The purpose of this study is to determine whether it is feasible to leverage current programs such as 'Smart Village' (SV) to address the rural challenges to implement SMART interventions for rural vulnerability. The study demonstrates through Problem Tree Analysis, that rural regions are particularly vulnerable to climate variations due to their reliance on environmental assets and weather-dependent occupations, as well as their comparative lack of access to information, and services. investments, and decision-making. Thus, there is a need for a shared understanding of the SV paradigm, with a set of criteria for such communities, across the context of overall rural development. Although no village in India has succeeded in absorbing all of the characteristics envisioned in the SV the cumulative knowledge gathered from these communities' efforts may pave the way for achieving smartness in their specific development sectors. There is an attempt to establish an SV Framework for rural vulnerability with a 360-degree approach.*

Keywords: *SMART Villages, Rural Vulnerability, Problem Tree Analysis, SV Framework*

1 Introduction

Rural Vulnerabilities continue to put a burden on not just the country's economy, but also the well-being and happiness of its inhabitants (Global Facility for Disaster Risk Reduction 2021). Due to limited social, economic, and physical resources, rural communities are more vulnerable to climatic extremes. The IPCC (Intergovernmental Panel on Climate Change 2021) found shreds of evidence that Climate change is anticipated to exacerbate the frequency, severity, and consequences of some types of extreme weather events (particularly short-term occurrences) (Diaz and Murnane 2008), and has already had an impact on food security as a result of global warming (Ribeiro et al. 2020).

Although rural and urban areas are closely linked, the rural vulnerability was assessed without consideration for its relationship to cities (Jamshed et al. 2020). However, with the inherent benefits of literacy and superior infrastructure, urban regions are more able to absorb and utilize information and communication technologies than rural places (Servon and Nelson 2001) which are more vulnerable to disasters due to poverty, declining population, inadequate planning, administrative incapability, and geographic isolation (DISD 2013). Consequently, people migrate in pursuit of social and economic opportunities, or due to environmental degradation, which contributes significantly to urbanization which is surplus being recognized as one of the 21st century's major concerns (Awumbila 2015).

Further, the geo-climatic characteristics of the regions expose India to a variety of hazards, including droughts and floods in the Indo-Gangetic Plain, landslides and earthquakes in the Himalayan region, and cyclones in the Bay of Bengal and the Arabian Sea, which portray a greater threat to those living in rural areas. Overall, about 60% of the entire landmass is vulnerable to earthquakes of varying magnitudes, 8% is vulnerable to cyclones, over 40 million hectares of the nation is vulnerable to floods, and 68 percent of India is vulnerable to severe drought impacts (MHA 2020).

Thus, with the goal of reducing rural-urban migration and driving rural communities toward self-sufficiency, India's rural development has seen significant changes in terms of emphasis, approaches, strategies, and programmes all over the years (GoI 2019). Until the 1970s, village development was connected with agricultural development and hence focused on increasing agricultural production (Saxena 2012). However, currently, the central government is attempting to redefine the rural development agenda by promoting cooperative federalism, developing a national consensus on developmental goals, redefining the reform agenda, serving as a platform for cross-sector issues between the Centre and State Governments, capacity-building, and serving as a Knowledge and Innovation Centre (Commission and Delhi 2012) (Aayog 2018).

Recently, the Central Government of India proposed a number of policy measures under this umbrella for rural development aimed at making the vision of Smart Villages (SV) a reality (MoRD 2021). The SV concept, according to several institutions and organisations, mainly pertains to the application of Science and Technology features combined with important local resources to boost the supply of rural services in a highly efficient manner (Ranade, Londhe, and Mishra 2015). Thus, in 2014 Sansad Adarsh Gram Yojna (SAGY) (MoE&IT n.d.) and in 2016 Shyama Prasad Mukherji Rurban Mission (SPMRM) are two programmes targeted at attaining sustainable rural development by enhancing Economic,

Social, Infrastructure, and Environmental elements (Kulashri and Negi 2017). According to the SV paradigm, transformative solutions must be ecologically and economically sustainable at their core, as well as adapt to evolving, diverse local requirements in order to stay relevant over time (Mashelkar and Pandit 2018). Thus, a 'Smart Village' is a rural community that leverages digital connections, Science and Technology solutions, and resources to expand and transform, eventually contributing to the achievement of the Sustainable Development Goals (SDGs) (International Telecommunication Union 2020).

Analogously, the objectives of this paper are (1) to provide an overview of existing rural vulnerabilities and their drivers, (2) to emphasise the role of Smart Villages in India in addressing rising challenges to sustainable rural development, and (3) to address the sustainability standpoint for rural vulnerability by developing a Smart Village framework. To effectively adapt and use smart development in the aforementioned contexts, a study of practices, rules, and initiatives is carried out to draw lessons about the implications of smart development and how communities have co-evolved with smart interventions. The paper's explanatory technique is based on a bibliometric study. The systemization of the paper is described in (Fig 1). However, the formulation of rural extents and indicators for smart rural villages is based on substantial literature research, which is followed by discussions highlighting major study findings, concluding remarks, and the availability of materials or information.

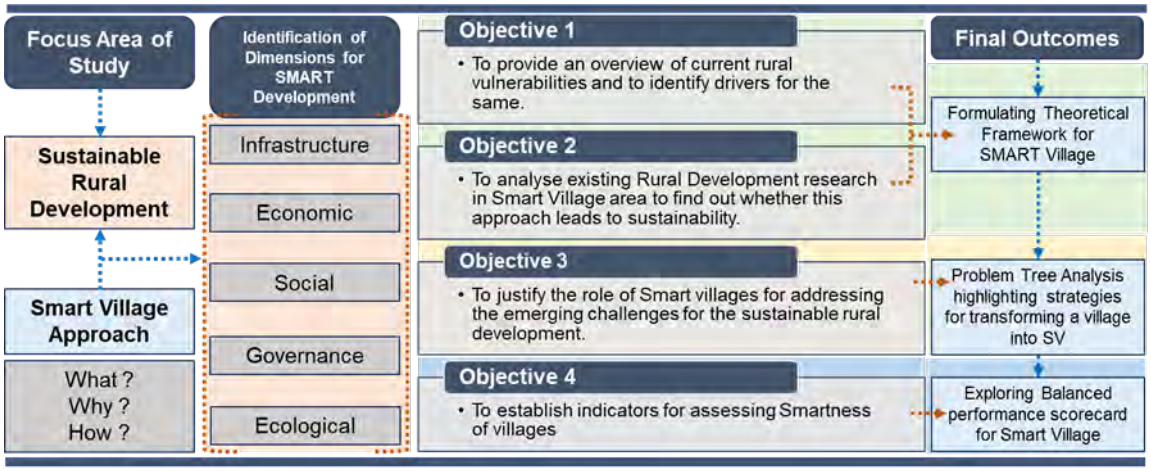


Figure 1: Methodology for design of SMART strategies, Source: Author

2 Literature Review

2.1 Understanding Rural Vulnerability

The notion of vulnerability has several meanings and recommendations. To comprehend the idea of vulnerability, it is important for understanding the correlation between Exposure, Sensitivity (capacity), Risk, and Resilience (UNDRR 2019). The intensity of the consequences of extreme and non-extreme events is greatly influenced by the amount of sensitivity and exposure to these occurrences (PBMC 2016)(Cardona et al. 2012). Vulnerability, which has its roots in the study of natural disasters and poverty, has several definitions but often covers the characteristics of individuals or communities dealing with the impacts of disruptions such as natural disasters (Janssen and Schoon 2006).

Accordingly, approaches for addressing the causes of vulnerability vary due to diverse conceptual frameworks and meanings, as well as disciplinary perspectives (Cardona et al. 2012) as highlighted in Table 1.

Table 1: Different perspectives for 'Vulnerability' by various organizations, Source: Author

Organization	Vulnerability Definition	Focus area
World Bank **(WB)** 2015	"Vulnerability is defined as the probability or risk today of being in poverty or to fall into deeper poverty in the future. It is a key dimension of welfare since a risk of large changes in income may constrain households to lower investments in productive assets -when households need to hold some reserves in liquid assets- and in human capital".	- Poverty Reduction - Equity - Measuring Vulnerability
Intergovernmental Panel on Climate Change **(IPCC)** 2013–2014	"The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt"	- Climate Change Perspectives on Disaster Risk Reduction
International Federation of Red Cross and Red Crescent Societies **(IFRC)** 2012	"The diminished capacity of an individual or group to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. Vulnerability is most often associated with poverty, but it can also arise when people are isolated, insecure and defenceless in the face of risk, shock or stress"	- Disaster & Crisis Management
Sendai Framework for Disaster Risk Reduction, **UNDRR** 2009, 2015-2030	"The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard"	- Disaster Risk Reduction
United Nations Environment Programme **(UNEP)** 2003	"The manifestation of social, economic and political structures, and environmental setting. Vulnerability can be seen as made up of two elements: exposure to hazard and coping capability. People having more capability to cope with extreme events are naturally also less vulnerable to risk"	- Assessing Human Vulnerability to Environmental Change

However, most current vulnerability research has focused on urban regions, with little attention paid to rural areas, particularly in developing nations (Ribeiro et al. 2020);(Cutter, Ash, and Emrich 2016). Rural livelihood is a complex structure dominated by agriculture (Mphande 2016) thus, it is especially vulnerable to natural calamities since it is so reliant on weather, climate, land, and water to survive (Assad, Ribeiro, and Nakai 2018).

2.2 Drivers of Rural Vulnerability

Vulnerability reduction and resilience promotion are complex and multidimensional endeavours, and structural inadequacies are frequently the primary causes and underlying determinants of vulnerability (ILO and Philip 2017). Vulnerable populations are at risk not just as a result of a threat, but also as a result of marginalisation, everyday patterns of social interaction and structure, and access to resources (Cardona et al. 2012), (Studies 2009). Accordingly, some of the driving factors for rural vulnerability are mentioned in (Fig 2) under five dimensions of development Social, Economy, Governance, Infrastructure, and Environment.

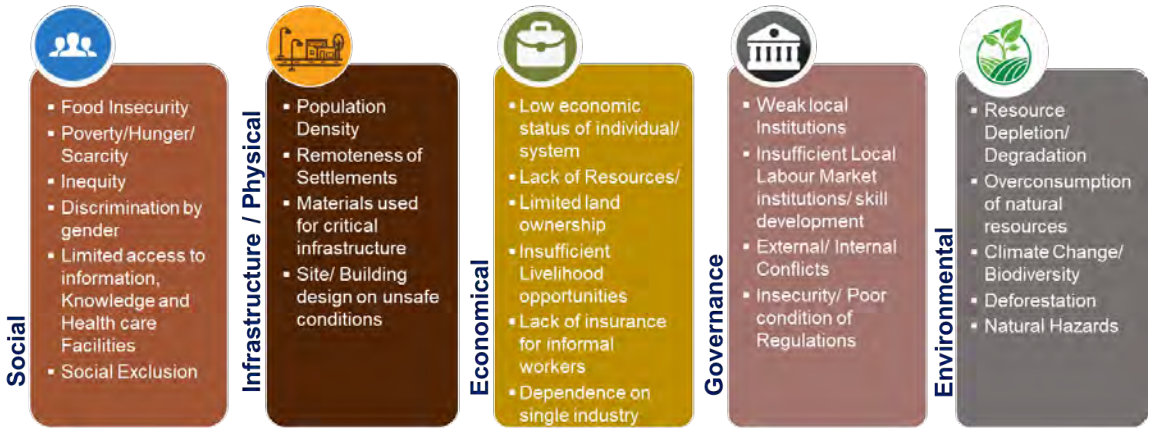


Figure 2: Drivers of Rural Vulnerability, Source: Author, Based on (ILO and Philip 2017)

2.3 An overview of SMART Villages

In terms of expanding developmental concerns, the concept of a Smart Village (SV) has grown into a widely recognised solution for improving rural quality of life (Zhang and Zhang 2020). Even though SV is not a new concept, no commonly accepted definition exists. Smart development is frequently linked to other aspects, such as the SDGs (Mihai and Iatu 2020), which address well-being, sustainability, education, management of water resources, access to renewable energy sources, women's and girls' empowerment, sustainable economic growth and dignified work, building resilient infrastructures, promoting innovation, and reducing inequalities (Pérez-delHoyo and Mora 2019), (Zavratnik, Kos, and Duh 2018). As a result, the SV concept states that "local resources and technology should function as development drivers (Komorowski and Stanny 2020), allowing education and local business opportunities, increasing health and welfare, promoting democratic participation, and raising the standard of living for people in rural villages" (Stojanova et al. 2021). SV will purposefully promote security, gender equality, and participatory democracy while also providing clean water, sanitation, and nourishment and creating efficient jobs (Mishbah, Purwandari, and Sensuse 2018). To further simplify, (Fig 3) depicts the underlying concept behind the name "SMART" as an acronym rather than a prefix to the word "village." It also demonstrates how the SMART method may be applied to the five elements of rural development, namely Infrastructure, Economic, Social, Governance, and Environment, as Sustainable/Stable, Measurable/Manageable, Acceptable/ Adaptable, Responsible/Ready, and Transformable/ Technological respectively.

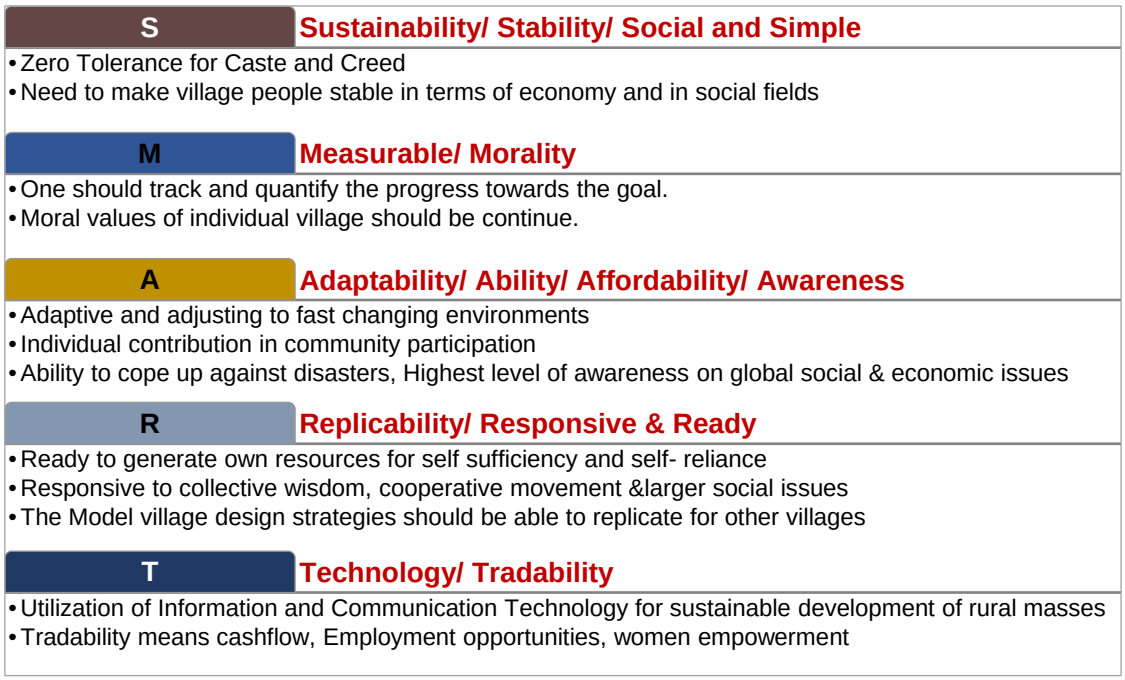


Figure 3: Core idea for SMART word under different dimensions of rural development, Source: Author, Based on (Huovila, Bosch, and Airaksinen 2019)

2.4 India's Initiatives for SV Mission

The smart village schemes have been given different identities by different states. Most significantly, while the aims of the programmes are identical, the target regions of the efforts vary (P. Pal and Ghosh 2007). Table 2 gives further information on the various SV methodologies used by various villages across India in respective fields of rural development and with their emphasis area. It is also noted that because rural regions are diverse related to physical differences or socio-cultural variety, successful SMART interventions would necessitate a place-based strategy.

Table 2: Different approaches and their focus areas under different domains of smart rural development, Source: Author, Based on (P. Pal and Ghosh 2007)(S. Pal 2017)

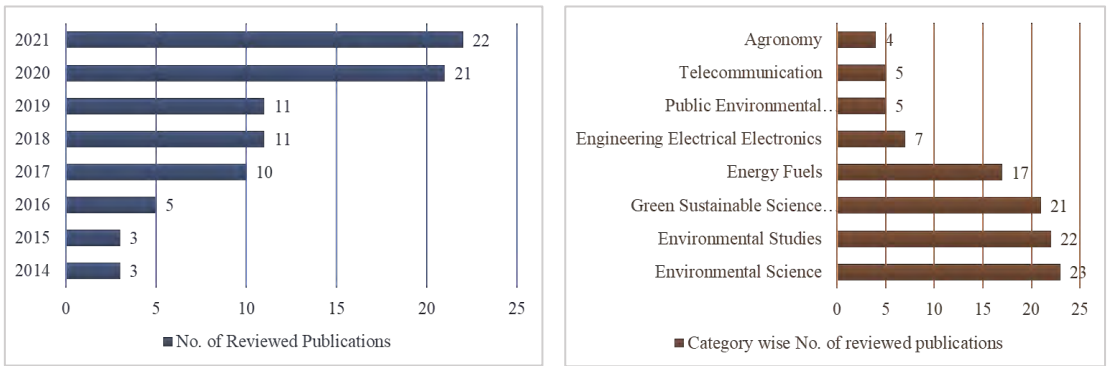
Domain of Development	Approaches	Examples
Smart Environment	- Planting native trees, Afforestation - Reuse and Recycling of waste materials - Reduce pressure on deforestation using efficient cook stoves to decrease the need for traditional biomass energy sources such as charcoal and wood a key driver of unsustainable forest use. - Acting as regional ecotourism hubs	1. Betul, MP 2. Payvihir, Melghat, Maharashtra 3. Anadwan, Hemalkasa, Gadchiroli, Maharashtra
Smart Energy	- Provision of clean and sustainable energy - Implementation of Smart Nano grid - Use of Renewable sources of energy like solar, wind and hydro power	1. Chhotkei, Odisha 2. Odanthurai, Coimbatore, Tamil Nadu 3. Dharni, Jehanabad, Bihar

Smart Water Management	- Soil and water conservation - Rain Water Harvesting - Water percolation tanks - Dams constructed by waste materials - Drinking RO water in schools - Water purification Plants - Rejuvenate rivers	1. Ralegaon Siddhi, Ahmednagar, Maharashtra 2. Hiware Bazar, Ahmednagar, Maharashtra 3. Paniyara, Uttar Pradesh 4. Dhanora,Dholpur Rajasthan
Smart Connectivity	- To provide reliable and high-quality broadband and voice communications - Through a range of ICT solutions, applications and services, be an integral part of smart technology solutions for all other domains like agriculture, water management, education, health-care - To allow rural communities to become more aware of their social, economic and political rights, engage in governance processes at all levels to the collective benefit and empowerment of all.	1. Mori Village, East Godavari, Andhra Pradesh 2. Paniyara, Uttar Pradesh
Smart Health	- Assisting mobile health diagnostic solutions which required relatively low levels of local medical skill	1. Anadwan, Hemalkasa, Gadchiroli, Maharashtra 2. Nandangram, Dinajpur, West Bengal
Smart Education	- By introducing skill development centers run by village residents who have links with the nearby city and a reasonable degree of organizing capability - By creating 'Hubs' for education, health & logistics for building economic avenues - By generating distance and adaptive learning which reduces the need to move to towns or cities to achieve higher levels of education.	1. Paniyara, Uttar Pradesh 2. Nandangram, Dinajpur, West Bengal

3 Methodology

3.1 Persisting Smart Villages Research in the domain of Rural Development

3.1.1 Content Analysis



(a) (b)

Figure 4: Content analysis for rural development and Smart Villages (a) Year -wise & (b) Category-wise no. of Publications (until 25/04/2022), Source: Web of Science

The references of peer-reviewed papers, articles, books, and other materials were obtained from the Web of Science platform (till 25/04/2022) for the content analysis of the existing work. (Fig 4) (a) and (b) depicts the number of reviewed articles by year as well as the number of reviewed publications by category. It highlights the trend in the study of

rural development using the SV technique has been growing over the last 2-3 years. In addition, in comparison to telecommunications and agronomy, a significant quantity of research has been conducted on creative solutions for villages related to environmental sciences, environmental studies, and green sustainable science. Furthermore, a large proportion of these study resources show that all of the interrelated areas of rural development and SV are often addressed and examined.

3.1.2 Prisma Analysis

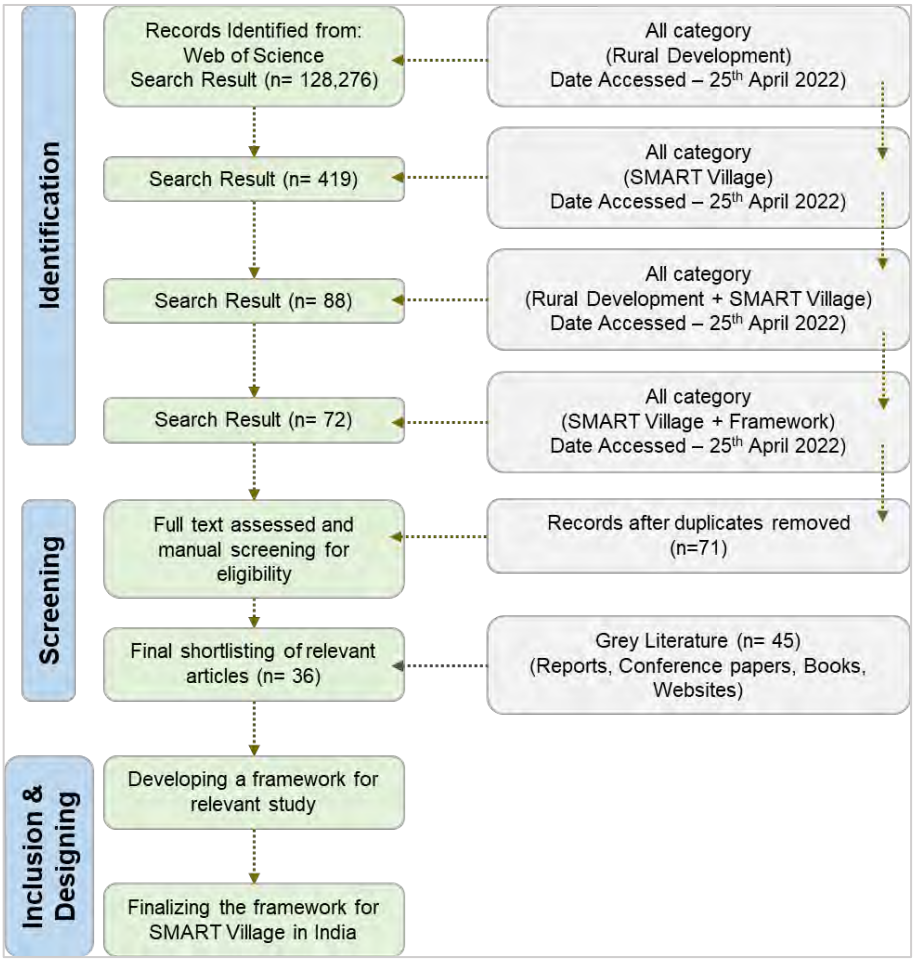


Figure 5: Prisma flow Application, Source: Author, based on (Page et al. 2021)

A systematic review was carried out in this analysis, with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (Mishbah, Purwandari, and Sensuse 2018) serving as a guideline. This review is utilised to investigate earlier conceptions linked to the subject under consideration; moreover, the association between those existing notions is determined by meta-analysis. Prior to the review process, strict eligibility criteria are specified, and only a representative sample of peer-reviewed original research is chosen for further study. This study developed research questions on the SV concept's components. These components are divided into numerous categories, including smart villages' goals, methodologies, dimensions, and the foundation or factors

that sustain SVs. (Fig 5) displays in detail the processes of a systematic review using PRISMA analysis.

3.2 The Role of Smart Villages in Addressing Emerging Rural Development Challenges through Problem Tree Analysis

This section highlights the issues that rural communities encounter. Climate change, land degradation, biodiversity loss, geographical isolation, and deforestation have all contributed to the emergence of new threats to rural development in the current context (Stojanova et al. 2021). As a result, rural inhabitants are more prone to extreme poverty, hunger, social marginalisation, and environmental damage, among other things. The introduction of these issues and impediments not only has a detrimental influence on people's living situations, but also presents barriers to their growth. As a result of using Problem Tree Analysis (Dearden et al. 2002), the following research will address some of the inherent challenges for rural development, as well as how SMART interventions might work as catalysts for the same.

Accordingly, (Fig 6) depicts Stage -1: Problem Analysis of a problem tree diagram, which gives a logical hierarchy of causes and consequences of rural vulnerability and illustrates the links between them. It produces a summary of the present negative situations. Similarly, Stage -2: Objective Analysis, in which all of the components in the issue tree are reformed into positive desirable criteria using SMART interventions.

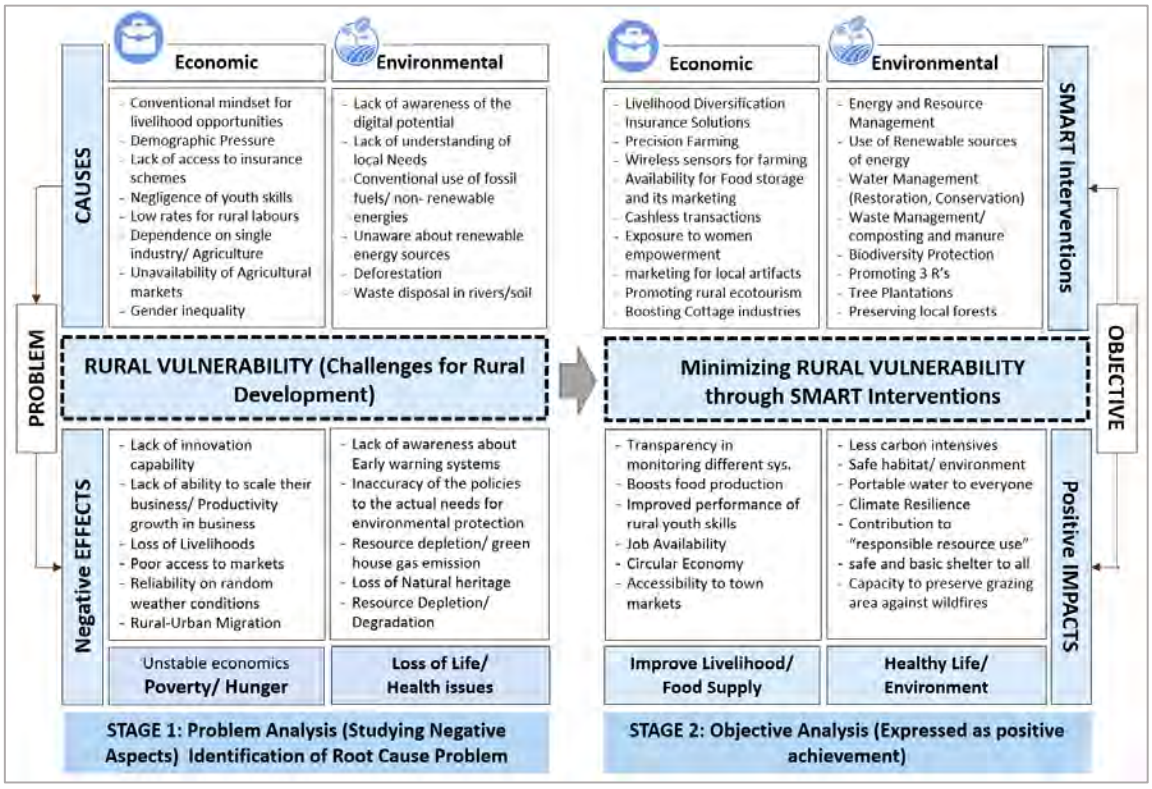


Figure 6: Stage 1- Problem Analysis (studying negative aspects) defines' the focal problem, its immediate and direct causes and its effects, Stage 2- Objective Analysis (Positive achievements through SMART interventions), Source: Author, Based on (Ghambarali et al. 2013)

4 Results and Discussion

4.1 SMART Village Framework

Regarding the Smart Village objectives stated in Section 4, the Smart Village theoretical framework, which is a systematic study illustrating how to build smart communities to promote sustainable development in rural areas, may be built around six key structuring aspects of Smart Economic, Smart Environmental, and Smart Social dimensions as Governance, Agriculture, Resource Management, Village services, Life quality, and Employment. This framework, as illustrated in (Fig 7), will accelerate the emergence of 21st-Century smart villages by focusing on three critical pivots: (a) Science and Technology (S&T), (b) Information and Communication Technology (ICT), and (c) Regulations and Management.

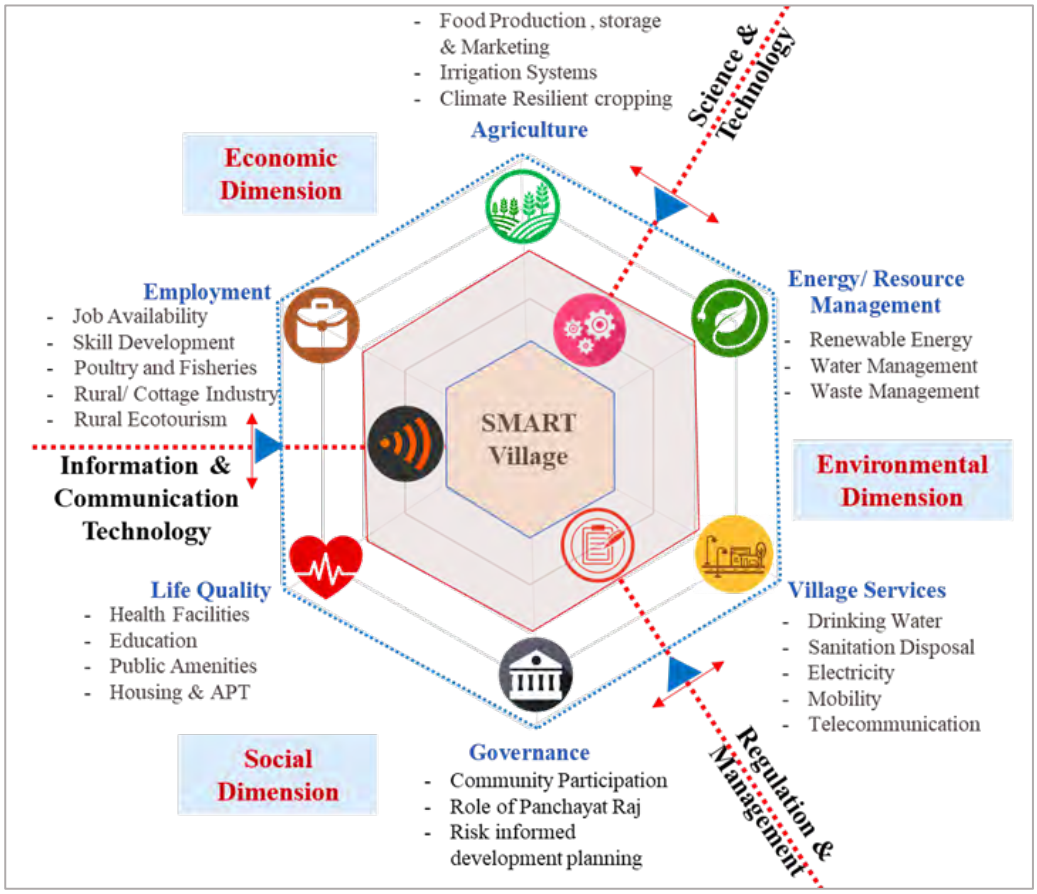


Figure 7: A SMART Village Framework for Sustainable Rural Development, Source: Author

The application of *science and technology* has the potential to significantly improve agricultural efficiency and resource management in rural regions. New ways to generate energy from renewable sources, practicing water and waste management, and using creative adaptive construction techniques utilising local skills, materials, and resources will all have a huge impact on rural communities. Furthermore, technological innovations in agriculture, such as precision farming, wireless sensors, farm management software, and agricultural machinery (Batchu and Pindoriya 2015) help to meet the growing population's

food needs. Whereas *ICT infrastructure* not only helps economic sustainability but also educates people about smartness by providing access to information and connectivity, ensuring that the distant community is connected to the rest of the world. ICT connectivity benefits emergency response activities, education access, healthcare facilities, and adopting initiatives to boost rural industries, such as increasing agricultural production and providing rural jobs, among many other things. Furthermore, community participation, imposed legal standards, transparency, concern and stakeholder engagement, majority opinion, equality for all, effectiveness and efficiency, accountability, and strategic vision are all part of the third pivot, *regulations and management*, by local governance (Panchayat Raj).

4.2 Indicators for Assessing an SV Framework

Even though significant efforts are made in several countries to build smart villages, no standard indicators for defining the smart rural village approach have been defined [67]. As a result, once resolved, the smart rural village indicator standard will enable villages in developing integrated policies that will benefit rural communities, protect the rural environment for future generations, identify the need for smart rural ICT infrastructure, and accelerate rural innovation and growth [68]. Thus, as listed in Table 3, some of the indicators and sub-indicators developed in the Smart Village model are formed under distinct dimensions of sustainable rural development. Positively, the emerging indicators will help to define what makes a community SMART: inexpensive electricity, clean drinking water, adequate housing, early warning systems for extreme weather, water conservation, and a consistent schedule for local physicians and public transit. However, the weights of these indicators will vary according to the assessment of a particular village as mentioned earlier in section 2, every village is unique, depending upon its geographic location, population, and its building capacity against any hazard.

Table 3: Dimensions, Aspects, Indicators & sub-indicators for assessing Smart Village Model, Source: Author, Based on (Aziiza and Susanto 2020)**,** (Jain and Sarkar n.d.)**,** (Bhattacharyya et al. 2018)

DIMENSION	ASPECTS	INDICATORS	SUB- INDICATORS
Environmental Development	- Energy	- Natural Resource Management	- Land conditions - Water availability - Energy (Solar/ Wind/ Hydro) use
	- Waste Collection & Management	- Organic	- Sewage/ sullage - Kitchen/ Agricultural waste
		- Inorganic	- Reuse & Recycling of Plastics, metals
Economic Development	- Agriculture	- Agricultural Production	- Irrigation systems - Horticulture - Storage & Marketing
		- Non-Agricultural	- Poultry and Fisheries - Rural/ Cottage Industry - Rural Ecotourism - Folk artifacts & Marketing - Skill Development for youths - Job Availability - Entrepreneurship

Social Development	- Basic Amenities	- Transport	- Ease of Access/ Roads
		- Drinking Water	- Quality of water - Availability/ Quantity - Ease of access
		- Electricity	- Source of Energy - Street Lights
		- Infrastructure	- Water Supply - Sanitation - Roads
		- Technology /ICT	- Telecommunication - Appropriate Technology for construction of structures - Internet availability - IT infrastructure
	- Village Services	- Essential Services	- Health Services - Education Services
		- Economic Services	- Banking facilities - Post office Services
	- Governance	- Public Services	- Administration services - Utilization of ICTs to provide services to the community
		- Policy	- Leadership - Public participation

5 Conclusion

By considering demographic and economic character, rural communities are particularly exposed to a range of risks. Economic reliance on agriculture and natural resource exploitation increases susceptibility to natural disasters such as drought, wildfires, and floods. Furthermore, rural populations frequently lack enough resources to plan for and respond to catastrophes.

As outlined in section 4.1, a SMART Village framework will improve public services such as water, sanitation, and waste management, as well as road networks, renewable energy, and digital technologies, and it lays the groundwork for a long-term-focused community. To develop a more inclusive and sustainable future, we need an inventive attitude as well as a desire to collaborate with all stakeholders. To be sustainable and sensible, we must learn to live with what we have without disrupting our ecosystems and surroundings by restoring and preserving natural resources and learning to recycle and reuse.

The COVID-19 scenario encourages the use and spread of digital technologies. Restriction measures promote remote working, distant learning, and e-services. This is especially true in rural locations, where commute times and distances are larger. All of this may enhance the value of rural places. As society changes and people become more inclined to accept digital technologies, government and private operators may expand their investments to capitalise on the potential benefits. Increased rural service connectivity can lead to more collaboration, synergy, and regional integration between rural communities and their environs.

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This study and the research would not have been feasible without the invaluable assistance of my supervisor, Dr. Sameer Deshkar. From my initial interaction with the concept of SMART Village through the final writing of this paper, his passion, expertise, and meticulous attention to detail have been an inspiration and kept my work on track. This study was partially supported by our institution VNIT, Nagpur, Maharashtra.

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Usefulness of data analytics in Smart Villages development

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Abstract: *With over 40% global population still live in rural with many under extreme poor conditions, effective management of resources for supporting the development is crucial. One of the key considerations in effective management is need-based and context specific intervention planning incorporating bottom-up information flow. Traditional top-down approaches in planning and development are considered not only wasteful but also irrelevant for transforming rural communities keeping the value, culture, heritage at the core of the development cycle. In the bottom up planning, empirical data at the grassroots level activities play a pivotal role. In this research, significance of the data-driven planning coupled with the strong data-analytics is demonstrated as one of the most critical elements supporting the planning and development of rural communities under the auspice of Smart Villages. Based on a case study conducted across 37 villages in the river island Majuli in Assam located in the north eastern part of India, the research highlights the functionalities and efficacies of a Smart Data Platform used for evaluating real-time data analytics and supporting context specific planning and development of a large area comprising 2300 plus households. The concept is further highlighted to signify the need for central data-centric Research and Development center for supporting policy making within the public governance.*

Keywords: *Data-driven planning, smart villages, smart data platform, India*

1 Introduction

Among the current 7.3 billion people currently live on the planet, over 3.4 billion live in rural areas. In just a few regions—Latin America, the Middle East and North Africa—less than 50% of poverty is now located in rural areas, but for the rest of the world's regions, between 55% and 80% of the poor continue to live in the countryside. Progress is being made, but much of the knowhow needed is under-disseminated and under-exposed, outside the small coterie of professionals who work in the area. Urban development now attracts a wide range of research and attention—the poorer rural areas deserve the same. Increasing trend of transformation of the traditional engineering-based professionals and multi-faceted interventions is not being able to converse the required new knowledge for realistic empowerment of the rural communities.

Given the disparities between the rural and urban communities, there is an increasing trend of rural communities being migrated to the city centres for better life opportunities. Due to the constraints of limited space and capacity of the infrastructure system along with the restrictions in the growth boundaries around the cities, such a constant population surge makes the cities almost impossible to govern efficiently. Taking state of Assam as an example with a total population of 35 million and over 70% population living in the villages in Assam, empowering the village communities is the only way forward for driving growth and prosperity and ensuring long term success in planning and public governance. While developing the rural communities, the use of traditional top-down approach is proven to be inactive from both sustainability and usefulness perspectives. In the advent of climate change and depleting natural resources, the best practice knowledge applied over many past decades for developing infrastructure in developed economies is not necessarily adequate to extend it to the rural settings in the 21st Century development. Not only the evaluation parameters and units of measurements are all different but also economic, social, environmental factors are completely different from urban to rural areas. In other words, future is not a natural extension of the past and thus there is a paradigm shift needed in planning and development cycle where location-based and context-specific considerations are priorities over the template based. Location based planning needs to be supported by empirical data sourced from community being considered within a specific geographical boundary and its interconnectedness among different jurisdictions. Filling the gap of this knowledge, this research demonstrates the significance of data-driven approach for supporting planning and development of projects especially in the rural context. The research exhibits the development of a smart data platform based on the empirical data collected across 37 villages over a six month period which is then used to derive necessary analytics for making local-specific planning and development decisions.

2 Challenges and opportunities in rural planning – the case of Assam

With the current trend of rapid urbanisation, there is a cultural shift being realised in Assam where more and more people from village communities are dreaming of embracing the modern life with a city centric approach. As a result, the simple but real life of the villagers is getting transformed at an unprecedented rate. While transformation takes place in any society, some of the grassroots level considerations that are essential for general wellbeing of the community can be easily lost in transition. In order to create an

empowered community, comprehensive understanding of the target community is crucial which is the key for devising appropriate policy for empowering the society holistically. Given the poor state of infrastructure and lack of adequate connectivity of the rural areas with the city centres, there is a significant difference in the lifestyle between the rural and the urban communities. Evidently, the traditional top-down governance system is quite inefficient for bringing such a gap closer due to numerous reasons such as scarce resources, conflicting requirements, change of national priorities etc. As the 7th Assam Pay and Productivity Pay Commission report states "Assam is a complex State from the governance point of view. It has immense diversity of culture, caste, religion, custom and language which not only gives it uniqueness but also creates a situation of competing aspirations of the people belonging to different groups. This situation puts a heavy responsibility on the Government in the matter of administration and development which requires a strong administrative machinery to respond to such problem in a fair and effective manner". (7th Assam Pay and Productivity Pay Commission report, Nov 2016) With the cultural diversity among the people residing over 26,000 rural villages across the State of Assam, every single village presents its own opportunities and challenges which require appropriate consideration in the intervention process. While a particular community could be highly active in farming and cultivation of rice, wheat, sugarcane or organic tea, another community alongside could be efficient in nurturing production of raw materials for weaving potential for contributing to the cotton industry. While one community has access to the safe drinking water supplied by the government schemes, another community may be reliant on water from a nearby natural stream throughout the year. Considering the diversity and associated challenges and opportunities, approaches for capitalisation of localised resources and steps for uplifting the community need to be developed based on appropriate scientific principles.

Another extreme change that is quite noticeable in the rapid urbanisation process of the state is the impulsive loss of traditional values and the transformation of the way of lives among the rural communities. As evident in the current trend of urbanisation in Assam, the tradition of independency through the family centric cultivation is being replaced with market-based economy. For instance, people are happy buying their daily commodities in the market place which could otherwise be produced locally with some effort. Growing economy usually results in opportunities for the community to embrace impulsively rather than objectively (Doloi, 2016). While the governance systems facilitate spread of such opportunity within the community, often it is not equally shared across the entire cross-section of the society. The old saying "Rich get richer and poor get poorer" is still true in some extent. No doubt, there will be winners and losers in the community but the principle of social equity can't be ignored when it comes to improving the societal bottom-line through the policy intervention and governance.

Despite the effort by the Government of Assam for supporting the community across all the key areas and improving the social bottom line, location specific planning focusing on the target community is not quite a usual practice in the devising the intervention schemes at the government levels. While State and National level efforts are highly crucial for supporting the community at large, location specific planning with target audience is highly effective and efficient. The efficiency in policy making and implementation planning can be achieved only if optimised utilisation of the scarce resources based on ground reality is ensured. However, such planning with a localised focus requires authentic empirical data but collection of such data is highly tedious and cumbersome.

3 Evidence-based intervention planning – a new research approach for developing Smart Community and Smart Villages

In this collaborative research between the University of Melbourne and the Government of Assam, an attempt has been made to capture the community specific real data for supporting location specific planning processes focusing on the housing and infrastructure sectors. A data-driven interactive system with facilitation of appropriate accesses for community and policy makers can potentially assist the political and bureaucratic systems for rolling out efficient policies and streamlining the resources effectively. The research aims to develop appropriate policy framework and governance models informed by the relevant scientific principles and best practice knowledge so that best steps can be put forward and the mistakes elsewhere are adequately reflected and rectified. Focusing on the village levels, the research is expected to support conceptualising the "Smart Villages" in Assam by empowering the rural community with the localised planning and policy support.

3.1 Configuration of Assam

Assam is a multi-cultural, multi-lingual and multi-religious place with over 33 million people. There are 28 districts, 58 sub-divisions and 84 municipal towns, 27 tribes and over 26,000 villages in Assam. Though Assam is a small state with an land area approx. 78,000 sq. km, due to poor infrastructure and lack of the fundamental services within the easy reach of the community, there is a huge disparity in the standard of living of the people across the state. In the advent of digital economy, such a disparity can be addressed with a methodical approach.

3.2 Understanding the needs and requirements – data collection

Assam is considered to be one of the backward states in India. The location of Assam is quite challenging in both geographic and natural contexts. Located at the valley of Himalaya, Assam witnesses a yearly rainfall of upto 6500mm which ends up inundating a huge area along the Brahmaputra valley each year. The Chicken neck connection between the mainland India and the state exerts significant logical challenges for maintaining the resources flow and meeting the growing demands in the community. The neighbouring seven other mountainous states surrounding Assam have significant dependencies on the state across multiple fronts.

In a state of over 33 million population, over 70% people live in villages. With the cultural diversity among the people across the state, every single village presents its own opportunities and challenges which require appropriate consideration in the in the intervention process. While a particular community could be highly active in farming and cultivation of rice, wheat, sugarcane or organic tea, another community alongside could be efficient in nurturing production of raw materials for weaving potential for contributing to the cotton industry. While one community has access to the safe drinking water supplied by the government schemes, another community may be reliant on water from a nearby natural stream throughout the year. Considering the diversity and associated challenges and opportunities, approaches for capitalisation of localised resources and steps for uplifting the community need to be developed based on appropriate scientific principles.

Addressing these challenges for such remote communities, one of the overarching objectives of this research was to design and develop a rich and accurate data-driven platform for supporting policy making and strategy development with a bottom-up approach. The remainder of the paper will focus on the processes of collecting the data and devise of a smart-data platform as a proof-of-concept.

3.3 Approaches and Methods – Big Data Analytics

In order to address some of the immediate challenges, it was hypothesised that there must be a way to capture the non-linear demographic data on the community so that intervention planning could be effective. This will result in empowering the community and assist in improving the social bottom lines. Some of the key considerations in the smart community creation require:

- Adequate education and health services
- Adequate ICT connectivity: distance learning and world's knowledge base
- Modern health services and tele-medicine
- Capture more of the agricultural value chain
- Clean water and sanitation
- Socio-economic conditions and growths, affordability, food security
- Appropriate land use and environmental issues
- Provision for transport and energy services
- Self-wellbeing and sustained growth
- Creating smart communities with strong rural/urban linkages Building more resilient communities better able to respond to shocks
- Create new businesses through ICT connectivity, participate in governance processes
- Law and orders, safety, security, stability
- Streamlining of policies and consolidation of actions at local, regional and national levels

One of the emerging new areas of research and development is the Big Data Analytics where vast amount of information on the above issues can be captured and streamlined for supporting development of appropriate policies and intervention strategies focusing at a local level. Figure 1 below is a schematic diagram highlighting the types of data and their interlinks within the context of Big Data analytics. As seen, Big Data Analytics supports the data driven governance with pro-active community engagements. Taking into consideration of the emerging Big Data Analytics, a data platform was developed as a proof-of-concept. It was demonstrated that the data driven approach provides a clear pathway for taking up developing activities in Assam in a targeted community and move forward progressively.

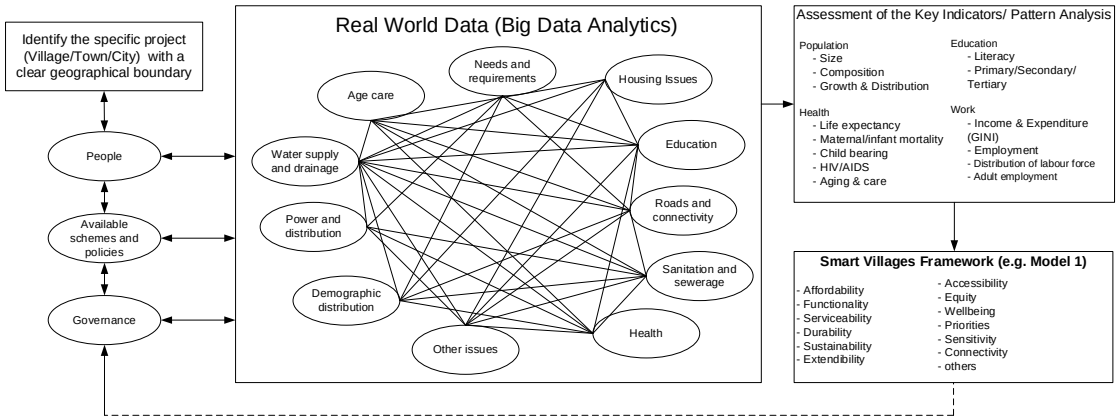

Figure 1: Schematic diagram highlighting the types of data and their interlinks

4 Fieldwork – an automated data collection system

One of the emerging new areas of research and development is the Big Data Analytics where vast amount of information on the above issues can be captured and streamlined for supporting development of appropriate policies and intervention strategies focusing at a local levels. In this project, comprehensive household level data was collected from over 2500 households spanning across 37 villages in the river island Majuli located about 300kms East of the capital city Guwahati in the State of Assam, India. Prior to collecting data, the comprehensive survey and the data collection processes were applied for necessary ethical consideration and clearance following the stipulated research ethics at the University of Melbourne. A custom-made App was designed and five local volunteers were trained to collect the data using the Tablets. The data were sent in real-time to cloud storage which were later accessed from the Smart Villages Lab (SVL) at the University for computing necessary analytics.

5 Smart Data Platform and Data Analytics

Big Data Analytics supports the data driven governance with pro-active community engagements. Taking into consideration of the emerging Big Data Analytics, a data platform was developed as a Proof-of-Concept (POC). The data platform integrated all the household level data including the Geo-referenced location of the houses within the geographical boundaries of the villages. This feature allowed conducting the data analytics at various levels of data abstractions such as household, village, cluster of villages, district or even state while accessing individual data collected from each household. Figure 2 shows the interface of the smart data platform with geo-referenced houses. Through this custom-built smart data platform, it was demonstrated that the data driven approach provides a clear pathway for taking up developing activities in Assam in a targeted community and move forward progressively.

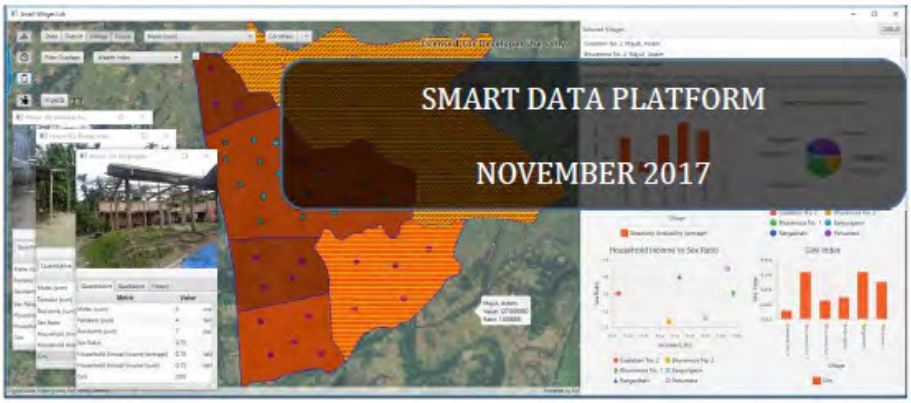

Figure 2: The interface of the smart data platform with geo-referenced houses

6 Future directions

Data Analytics initiatives taken in this project is due to the fact that empirical data acts as enablers in objective planning of the polices where the location specific data assists in devising specific planning solutions to a particular community within the society. The Smart Village concept lends itself to the idea of data driven policymaking where smart solutions are required for supporting smart community.

With a focus on housing and infrastructure sectors in the current research project, some of the fundamental questions include:

1. How can we support a selected community with an “affordable housing” program to uplift the living conditions generally?
2. How can we ensure that the upgraded community is resilient against the known disasters such as flood, earthquake etc.
3. How much affordability do they have in relation to their current conditions and what is a balanced situation for a sustained development?
4. What are the key means (such as earning avenues, industry growth) for a community to be self-dependent and increase the affordability?
5. What other basic amenities are required for the community for adequate functioning (such as road connectivity, internet connectivity, public transport, health care, food supply chain, education etc.)
6. What sort of interventions currently exists and how are they are impacting to make any change in the community at large?
7. What sort of policies / regulations is required for developing partnerships with local community, NGOs, private and public agencies including the government for the transformational process?
8. What sort of financial model(s) can be used to support building “affordable houses” in the selected community?

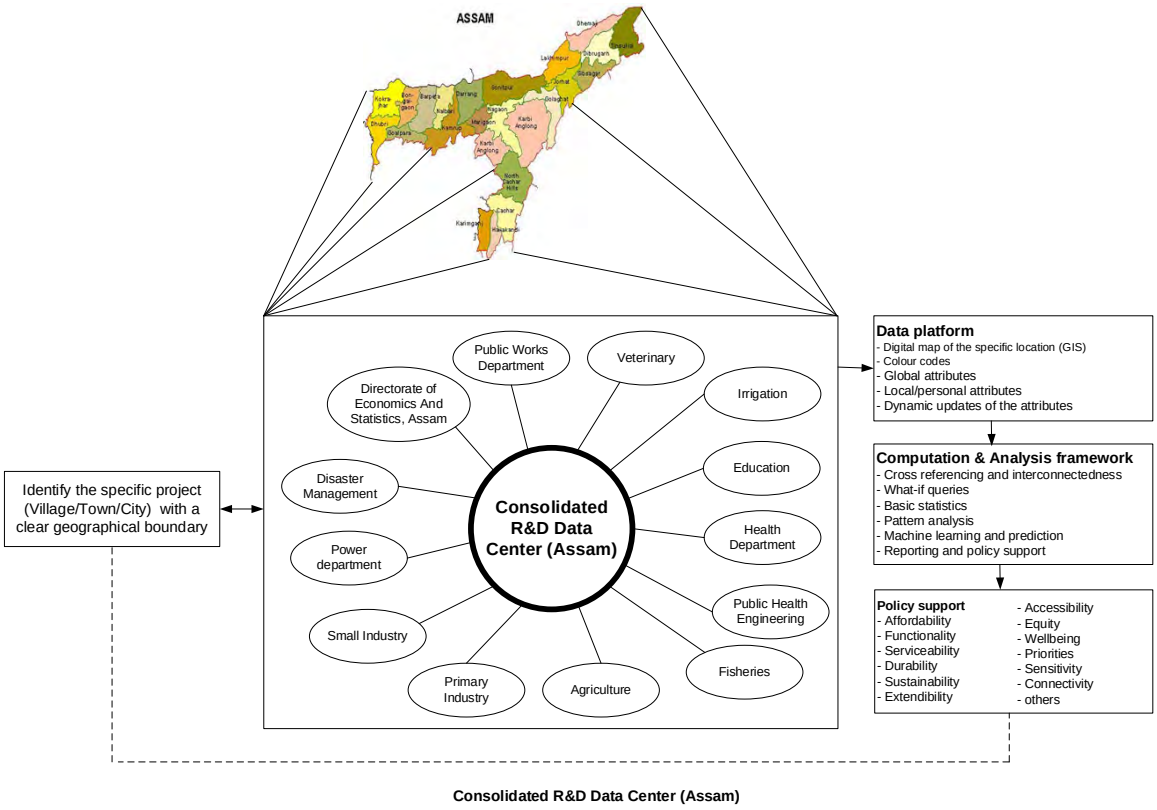

Figure 3: Consolidated data center for Research and Development

The research has started examining of some of the basic features of the selected community and their liveability in relation to paving a path for empowerment and sustainable growth. At the core of the research is the set of rich empirical data that reflect the community's demography, needs and requirement accurately. In order for a seamless policy support and effective use of scarce resources, a central data-repository needs to be established encompassing the entire jurisdiction in relation to the public funds. Figure 3 above shows a schematic diagram of consolidated data center for necessary Research and Development within the state of Assam.

7 Conclusions

In this research, a new data-driven approach has been put forward for supporting an alternative form of development targeting over 40% world's population living in rural. It has been contemplated that the traditional top down development model cantered around urban community cannot be used for upgrading rural communities effectively. Evidently, the plethora of urban-centric literature and top-down development approaches have not only failed to achieving the target of global poverty reduction but also ignored some of the key goals being set by the leading organization such as UN's Sustainable Development Goal (SDG) (Legros et al., 2011).

While rural development is one of the key priorities in many developing economics around the world, in the context of India, the effort is at multi-fold. Yet, some of the grand public schemes of the central government of India shows little sign of making a real difference

due to perhaps the over-reliance of the traditional top-down development models. In this research, taking into consideration of the context-specific needs and requirements of the local community, a data-driven development model has been established as a proof-of-concept. The relevance of this model is of high significance especially in the context of India where over 800,000 million rural population spanning across 700,000 villages are undergoing a massive transformation in order for meeting the national and global poverty reduction targets. The empirical evidence drawn from over 2500 household across 37 villages in one local area can be easily scaled up for creating a digital data-driven policy making and smart governance framework for upgrading the rural communities and establishing the smart villages with bottom-up location based planning and development.

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A REVIEW OF CONSTRUCTION ISSUES LEADING TO CONSTRUCTION PROJECT UNDERPERFORMANCE IN TANZANIA

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Abstract

As of 2021, the Tanzanian construction industry was the second largest contributor to the country's GDP. Recently, there has been increased investment in large-scale infrastructure projects as part of the government's drive to promote economic development and strengthen its position regionally. While the construction sector has registered strong growth in the past few years, many construction projects are plagued with issues across the project lifecycle that impede the attainment of set performance targets. The present study seeks to identify the significant issues through a review of the academic literature and official documents. To that end, literature review and documentary review are employed. A total of 19 issues leading to project underperformance were identified from the review of scientific literature. A further 53 issues were identified from the review of official technical audit reports. Significant issues that were identified included delays in payment, design errors, poor communication and coordination among the parties of the project, and design changes. It was revealed that a number of the issues could potentially be addressed by the adoption of BIM. However, barriers to BIM adoption have to be considered and industry experts consultation are needed to develop a structured BIM adoption framework that is tailored to the unique aspects of the Tanzanian construction industry.

Keywords: *infrastructure projects; construction industry; lifecycle; Tanzania; performance.*

1 Objectives

The present study aims to identify the major issues contributing to project underperformance in the Tanzania construction industry. Upon identifying the construction issues, the present paper proposes and maps various BIM applications for addressing the significant issues identified by past researchers.

2 Introduction

Tanzania is a fast-growing East African economy that occupies a strategic geographical location, serving as an access point to trade for surrounding land-locked countries (AFDB, 2009). Recently, the Tanzanian construction industry has been growing at a consistent rate. In 2019, the industry's contribution to the GDP was 14.2%. This growth has been largely driven by increased spending in infrastructure projects (MFP, 2021). In particular, starting from 2015, there has been a gradual transition away from building projects and towards infrastructure projects (OBG, 2018b). These projects have mainly been conducted by the public sector (OBG, 2018a; NCC, 2020). The significance of infrastructure projects to the development of the country has been underscored in the past by the National Construction Council (NCC) (MOW, 2003), which has stressed the need to prioritize the construction of new infrastructure and the rehabilitation of existing infrastructure for the rapid development of other economic sectors which rely on it. It is expected that the government will continue to invest in infrastructure projects in the future (MFP, 2021).

Despite its recognized significance, as outlined above, the Tanzanian construction industry has been underperforming. This is evidenced many challenges observed on the ground. In the first instance, the lack of competitiveness of local construction firms has been a long-standing challenge attributed to a multitude of sources (MFP, 2021). The consequence of this has been the disproportionate share of projects, where foreign construction firms, despite constituting a small proportion of the population, enjoy a larger share of the projects in terms of value. In addition, regardless of whether the project is conducted by local or foreign construction firms, a majority of the projects underperform by missing their completion dates, experiencing cost overruns, failing to meet quality standards, and failing to commence in a timely manner, among other issues. These underperforming projects can have far-reaching implications, adversely impacting the local community and the economy at large. This is especially critical for public sector projects in which any added expense for completing or maintaining substandard projects equates to funds that could otherwise be diverted to improve other sectors of the economy (Monko and Roider, 2014). Recognizing this, over the years, the government and its agencies have introduced numerous initiatives and programs to reverse this trend. However, recent research indicates that local construction industry continues to struggle (Tesha *et al.*, 2017; Luvara *et al.*, 2018).

The present study aims to identify key issues faced by the Tanzanian construction industry as reported by the scientific literature. In addition, the present study reviews official documents to identify contextual-based issues in five large-scale infrastructure

projects. The identification of these issues will facilitate in the formulation of remedial measures. Further, the identification of these issues will be useful to other developing countries which share a similar structure to that of the Tanzanian construction industry, such as Ghana whereby the government is the principal client and the construction industry is dominated by foreign contractors (KOG, 2017).

3 Overview of the Tanzanian construction industry

In 2021, Tanzania was ranked 10th in terms of GDP, with a GDP of $70.28 billion (Statista, 2021). Over the past decade, Tanzania has maintained its growth trend, registering an annual GPD growth rate of between 6 to 7 percent. This strong growth rate has allowed the country to attain lower middle-income status ahead of the original timeframe set by the Ministry of Finance in its Vision 2025 (MFP, 2021). Furthermore, according to a market report published by (FITCH, 2022b), the Tanzanian construction industry has been outperforming other Sub-Saharan African countries in terms of growth since 2015 as presented in Figure 1. One of the main drivers behind this growth has been the increased construction of large-scale infrastructure projects, most notably in the transport and energy sectors (Saadan, 2013; MFP, 2021). These projects are large in scale, some of which spanning borders such as the liquified natural gas pipeline and

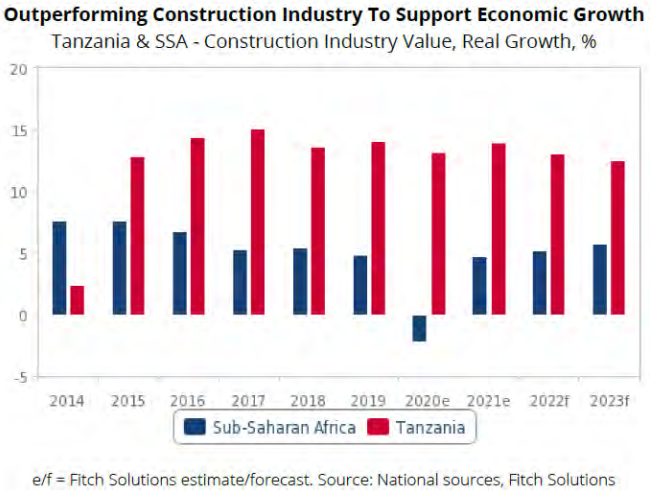

Figure 1: Tanzanian construction industry growth compared to sub-Saharan countries (FITCH, 2022b)

the SGR project (Deloitte, 2016; TCR, 2022).

4 Methodology

The present study conducts an in-depth review of the scientific literature and official documents to identify issues contributing to project underperformance in the Tanzanian construction industry. It is envisioned that the identification of these issues will assist in the development of mitigation strategies.

5 Literature review

This section is divided into two subsections. The first section presents a discussion and analysis of scientific literature investigating the Tanzanian construction industry. The

following section presents an analysis of technical auditing reports of large-scale infrastructure projects to give an overview of the contextual issues contributing to construction project underperformances in Tanzania.

5.1 Scientific literature

Scientific literature investigating the issues faced by the Tanzanian local construction industry have identified numerous issues across the project lifecycle phases leading to poor project performance. These underperformances have included budget and schedule overruns, poor quality, disputes, and project abandonment (Ntiyakunze, 2011; Valerian, 2014; Mpangule, 2016; Banobi and Jung, 2019). According to the literature, some of the issues faced by local contractors that have compromised the performance of projects include inadequate funds for obtaining resources necessary for the execution of construction (Chiragi, 2000), fierce competition owing to an overcrowded marketplace, insufficient capital (Kikwasi and Escalante, 2018), insufficient finance, lack of financial support, construction equipment shortages, skilled labor shortages, high expenditure of conducting business (Kikwasi and Escalante, 2020), and prolonged duration for obtaining construction permits (Kikwasi and Escalante, 2018).

The issues highlighted above are among the many underlying issues that have led to projects failing to meet their targets. Additional issues have been identified by researchers who have investigated the causes of project underperformance in the Tanzanian construction industry. For example, Ntiyakunze (2011) administered a pilot survey among 15 public building projects based in Dar es Salaam, executed between 1998 and 2003. It was found that all the projects were behind schedule, had exceeded their initial planned budget, and had failed to meet the standards of the clients. Issues leading to underperformance included “failure of the contractors to conform to specifications during tender action or construction stage or both”, “delays caused by parties to complete their assignments”, “delays in honouring contractor’s claims for additional payments”, and “increase in cost of project inputs beyond the anticipated levels”. Further, in looking at the causes of conflict between parties, it was found that poor communication among the members of the project, design errors, and differing site conditions were among the significant causes. Kikwasi (2012) found that “design changes” was the main cause of delays in Tanzanian-based construction projects. Other causes of delays included “delays in payment to contractors”, “information delays”, “funding problems”, “poor project management”, “compensation issues” and “disagreement on the valuation of work done”. Rwakarehe and Mfinanga (2014) investigated the causes of time and cost overruns in Tanzanian road construction projects. It was found that the reviewed projects were delayed by an average of 44% and experienced average cost escalations of 26%. It was concluded that inadequate design was the main cause of both the time and cost overrun. The study also found that the public client had insufficient capacity to conduct design review leading to design variations at the execution stage which ultimately led to time and cost overrun. Suleiman and Luvara (2016) investigated the factors leading to design changes and the impact they had on the execution stage of building projects based in the city of Dar es Salaam. For the factors related to the design consultant, it was found that, among several issues,

"unclear and inadequate details in drawings", "underestimation of the cost of the project", and "structural detail does not match architectural detail" were the key causes of design changes. Simon (2017) studied the cause of delay in road construction projects in Tanzania. It was noted that most of the projects were not completed within the original schedule. Five major causes of delay were identified, including disruption due to changes in political administration, poor contract management, inadequate design, poor communication between parties, shortages in resources, and contract relations. Simaya and Maro (2018) investigated the performance of building construction projects implemented by local government authorities (LGA) in five consecutive fiscal years. Data was collected through document review of audit reports and interviews with heads of procurement units of various regions. The study found that the projects underperformed with respect to time, cost, and quality. A range of issues were identified, including inadequate BOQs, insufficient progress reports, and lack of approvals from Tender Boards, poor management, late payments, and absence of skilled contractors. Luvara *et al.* (2018) investigated the causes of time and cost overrun in public building projects in Dar es Salaam. A questionnaire survey was randomly administered to various stakeholders, including clients, contractors, and consultants. The causes were ranked based on frequency and severity index. Among the five most significant causes were "incomplete design and estimate at the time of tender", "design change during construction", "design errors", and "omission in both drawings and in the bill of quantity", "delay of material delivery", and "poor site management". Shawa *et al.* (2018) looked at sources of conflicts between consultants and engineers. Overall, six categories of conflicts were identified. These include conflicts related to task, process, relationship, cognitive, contractual, and procedural. The most significant category of conflict was found to be the task conflict. With respect to this conflict, it was found that the most significant causes giving rise to this conflict were "inadequate information for preparation of bills of quantities (BOQ)", "failure to respond in timely manner", "delay in preparation of drawings", and "delay in approval of drawings". The authors recommended improvement in communication and coordination as an effective means of addressing conflicts within design teams (consisting of architects, quantity surveyors, and engineers). Banobi and Jung (2019) observed that more than 80% of power construction projects have experienced an average of 6 months delays. It was found that the major causes of delay were "poor cost estimation", "vandalism", "late delivery of material and equipment", "late procurement orders for material and equipment", and "additional work attributable to errors". Ndunguru *et al.* (2020) reviewed 190 Tanzanian-based projects for the cause of time and cost overruns. In studying the causes of time delays, the most significant causes were found to be "lack of proper communication and coordination between parties", "frequent design changes", "inadequate production of raw material", "cash flow and financial difficulties faced by contractors", "late in certification and payment of completed work", "technical incompetence and poor organization structure" and "additional works/change orders by the client". On the other hand, in looking at the cause of cost overrun "frequent design changes" was found to be the key contributor. Jongo *et al.* (2019) looked at causes and effective mitigation strategies of time and cost overruns in public building projects conducted in Dar es Salaam, Tanzania. The five most effective strategies in descending

order of significance were found to be “effective project planning and scheduling”, “design change should be controlled”, “effective coordination and communication between parties”, “promptly paying the parties progressively”, and “having accurate cost estimates”.

Table 1 summarizes the ten scientific papers that were reviewed in this study. The papers were published between 2011 and 2019. The works mainly adopted questionnaire survey as a data collection instrument to solicit the opinions of industry experts on issues impacting the performance of projects in terms of cost, time, and conflicts. However, some of the reviewed research works adopted qualitative approaches to identify the causes of construction performance, including interviews, case studies, and documentary review. However, these were applied to a limited extent. In terms of project type, some of the research works covered specific projects (such as public buildings, roads, and power generation projects), while others were more general in scope. Analysis of the findings of these research works reveals key issues leading to construction project underperformance in the Tanzanian construction industry. The most significant issues reported by these studies include delays in payment, design errors, poor communication and coordination between the project stakeholders, and design changes. A summary of these issues is presented in Table 2.

Table 1: Summary of 10 scientific papers reviewed in the present study

	Reference	Data collection method	Data analysis method	Project type	Performance indictor	Findings
1	Ntiyakunze (2011)	Questionnaire Case study	Ranking analysis Cross case analysis	Building	Conflict	Revealed two forms of conflict, including contract- and role-related factors. A framework was developed to reduce the emergence of conflicts in building-related projects.
2	Kikwasi (2012)	Questionnaire Interview	Ranking analysis	General	Time	Revealed numerous key causes of delays and disruptions, including changes in design, late payments to contractors, late issuance of information, issues related to funding, inadequate project management, and differences in the valuation of completed work.
3	Rwakarehe and Mfinanga (2014)	Documentary review Questionnaire survey Roundtable discussion	Project analysis	Road	Time and cost	Revealed that time and cost overruns were mainly due to issues originating from the design stage. Further, the study found that design review was either poorly conducted or not conducted and that the agency under review lacked manpower to conduct design review.
4	Simon (2017)	Questionnaire	Ranking analysis	Road	Time	Revealed that political interference was the main contributor to delay.
5	Simaya and Maro (2018)	Document review Interview	Ranking analysis	Building	Time and quality	Revealed underperformance of projects with respect to time, cost, and quality, owing to a number of issues. These issues included inadequate BOQs, insufficient progress reports, and lack of tender document approvals, poor management, late payments, and absence of qualified contractors.
6	Luvara et al. (2018)	Questionnaire	Ranking analysis	Public building	Time and cost	Revealed that time and cost overrun were due to issues originating from the design, tendering, and construction phase. In particular, the issues included the lack of complete design and estimate when tendering phase had commenced, changes in design at the construction phase, design errors, missing items in drawings and BOQ,

						late delivery of material, and inadequacy in site management.
7	Shawa et al. (2018)	Questionnaire	Ranking analysis	Building	Conflict	Revealed several causes of conflicts, including late payment, alterations to the scope and specifications, late issuance of requested information, insufficient communication, and a lack of team spirit among members.
8	Ndunguru et al. (2020)	Questionnaire	Ranking analysis	General	Time and cost	Revealed a range of issues contributing to time and cost overruns. These included poor communication and coordination, excessive design changes, shortages of raw material, financial challenges experienced by contractors, delayed issuance of certification of completion, delayed payment, inadequate technical capacity, poor organizational structure, and scope creep originating from the client.
9	Jongo et al. (2019)	Questionnaire Interview	Ranking analysis	Public building	Time and cost	Revealed several mitigation measures for addressing time and cost overrun of projects. These measures imply issues in the effective planning and scheduling of projects, management of design changes, effective coordination and communication, timely payment of parties, and development of accurate cost estimates.
10	Banobi and Jung (2019)	Questionnaire	Rank analysis	Power	Time	Revealed key contributors of delay to be inadequate cost estimation, vandalism, late procurement and delayed delivery of material and equipment, and extra work due to errors.

Table 2: Summary of significant issues leading to underperformance of projects in the Tanzanian construction industry

SN	Issues	Stakeholder	1	2	3	4	5	6	7	8	9	10	F
1	Unclear scope of work	Owner			×				×				2
2	Delays in payment	Owner	×	×			×		×		×		5
3	Delay in approval of drawings	Owner							×				1
4	Inadequate design documents	Consultant	×		×	×	×	×	×				6
5	Inadequate information for preparation of bills of quantities (BOQ)	Consultant			×				×				2
6	Delay in preparation of design documents	Consultant						×	×				2
7	Insufficient progress reports	Contractor					×						1
8	Vandalism	Contractor										×	1
9	Political interference	Government				×							1
10	Poor communication and coordination among the members/parties of the project	All	×			×				×	×		4
11	Design changes	Owner/Consultant		×				×		×	×		4
12	Information delay	Owner/Consultant		×					×				2
13	Financial problems	Owner/Contractor		×						×			2
14	Shortages in resources	Owner/Contractor				×		×				×	3
15	Poor cost estimation	Consultant/Contractor/Engineer									×	×	2
16	Additional work attributable to errors	Consultant/Contractor										×	1
17	Limited sources of material in market	Market								×			1
18	Lack of qualified contractors	Market					×						1
19	Inadequate planning and scheduling	Contractor										×	1

Note: 1= Ntiyakunze (2011); 2 = Kikwasi (2012); 3 = Rwakarehe and Mfinanga (2014); 4 = Simon (2017); 5 = Simaya and Maro (2018); 6 = Luvara et al. (2018); 7 = Shawa et al. (2018); 8 = Ndunguru et al. (2020); 9 = Jongo et al. (2019); 10 = Banobi and Jung (2019); F = Frequency

5.2 Status of BIM in the Tanzanian context

Research on BIM adoption and application in the Tanzanian construction industry has been limited. Overall, four studies have reported on BIM in Tanzania. The earliest study in this area was conducted by Monko and Roider (2014) who investigated BIM adoption status among architects, engineers, contractors, and quantity surveyors. It was found that a large segment of the construction professionals (above 81%) practicing in Tanzania were of the opinion that advanced technology was needed in the industry. Furthermore, with respect to attitude towards BIM adoption at their respective companies, a majority (69.9%) of the respondents expressed their interest in exploring the potential value of BIM. However, a majority (58.4%) of the professionals indicated that lack of BIM capability in their respective companies had minimum impact on whether their companies were awarded new projects, reflecting a lack of demand for BIM. With respect to the barriers to BIM adoption, inadequate training, limited time to evaluate technology, and absence of BIM adoption drive by the clients were significant. When asked about the type of BIM software adopted in their respective companies, it was revealed that only a limited number of companies used BIM software, with some respondents indicating that they used BIM at a personal level. Most of the respondents anticipated that BIM will be more significant in the next five years (from 2014). Mpangule (2016) looked at BIM adoption in the preparation of BOQ. The study demonstrated that BIM can be employed to improve the productivity of preparing BOQ but the rate of BIM application in the preparation of BOQ was low. The study further finds that the BIM related software were limited and were mainly used by architects. Senkondo (2018) elicited the views of Tanzanian consultants (architects, quantity surveyors, engineers, and project managers) with respect to their perception of BIM adoption barriers and implementation strategies. The most significant barriers were found to be “social and habitual resistance to change”, “legal and contractual constraints”, “high cost of training”, “lack of enabling environment (government policies and legislations)”, and “lack of trained professionals to handle the tools”. On the other hand, the top strategies were found to be “availability of trained professionals to handle the tools”, “BIM software availability and affordability”, “enabling environment”, “clients’ interest in the use of BIM in their projects”, and “awareness of the technology among industry stakeholders”. Makenya and Ally (2018) investigated how BIM could be adopted by quantity surveying professionals based in Tanzania. The organizations participating in the study indicated time constraints as an obstacle preventing them from dedicating time to learn BIM tools. Government support was considered to be strong driver to BIM adoption. It was concluded that quantity surveyors had limited knowledge of BIM which acted as an impediment to the application of BIM in the profession.

The above studies indicate that the level of BIM maturity in Tanzania is low with low level of awareness and several BIM adoption barriers related to social, institutional, and economic aspects. However, despite the barriers, the studies report a level of interest by professionals to adopt BIM.

5.3 Documentary review of case study projects

There are numerous ongoing and completed large-scale infrastructure projects in Tanzania (Rwelamila and Abdul-Aziz, 2020). As noted by Patanakul *et al.* (2016), the analysis of project performance report prepared by the government agencies / public institutions offers valuable insights on the status of public projects. Accordingly, to provide insights into the development, performance, and contextual-based issues that arise in large-scale infrastructure projects conducted in Tanzania, this section provides an analysis of five projects derived from the performance audit reports published by the National Audit Office of Tanzania. Some of the characteristics of these large-scale projects include:

- Based on the scale, major infrastructure construction projects can comprise several phases. These phases will have their own separate contracts and, in some cases, require the involvement of various consultants and contractors, local or foreign, based on the type of construction works to be undertaken. For example, some projects might have road and building works component which have to be conducted by contractors specialized in these distinct project types. Projects may therefore progress through a series of tendering stages associated with each phase. An example of a large-scale project with numerous stakeholders is the Dar es Salaam - Chalinze (Bagamoyo) Expressway Project, which at the time of writing was suspended. This project involved at least 17 stakeholders, including ten consultant/project managers, four financiers, and three sponsors. To add to the complexity, some of these entities were foreign organizations (FITCH, 2022a).
- Large-scale projects might be financed, administered, and conducted by foreign agencies (Mansfield and Sasillo, 1990).
- In some projects, foreign construction firms might be responsible for undertaking various aspects of the projects, including feasibility studies, design, and the supervision of the projects (Mansfield and Sasillo, 1990).

1. Bus Rapid Transit (BRT) project: The BRT is a mass public transportation system. The system is comprised of dedicated lanes, large buses, and large stations. The BRT project consists of a total of six phases. The first phase which involved the construction of infrastructure was funded by the World Bank and the Tanzanian government and has been completed (AfDB, 2015). The project reviewed in this paper was the second phase of the project which was comprised of two parts (Lot 1 and Lot 2). The agencies responsible for overseeing the project are DART and TANSROAD. Due to the large-scale nature of the project, close communication and coordination with other entities was paramount to the successful delivery of the project. The participating stakeholders include Ministry of Lands and Human Settlement Development, consultants, contractors, utility bodies, regulatory bodies, and financiers (NAO, 2021b). Figure 2 depicts the interaction of the various entities described above in the realization of the project.

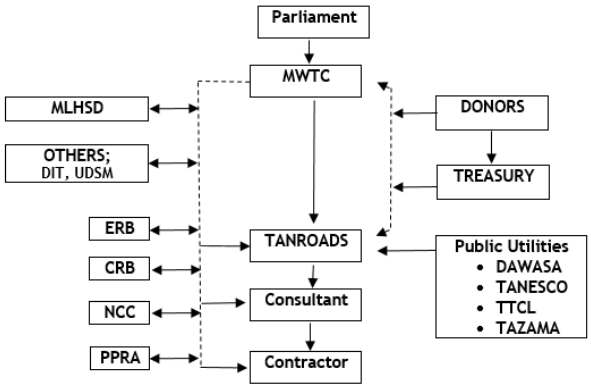

Figure 2: Interaction between various entities in the construction the BRT phase 2 (NAO, 2021b)

2. Standard Gauge Rail (SGR) project: The SGR is a 2,561 km railway system that aims to link different regions within the country as well as link the country to neighboring countries such as Rwanda, Burundi, and DRC. The railway is designed to run on electricity (TCR, 2022). The SGR project consists of five phases, the first two of which were awarded to two different foreign contractors. The project is implemented by the Tanzanian Railway Corporation (TRC). As with the BRT project, the SGR project includes a resettlement program since the land in which the project will be executed (e.g., areas needed for camps, laydown areas, as well as other activities) traverses occupied land.

3. Julius Nyerere Hydro-Power Project (JNHPP): The Julius Nyerere Hydro-Power Project (JNHPP) situated along the Rufiji River, with a contract price of $ 2.9 billion, aims to provide affordable power, facilitate flood control, and provide water supply. The client of the

project is Tanzania Electric Supply Company (TANESCO). The project has been contracted to a joint venture of two foreign contractors. The project is financed by the Government of Tanzania. In the course of its construction the project has experienced numerous issues which has placed it at a risk of underperforming

4. Same-Mwanga and Korogwe Water Supply Project: The Same-Mwanga and Korogwe Water Supply project, with a total contract price of $112.69 million, was divided into four contracts. Two of these contracts were undertaken by local contractors, one contract was undertaken by a foreign contractor, while one contract had yet to be awarded due to budgetary issues. The project was jointly financed by the Government of Tanzania and other foreign financiers. The implementation of the project began in 2013/2014 with a design review by the Ministry of Water. This project failed to meet its planned schedule owing to various issues.

5. Widening of the Morogoro road: The widening of the Morogoro road is a project implemented by TANSROAD. The project has been contracted to one consultant and contractor and is financed by the Government of Tanzania. The aim of this project is to minimize travel between the regions of KIMARA and KIBAHA. As with the previous projects, this project also experienced issues across its life cycle which led to its underperformance.

The above projects and a brief summary of their respective issues leading to underperformance is summarized in

Table 2. It can be seen that regardless of the project cost, type, and procurement method, most of the projects underperform. Potential BIM applications to address the identified issues are proposed. Table 4 provides a summary of the various issues faced by the projects across the lifecycle phases.

Table 3: Summary of case study projects

SN	Project	Cost ($ million)	Client	Procurement	Underperform	Description of experienced issues	BIM applications
1	BRT	159.39	TANROADS DART	Design bid build	Yes	- Experienced delay in design and procurement phases - Design delayed by four years due to design changes requested by client (DART) and delayed payment - Design changes	- Generation of interconnected drawings - Digital design review session
2	JNHPP	2,900	TANESCO	Design build	Ongoing	- Design change - Design specifications not meeting client's requirements	- Generation of interconnected drawings - Digital design review session
3	Widening of the Morogoro road	60.2	TANROAD	Design bid build	Yes	- Cost of items underestimated in BOQ - Design specifications not meeting client's requirements (material not in compliance with client's requirement) - Design deficiency (overlooked key design element)	- Quantity takeoff and cost estimation - Digital design review session
4	Same-Mwanga and Korogwe Water Supply Project	112.69	MOW	-	Yes	- Cost overestimation in BOQ - Pricing of duplicate items in BOQ - Inconsistency in tender documents - Design changes	- Digital design review session - Quantity takeoff and cost estimation - Generation of interconnected drawings
5	SGR	3,800	TRC	Design build	Yes	- Design deficiency - Design complexity - Lack of coordination with other ongoing projects	- Generation of interconnected drawings - Digital design review session - 3D coordination - Clash detection report

6 Discussion

The issues faced by the reviewed case studies of large-scale infrastructure projects are diverse and wide ranging. Most of these issues, as summarized in Table 4, stem from the client and arise at the various lifecycle phases of the project, from the inception, through planning and design, procurement, up to the construction stage. These issues have a high likelihood of even impacting the operation and maintenance stage of the project. While BIM will require relevant policies, guidelines, and standards before its proper adoption, tentative assessment indicates that some of the identified issues lend themselves to BIM applications. For example, BIM can limit the disruption caused by client-initiated design changes, since any alteration made to a drawing will be reflected across other associated drawing(s) (such as sections and elevations). Other identified issues that can potentially be addressed by the proper implementation of BIM include “design defects”, “design complexity”, “specified material not in compliance with employer’s requirement”, “underestimating cost of key items in BOQ”, “pricing of duplicate items in BOQ”, “pricing of unnecessary items included in the BOQ”. BIM allows for the three-dimensional visualization of projects, thereby assisting the designer in better conveying the final design intent to the client for their approval, potentially avoiding unnecessary changes down the road. The client who may not be competent in interpreting 2D drawings can see the 3D model of the project and walk through the project to ensure their requirements have been met. BIM also aids in the coordination of the various design components. In terms of coordination, one of the major issues observed in the case study projects was the lack of coordination between government entities which adversely impacted the progress of the project (NAO, 2021a). The employment of a federated model which is comprised of different models from various stakeholders could have potentially mitigated this issue (Eastman, 2011). Furthermore, clash detection (both soft and hard) helps in the identification of design defects before they reach the execution stage, where the deployment of any corrective measure becomes a costly and time-consuming proposition. The issues related to BOQ (such as overestimation, underestimation, and the pricing of duplicate items) can also be addressed through the application of BIM. In particular, BIM allows for the automatic quantification of design elements, such as the quantity of components and materials, and the area and volume of various spaces. All these can be presented in tabular formats. In addition to this quantification, BIM can also price items by linking the quantities generated from BIM with a cost database (Makenya and Ally, 2018). BIM also allows a designer to explore various design alternatives to make more informed decisions. As a designer applies modifications to designs, the BIM automatically updates the model and computes the corresponding cost allowing for quick and easy comparisons of the alternatives (Eastman, 2011). This feature would be particularly useful in avoiding the overdesigning and thus overpricing of work. The above indicates the potential of BIM implementation in the Tanzanian construction industry to address many of its pressing issues. However, an unstructured approach to its implementation could lead to unintended and counterproductive implications. Therefore, it is essential to formulate a BIM

implementation framework tailored to the distinctive nature of the Tanzanian construction industry.

Table 4: Summary of issues faced across various lifecycle phases of case study projects in Tanzania

	Planning	Design	Procurement	Construction
Consultant	- Failing to develop detailed master plan	- Design defects - Design omission - Design complexity leading to delays - Specified material not in compliance with employer's requirement - Overdesign leading to overpricing of construction work		- Design changes - Late submission of progress report
Engineer				- Delay in submitting certified IPC leading to delayed payment
Financier				- Lengthy approval process for payment - Delay in disbursement of funds
Client	- Failing to conduct feasibility study - Failing to coordinate with other entities - Inadequate allocation of time for conducting feasibility study - Delay in upgrading access roads to the project - Lack of information related to the budget - Inadequate allocation of time for conducting environmental impact assessment	- Design changes at design stage - Contract documents prepared following foreign standards	- Violating procurement regulations - Violating employment regulations - Submitting incomplete tender documents - Omitting tender evaluation criteria - Underestimating cost of key items in BOQ - Pricing of duplicate items in BOQ - Pricing of unnecessary items included in the BOQ (e.g., security bond) - Payment of unspecified item - Overpricing of items in BOQ - Inadequate responses to bidders' queries and clarifications - Understatement of liquidated damage - Commencement of project while tendering process is ongoing	- Design changes at construction stage - Late payment of contractors - Late payment of consultants - Inadequate site supervision - Payment without evaluation of completed work - Granting excessive time extensions - Failure to keep track of environmental performance of project - Failure to follow loan requirements set out by financier - Payment of salaries in excess of original approved amount - Inadequate monitoring of environmental pollution - Using incorrect currency exchange rates - Late responses to claims raised by contractor
Contractor				- Slow progress of work - Delay in commencement of project - Failure to prepare schedule recovery plan - Delay in mobilizing key equipment - Negligence in the disposal of waste - Damage to community - Inadequate restoration of area impacted by construction - Violating local employment regulations - Labor shortages - Constructed work not adhering to design

External				Unfavorable weather conditions

7 Conclusion and recommendations

The realization of a successful construction project can be achieved through the identification and mitigation of issues contributing to its underperformance. The present study reviewed ten past research works to identify significant issues. The dearth of work in this area suggests that this research domain is still at its early stages. A review of the reported significant issues revealed that these issues included delays in payment, design errors, poor communication and coordination among the parties of the project, and design changes. Moreover, the review of five case study projects illustrated that many of the major infrastructure projects suffered from underperformance owing to numerous issues. BIM represents a technological intervention that can potentially address some of the identified issues. However, before such an intervention can be adopted, a detailed appraisal of the industry with respect to the various issues and the root issues across the project lifecycle is needed. In addition, an evaluation of the BIM capability of the industry is required to determine the extent to which BIM can mitigate the issues.

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Traditional Boats Incorporated in Indonesian Inter-island Freight Transport System

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Abstract: *As an archipelago of around 6,000 inhabited islands, safe and reliable inter-island sea transport becomes a critical factor affecting all aspects of development. However, most inhabited islands are small, rural and remote; and sea transportation is mostly informal traditional boats, beyond monitoring and control of the government. This paper uses the case study of Anambas Islands District in Riau Islands Province, Indonesia – one of the most remote small island districts in the archipelago. Only recently has the government acknowledged the importance of supporting traditional sea transport through President Regulation No.74/2021, but this is yet to be implemented. This paper firstly examines existing conditions of inter-island freight system in Anambas Islands, including a qualitative elaboration of challenges and a breakdown of the supply chain cost structure. Following this, a concept is proposed to incorporate traditional boats into a formal orchestrated system in order to provide better standardization, support and create a collective system that makes inter-island transport safer, cheaper and more reliable for passengers and goods.*

Keywords: *Anambas Islands, small islands, traditional boats, inter-island freight*

1 Introduction

Small islands and archipelagos are unique geographies with attributes such as insularity, remoteness, small dispersed population, and limited natural resources (Buts & Nicolaides, 2017; Grydehøj, 2019; UNEP, 2014). Due to these conditions, they face several developmental challenges, namely accessibility challenges, high cost of public service, and prone to changes in weather and natural disasters (Liarakou et al., 2014; Unctad, 2019; United Nations & UNCTAD, 2014). In the spirit of developmental cohesion and inclusion, it has been generally agreed upon by scholars, policy makers and international developmental agencies that small island and archipelagic geographies are considered peripheral areas, having natural handicaps that need to be supported (CPMR, 2022; ESPON, 2013; Spilanis et al., 2013). And an interest towards island particularities within the larger context of peripheral regions has been long been shown by academic literature, for example in the studies of Japan's 'remote islands', the Faroes and the Alands in Europe's northern periphery (Baldacchino, 2020; Efimova & Kuznetsova, 2012; Kuwahara, 2012)

One of the most important aspect that require external support is the provision of safe, affordable, and reliable island transport systems for both passengers and goods (Finlay et al., 2003; Grydehøj & Casagrande, 2020; Widodo & Kurniawan, 2018). In developing countries, the issue of inter-island logistics can be even more critical, due to sub-standard boats or ships along with safety measures, and the lack of subsidies that can be allocated for island logistics. This paper provides valuable insight on challenges and possible solutions for inter-island logistics, using the case study of Anambas Islands, Indonesia. To some extent, lessons can also be generalised to other developing archipelagic countries, namely The Philippines, and Small Islands Developing States (SIDSs) in the Pacific and Atlantic Oceans, as well as archipelagic regions in continental developing countries.

As an archipelago country, Indonesia has long given subsidies and public service obligations for the transport of passengers to remote parts of the archipelago, but has only since 2021 explicitly made policies to support the logistics transport through the Presidential Act No. 27/2021 on The Provision of Public Service Obligation for Logistics to and from Underdeveloped, Remote, Peripheral and Border Regions. Interestingly, in the same year, another regulation provided legal basis for the standardisation of traditional boats regarding safety, tariffs, and operation through Presidential Act No.74/2021 on Empowerment of Community Sea Transport. These two regulations become the backdrop upon which this paper is made, by utilising traditional sea transport to support freight transport in small islands. Before elaborating the research methods and conceptualization of solutions, the following section provides insight from literatures.

1.1. Accessibility and insularity

Inadequate services in rural areas lowers liveability, which in turn increases the rate of depopulation and contributes to the downward spiral of degradation of rural areas (Halseth et al., 2018). Small islands have distinctive nature regarding spatial development, as the geographical discontinuity creates challenges in integrating socio-economic activities and public services (Fernandes & Pinho, 2017). In regards to transportation, small islands and archipelago regions face issues such as access to international shipping, cargo imbalances, and domestic inter-island transport which conflates the issues faced by rural

areas in general, hence islandness is seen as a unique handicap compared to other rural or peripheral regions (Davis & Michie, 2011; Narotama, 2021; UNCTAD, 2014).

Due to the close causal relation between island or archipelagic accessibility and connectivity with development, numerous academicians have attempted to formulate indicators reflecting the geographical features of islands relating with developmental implications. One of the earliest efforts to classify island geographies based on different aspects of insularity and remoteness is by Depraetere (2008). He proposed a so-called insularity index based on how small islands were clustered and their proximity to the mainland. Although not being directly connected with other developmental indices, it serves as a basic model to quantify and classify insularity and connectivity, as proximity to other islands and the mainland was presumed to have positive relation with the degree of connectivity and less insularity. Other efforts to quantify island accessibility can be seen, for example, in the work of (Castanho et al., 2020). Licio et al. (2013) focused more specifically on economic outcomes, by producing economic indicators based on insularity. These quantitative researches are strengthened by qualitative research on the implications of the lack of connectivity towards developmental progress and island inhabitant's well-being in general. See, for example, the work of Sunarti (2018) that observes how the lack of inter-island connectivity in Binggai effects the provision of service delivery and Grydehøj & Casagrande (2020) brings forward an example of how changing connectivity shifts centrality and peripherality of islands.

In the transition from traditional towards modern use of transport, the most common mode of inter-island transportation is traditional wooden boats with motor propellers, sometimes from reused car engines. In the Riau Islands, Indonesia, such boats are known as *pompong*. An example of a pompong is shown in Figure 1. The basic design for these boats is for fishing, but they are often converted to transport people and goods as needed. They are loosely regulated and have concerning safety issues, where it is recorded that in Indonesia, between 2018-2021 483 fishing boats (mostly informal and often used also for passengers) and 49 passenger vessels have been involved in accidents at sea (Darilaut.id, 2022; KNKT, 2022). Thus, the need to transition to a more reliable and safe mode of inter-island transport. Another issue for inter-island travel is weather; during the monsoon season, traditional wooden boats are vulnerable, hence delaying distribution of logistics.

Figure 1. Pompong, a traditional boat in the Riau Islands, Indonesia (Narotama, 2022)

1.2. Rural logistics in Small Islands

Transportation and logistics to and from rural areas in general are usually not financially feasible for the private sector, thus most services are either provided directly by the government or by private sector with subsidies from the government. Rural areas, including small islands in this context, are target areas of what is known as government Public Service Obligation (PSO). Examples of PSO mechanism where services are arranged directly by the government can be seen in the Pacific Island countries, where they have used contracting schemes to provide inter-island transport; private shipping operators are contracted to serve specific routes with predetermined service quality (UNCTAD, 2014). The results are mixed, where some issues include ensuring private partners to maintain quality of service and some routes were hardly used. There are many cases spatial mismatch of transport routes due to lack of research and the prominence of political decisions being the basis of which area to serve rather than reliable data (Makkonen et al., 2013). Previous studies have shown that it is best to begin with strengthening existing links by increasing frequency (Börjesson et al., 2020). Existing links, especially those that form gradually by traditional boats are strong indications of inter-island regionality, or what can be considered a functioning archipelago (Kearns & Collins, 2016; Pugh et al., 2013; Stratford, 2013). In rural areas, the most important connections may not always be valued on the basis of proximity towards a nearby regional city, but towards a major export market (Goodwin-Hawkins et al., 2019). Strengthening these linkages stimulates further socio-economic developments of the archipelago as an entirety.

In terms of the technical aspect, there have been various studies and best practices. Innovation has been developed for short distance shipping technology, trans-modal

transportation system, and supply chain infrastructure (Malindretos, 2018). A study in Hunan, China provides evidence of the positive effect of RFID technology use in rural logistics (Yuan & Chen, 2020). A study in Germany finds that companies movement towards digitalization has high impact of rural logistics operations (Bernecker et al., 2021). The trends in rural logistics innovation suggests a strong need for complementary infrastructure and services, namely internet connection. Besides assisting functions such as logistics, to some extent, online connection also decreases insularity and remoteness in a broader context of integration (Liarakou et al., 2014).

1.3. Rural inter-island logistics governance

Besides technological innovation, public service delivery for remote and rural areas also require innovation in terms of management and governance through a combination of pooling service deliveries, re-arrangement of public institutions, and cooperation between multiple sectors and actors (Chittoo, 2011; Devesi, 2018; ESPON, 2017; Ismail, 2019a; Kitchen & Slack, 2001; Osborne et al., 2015). Combining service delivery and volume of logistics has become best practice for rural areas. For example, postal services can also help distribute medical and schools supplies, election ballots, and become retail shops, and it is also common practice to combine transportation for passengers and goods (Bruzzone et al., 2021; Qasim Hussaini & Alexander, 2020). Coalition and cooperation among communities and businesses helps lower the cost of imports and exports, hence, cooperatives and pooling services are beneficial for rural logistics (Yang et al., 2020). For the purpose of pooling, proximity and existing inter-island network need to be prioritized over administrative borders and hierarchies (Ismail, 2019b). Japan is among the best examples of rural and small islands logistics; many rural co-ops have been established, subsidised inter-modal system is operational, with Japan Post as the main service provider for small scale rural logistics (ADB, 2017).

In order to make cooperation and coalition among various actors work for small island logistics, there are several imperative aspects that need to be acknowledged. Firstly, is that each member needs to feel equal benefit; this is especially true for bottom-up initiatives for pooling imports and exports among different communities, businesses and islands (Dornan & Cain, 2013). Secondly, institutional reform, including local governance adjustments need to be made to break down bureaucratic and administrative barriers often hindering local initiatives to improve public services in rural and peripheral areas (Devesi, 2018; Malindretos, 2018). Various studies have suggested the need to avoid simple transfer of sectoral and national policies to peripheral areas (Burnett & Danson, 2016). Systems where government trumps governance need to be avoided (Zirul et al., 2015), as conditions in peripheral areas are complex and requires flexible and innovative solutions focusing on delivering services. The definition of governance need to be taken at its core; to mediate, broker, facilitate, and coordinate different activities for the best interest of the people, with a careful balance between formal and informal governance mechanisms to achieve a desired outcome (Morrison, 2016; Vasstrøm & Normann, 2019). With many factors and actors involved in island logistics, this paper provides valuable insight of formal-informal intersection in the provision of logistics services in small islands.

2. Methods

This paper consists of mainly two parts, a survey of existing supply chain condition and a conceptualization to innovate inter-island supply chain. For the first part, purposive sampling is used to select which ports, consumer items, and retail price to observe and record. For main import avenues, ships coming in from Jakarta and Tanjungpinang (the province capital) as the main departure of imported goods were recorded at two main ports in the Anambas Islands – Letung Port located on Jemaja Island, and Tarempa Port in the district capital of Tarempa on Siantan Island. The main distribution route to Anambas Islands is shown in Figure 2, Three main consumer items were selected; rice, sugar, and eggs. The maximum retail price of all three items is regulated by the government, hence, they were selected to compare the real retail price to the determined price by the government in bulk items (rice and sugar) and more fragile items such as eggs. At the main ports, transport and unloading costs were recorded. Anambas islands comprises 54 villages spread across 26 inhabited islands (Anambas Islands administrative shown in Figure 3), however, due to the limitation of time and funding for this research, retail price was only recorded at ten sub-district centres, while retail prices at more remote islands were not recorded.

Figure 2. Main distribution route from Jakarta and Tanjungpinang to Anambas Islands

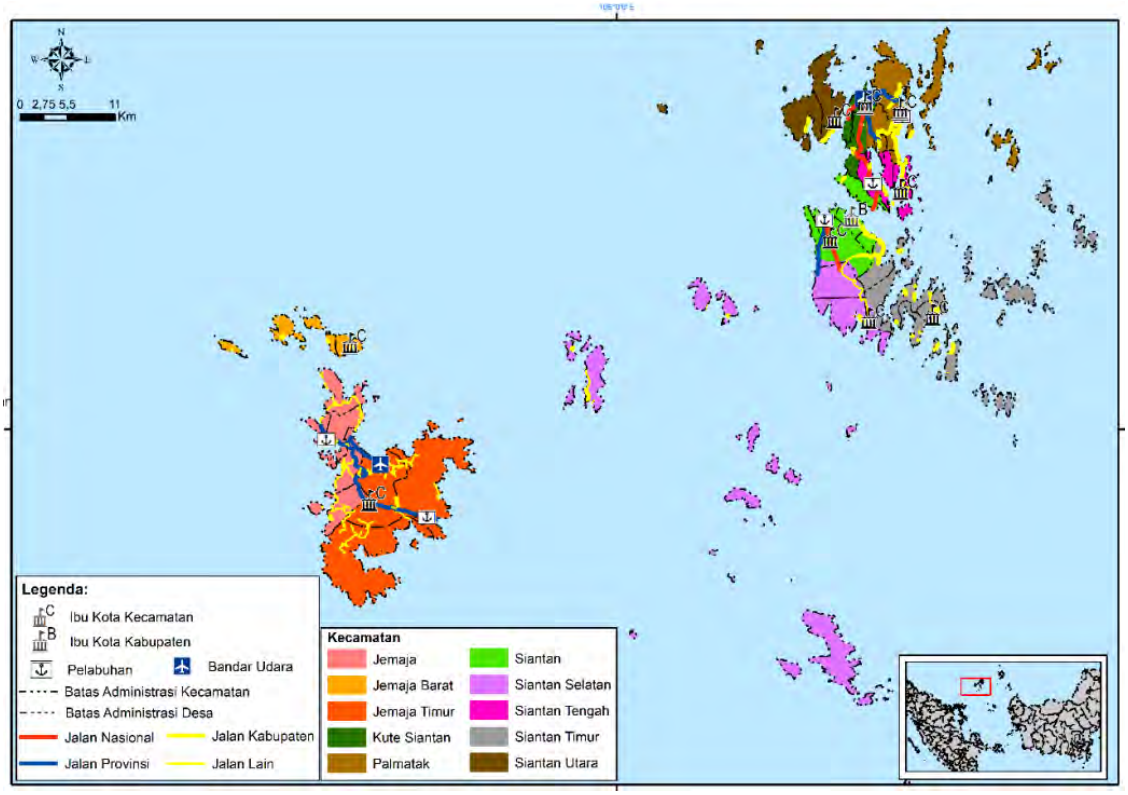

Figure 3. Anambas Islands administrative map

The second part of this paper relies upon literature review on best practices of rural supply chain, and a review of existing regulations and policies as a basis to conceptualize an inter-island supply chain incorporating traditional boats. A system design approach is used to illustrate the flows of processes.

3. Results and Discussions

3.1. Evaluating existing supply chain in Anambas Islands

The informal logistics distribution between islands is neither managed, monitored nor regulated. This does not mean the logistic system does not work; fieldwork observation has provided insight that despite the absence of government intervention in inter-island logistics, even the most rural islands have access to modern standards of daily needs, not only food, but also soap, shampoo, clothes, etc. However, there are several issues regarding inter-island supply chain in the Anambas Islands. The survey results conducted on the Anambas Islands Supply Chain is summarized as follow:

a. Operational issues in main ports

There are two main ports in the Anambas Islands, Letung Port on Jemaja Island and Tarempa Port on Siantan Island. In both ports, the general issues are that loading and unloading processes are done manually, there are no cranes or forklifts at the port. As most islanders rely on fishery for their livelihood, port labor is also limited. When the large

government cargo ship (Sea Tol) arrives from Jakarta, all the labors focus on unloading this ship, leaving other smaller private cargo ships unattended.

b. Inadequate infrastructure and access

Besides the challenges of inter-island transport, there are also issues of infrastructure within the islands. Transporting goods from the port to shops and consumers can also be challenging due to substandard road conditions. For example, Tarempa (as shown in Figure 4) is a port city that lies between the sea and a rocky mountain, forcing streets to become narrow and following the contour of the rocky terrain. Hence, only three wheelers and small pickups can be used to transport goods from the port. Other islands also have similar conditions, and some have additional challenges where the islands' port is far from the main settlement, increasing the cost of local transport.

Figure 4. Narrow roads in Tarempa city (Author's documentation, 2022)

c. Limited warehouse

For remote islands, warehouses are needed to secure important logistics such as food stocks, especially to anticipate times when ships and boats cannot operate due to bad weather. However, integrated warehousing is limited in the main ports, hence, goods offloaded from ships need to be immediately transported to the final destination. There is risk in transporting goods from the main port to other islands when the weather is bad, thus, warehousing on the main ports is critical.

d. Sparse island communities

Like many other archipelagos, a majority of the population of Anambas Islands lives on a few main islands while others are sparsely spread across the archipelago, where some

islands have less than 50 households. The most remote islands have the highest challenge, both physically and financially to acquire daily needs.

The diagram in Figure 5 below shows the existing inter-island supply chain. Coming close to the schedule of the cargo ship arrival, smaller boats surround the port. As soon as the ship arrives at the main ports, goods are unloaded directly to three-wheelers, pickups, and boats. Boats belong to or are hired by people from surrounding islands, in some cases, the goods have to be transferred to other boats for longer journeys. Upon arriving at other islands, in some cases, there needs to be additional costs for land transport if the island dock is far from the final destination, there may be additional constraints depending on road conditions.

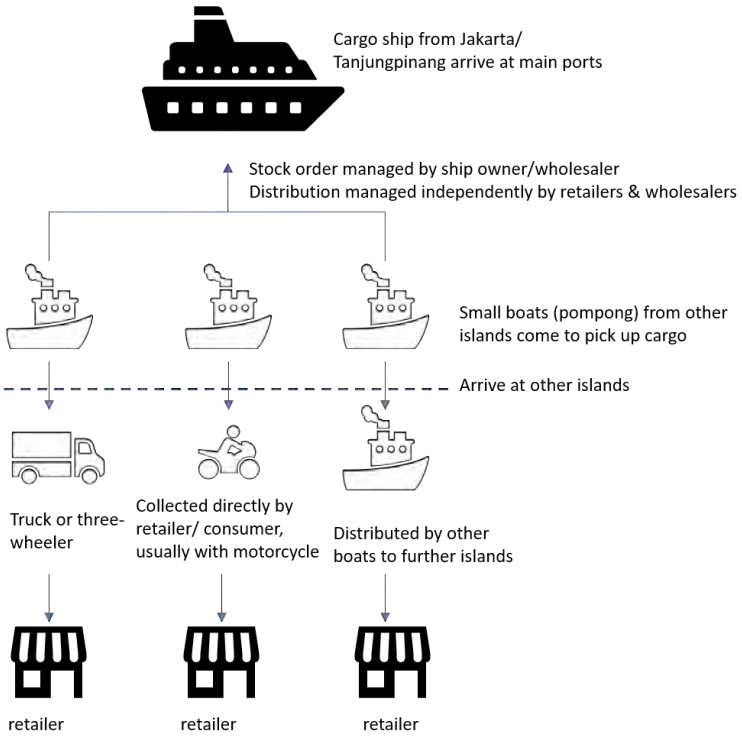

Figure 5. Existing inter-island supply chain

A survey was conducted to understand the supply chain cost structure from Jakarta and Tanjungpinang (the province capital) to the main ports of Tarempa and Letung, then to the surrounding sub-district centres. The survey observed three main consumer items; rice, sugar, and eggs, as shown in Table 1and Table 2 below. For goods transported from Jakarta via Letung Port, the local costs comprising loading-unloading and local transport contributes to 28-57% of the total distribution cost. Where the local transport has the highest deviation from 10-44%, the highest being Jemaja Timur. Local costs for goods transported from Jakarta via Tarempa Port contributes to 21-56%, where the highest local transport cost is recorded in Siantan Timur (43%). The highest local cost to Jemaja Timur is similar to Siantan Timur despite being land journey, in contrast to Siantan Timur which

is on another island. This proves that cost structure estimation cannot simply be based on inter-island/inner island transport, and needs more detailed survey.

Table 1. Distribution from Jakarta to Letung Port

Destination (Sub-district)	Commodity	Unit	Distribution Cost Component			
			Cargo ship Jakarta – Letung	Unloading	Local transport	Total
Jemaja	Rice/ sugar	Rp/kg	400	100	57	557
		%	72%	18%	10%	100%
Jemaja Barat	Rice/ sugar	Rp/kg	400	200	164	764
		%	52%	26%	21%	100%
Jemaja Timur	Rice/ sugar	Rp/kg	400	100	390	890
		%	45%	11%	44%	100%

Note: Eggs are not imported from Jakarta

Table 2. Distribution from Jakarta to Tarempa Port

Destination (Sub-district)	Commodity	Unit	Distribution Cost Component			
			Cargo ship Jakarta – Tarempa	Unloading	Local transport	Total
Siantan	Rice/ sugar	Rp/kg	400	60	48	508
		%	79%	12%	9%	100%
Siantan Selatan	Rice/ sugar	Rp/kg	400	120	254	774
		%	52%	16%	33%	100%
Siantan Timur	Rice/ sugar	Rp/kg	400	120	394	914
		%	44%	13%	43%	100%
Siantan Tengah	Rice/ sugar	Rp/kg	400	120	124	644
		%	62%	19%	19%	100%
Siantan Utara	Rice/ sugar	Rp/kg	400	120	119	639
		%	63%	19%	19%	100%
Kute Siantan	Rice/ sugar	Rp/kg	400	120	200	720
		%	56%	17%	28%	100%
Palmatak	Rice/ sugar	Rp/kg	400	120	212	732
		%	55%	16%	29%	100%

Note: Eggs are not imported from Jakarta

The range of local costs for goods coming in from Tanjungpinang is similar to that coming in from Jakarta. Table 3 and Table 4 below shows that local costs for goods coming in via Letung Port contribute to 35-55%, where local transport contributes to 11-49%. Whereas for goods coming via Tarempa Port, local costs range from 21-61%, where local transport contributes to 9-44%.

Table 3. Distribution from Tanjungpinang to Letung Port

Destination (Sub-district)	Commodity	Unit	Distribution Cost Component				
			Cargo ship Tj. Pinang – Letung	Unloading	Local Transport	Damage risk	Total
Jemaja	Rice/Sugar	Rp/kg	300	100	57	0	457
		%	66%	22%	12%	0%	100%
	Eggs	Rp/kg	600	300	114	13	1.027
		%	58%	29%	11%	1%	100%
Jemaja Barat	Rice/Sugar	Rp/kg	300	200	164	0	664
		%	45%	30%	25%	0%	100%
	Eggs	Rp/kg	600	600	328	13	1.541
		%	39%	39%	21%	1%	100%
Jemaja Timur	Rice/Sugar	Rp/kg	300	100	390	0	790
		%	38%	13%	49%	0%	100%
	Eggs	Rp/kg	600	300	780	13	1.693
		%	35%	18%	46%	1%	100%

Table 4. Distribution from Tanjungpinang to Tarempa Port

Destination (Sub-district)	Commodity	Unit	Distribution Cost Component				
			Cargo ship Tj. Pinang – Letung	Unloading	Local Transport	Damage Risk	Total
Kec. Siantan	Rice/Sugar	Rp/kg	400	60	48	0	508
		%	79%	12%	9%	0%	100%
	Eggs	Rp/kg	700	150	96	13	959
		%	73%	16%	10%	1%	100%
Kec. Siantan Selatan	Rice/Sugar	Rp/kg	400	120	164	0	684
		%	58%	18%	24%	0%	100%
	Eggs	Rp/kg	700	300	328	13	1.341
		%	52%	22%	24%	1%	100%
Kec. Siantan Timur	Rice/Sugar	Rp/kg	400	120	390	0	910
		%	44%	13%	43%	0%	100%
	Eggs	Rp/kg	700	300	780	13	1.793
		%	39%	17%	44%	1%	100%
Kec. Siantan Tengah	Rice/Sugar	Rp/kg	400	120	57	0	577
		%	69%	21%	10%	0%	100%
	Eggs	Rp/kg	700	300	114	13	1.127
		%	62%	27%	10%	1%	100%
Kec. Siantan Utara	Rice/Sugar	Rp/kg	400	120	164	0	684
		%	58%	18%	24%	0%	100%
	Eggs	Rp/kg	700	300	328	13	1.341
		%	52%	22%	24%	1%	100%

Kec. Kute Siantan	Rice/Sugar	Rp/kg	400	120	390	0	910
		%	44%	13%	43%	0%	100%
	Eggs	Rp/kg	700	300	780	13	1.793
		%	39%	17%	44%	1%	100%
Kec. Palmatak	Rice/Sugar	Rp/kg	400	120	390	0	910
		%	44%	13%	43%	0%	100%
	Eggs	Rp/kg	700	300	780	13	1.793
		%	39%	17%	44%	1%	100%

The supply chain cost structure depends on many variables, besides distance between islands, facilities and labor for loading/unloading at the port is crucial. Letung Port has a relatively higher unloading cost than Tarempa Port due to the lack of facilities and labor. Another important factor is road infrastructure from an island's port to the final destination. Different type of boats and ownership status (privately owned or rented), and adds to variation of inter-island supply chain. Due to the limitation of this research, data was not collected on all inhabited islands, therefore the findings above serve to provide insight on the general supply chain process in Anambas Islands.

3.2. Innovation in inter-island supply chain: Enhancing existing networks, empowering traditional boats

The purpose of conceptualizing a new inter-island supply chain is to provide better logistics service that is cheaper, safer, and more reliable. Two main considerations are pivotal. Firstly, as the literatures suggests, strengthening existing networks would work best for rural areas, including small islands. These existing networks use traditional boats, hence the continuation of incorporating traditional boats in the supply chain is required. Secondly, in order to receive subsidies from the central and local government, there needs to be a formal institution responsible for managing the supply chain in small islands, hence the need for centralized management to orchestrate logistics that also provides the opportunity for better consolidation and distribution, enhancing efficiency. Based on these considerations, the following concept is proposed in order to innovate inter-island supply chain.

From the main ports of Anambas Islands, shorter inter-island trips will be subsidized by the government and managed through a concerted distribution system supported by traditional boats and land transport provided by the local private sector. Contracts are made to provide transportation service from the main port to final destinations with a number of designated routes, be it by boat or boat-land. An illustration of the logistics process can be seen in Figure 6 below, this concept is further elaborated on each aspect.

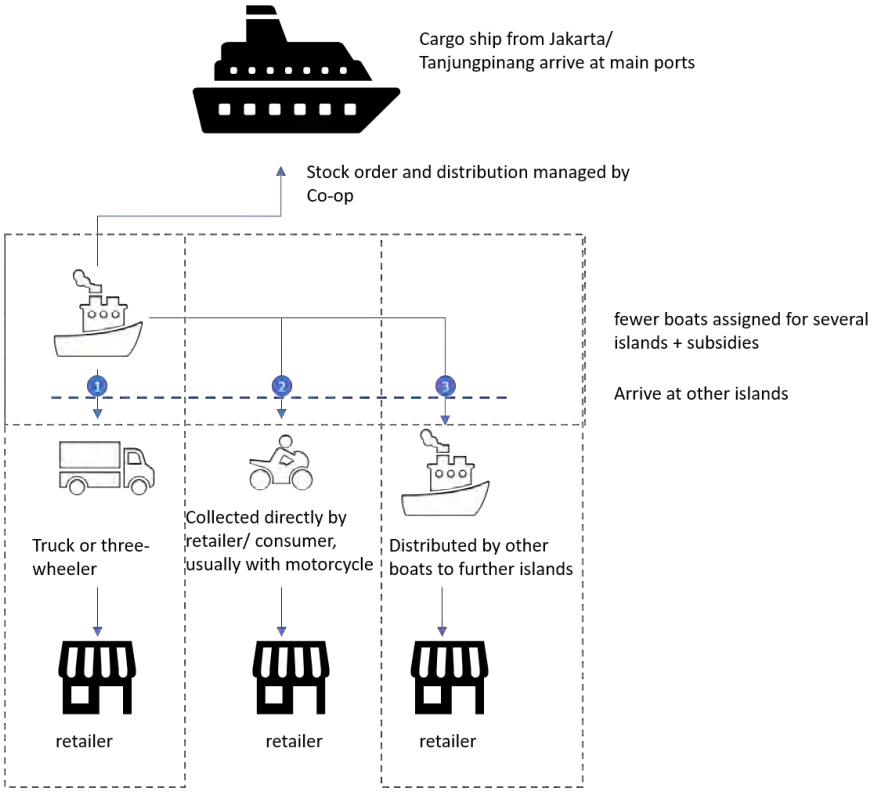

Figure 6. Proposed concerted inter-island supply chain

a. Institutional requirement

Regulation and rigid bureaucracy can become obstacles in governance innovation; hence it is important that there are regulatory frameworks to safeguard initiatives. In this case, there are two regulations stated in the Introduction section that provide a basis for the proposed concept. Presidential Act No. 27/2021 on The Provision of Public Service Obligation for Logistics to and from Underdeveloped, Remote, Peripheral and Border Regions, and Presidential Act No.74/2021 on Empowerment of Community Sea Transport. These regulations provide legal basis for government subsidies in rural logistics, cooperation between multiple actors (central government, local government, private sector, and communities), also to empower traditional boats.

Regulations states that the government has appointed existing government institutions responsible for PSO in rural logistics; Perum DAMRI for logistics on road, and PT ASDP for logistics by boat/ ship. Based on the nature of inter-island travel, PT ASDP is the main institution responsible in the provision of subsidised sea transport. Currently ASDP serves larger passenger ships, cargo, and ro-ro vessels. For smaller modes of transport, ASDP can work with other institutions. In terms of operations, there are several options in which ASDP can orchestrate small island logistics:

- **ASDP:** ASDP can establish a local entity for the provision of small-scale inter-island transport and manage the operations by itself
- **Not-for profit enterprise or Cooperative:** Local transport service providers and traders can for a not-for profit enterprise or cooperative which will operate under the supervision of ASDP and receive central government subsidies through ASDP or directly from local government.
- **Local government enterprise:** The local government may opt to establish its own enterprise to manage inter-island logistics, and manage government subsidies.
- **Postal services:** Literatures on rural logistics have provided examples of how postal services can also be given additional responsibility to support rural areas in terms of supply chain. However, in the case of Indonesia, the cross-sector governance mechanisms need to be further explored, as the postal services are under the Ministry of Communication and Informatics, whereas the logistics PSO is under the Ministry of Transportation.

b. Logistics Service Standards

The management is responsible to set logistics tariff for each destination based on overall transportation cost (including sea and land transport), and to ensure minimum service standards, including safety and navigational measures. In order to prioritize the empowerment of traditional boats, the definition of traditional boats can refer to regulations. The definition of simple traditional boats are boats made mainly from wood with size ranging from 7 – 174 Gross Tonnage (GT), while the definition of traditional sail boats are wooden boats mainly using sail to move with a maximum dimension of 500 GT. Albeit being traditional boats, in order to incorporate them in formal logistics, standardisation is required, especially regarding load capacity, safety and navigational equipment and operations. These standards should at least refer to the following:

- International Ship and Port Facility Safety Code
- Maritime Labour Convention
- Government Act 31/2021 on Shipping
- Presidential Act 74/2021 on the Empowerment of traditional boats

c. System design

The system design diagram can be seen in Figure 7 below:

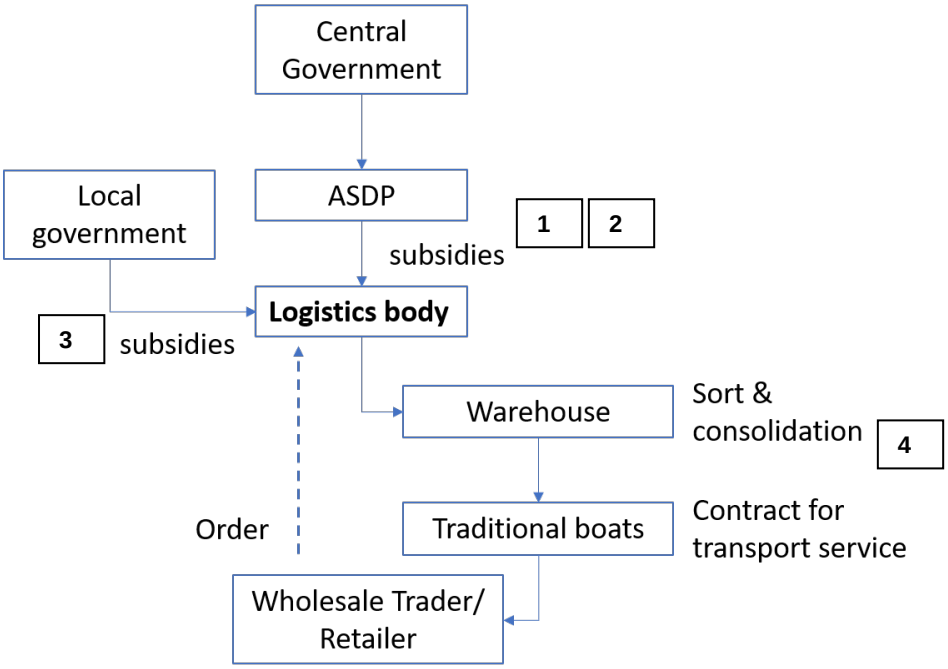

Figure 7. Proposed concept of inter-island supply chain

1) The logistics body determines tariff to each destination based on weight, volume, and type of item
2) Subsidy from the government is requested to balance the cost of items. The government has regulated the highest retail cost (HET) for certain items, such as rice, sugar, medicine, etc. The amount of subsidy is determined by the gap of real distribution cost with the maximum cost allowed in order for items to be sold at HET. Both central and local government can allocate subsidies for small island logistics.
3) The logistics body receives order from local customers and traders with information including item, volume, and destination
4) Goods from Jakarta and Tanjungpinang are unloaded and sorted directly at the dock or in the port warehouse, and then systematically distributed with assistance of logistics software to efficiently plan delivery

Regarding information technology, the main ports of Letung and Tarempa already have internet and communication connection but not stable, while many remote islands do not have internet and communication signal. As internet cannot fully be relied upon for inter-island integrated supply chain software, a hybrid logistics system is preferable, that uses a combination of internet and close range/ Bluetooth data transfer.

4. Conclusions and Recommendations

Rural logistics is financially challenging due to sparse population, it also has operational challenges for certain geographies such as small islands. This paper has provided insight into the existing challenges of inter-island supply chain and how different factors contribute to the high cost of island logistics, using the case study of Anambas Islands, Indonesia. Besides the high cost of sea travel itself, the lack of equipment and labour for loading/unloading at ports, poor road infrastructure from port to final destination, and lack of warehouses for consolidation and sorting are factors contributing to the supply chain cost structure. The high cost of local inter-island travel is also due to unorganized distribution using traditional boats. Indonesian Public Service Obligation (PSO) for rural logistics only reaches the main ports, while the local inter-island last mile is provided by the private sector. This paper conceptualizes innovation in rural supply chain for small islands that allows the government to extend its PSO to the most remote islands and reach the final destination wholesalers. The main idea being a local body subsidised by central and local government to orchestrate last mile inter-island networks of supply chain.
Due the limitation of this research, data was only collected on the main islands. Further research needs to be made to understand supply chain processes and cost structures for the most remote islands. A thorough study also need to be made regarding institutional mechanisms for PSO, and the readiness of traditional boat owners to cooperate in an orchestrated supply chain.

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DEVELOPMENT OF LOCAL LEAD COMMODITIES TO REDUCE EMPTY BACKLOAD ON SEA TOLL PROGRAM IN INDONESIA

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Abstract: *The sea toll is an Indonesian government program that has been running since 2015. The program aims to serve the logistics for the outermost, underdeveloped, remote, and border area (3TP). In 2021, the sea toll program had 30 routes with 4 main ports, 5 transhipment ports, and 103 stopover ports. One of the problems in the sea toll program is the imbalance between departing and returning cargo. Data from the Ministry of Transportation Indonesia shows that in 2020, the volume of departing cargo transported were 13,825 TEUs, while the return cargo were 4,303 TEUs. The results of data processing indicates the potential of local lead commodities to be developed through sea toll to fill the gap.*

Keywords: *sea toll, empty back load, logistics, Indonesia*

1. Introduction

The sea toll is an Indonesian government program that involves 14 Ministries/Institutions, including the Ministry of Transportation, Ministry of Trade, Local Government, and ship operators. The sea toll aims to embody sea connectivity effectively through ships that sail regularly and on a scheduled basis from west to east of Indonesia with the aim of increasing distribution smoothness and reducing price disparities in disadvantaged, remote, outermost, and border areas or 3TP region (Presidential Regulation of the Republic of Indonesia Number 27 of 2021).

The sea toll program in 2021 includes 30 routes involving Pelni, ASDP, Djakarta Lloyd, and private companies as operators. The sea toll program in 2021 has 4 base ports, 5 transshipment ports, and 94 stopover ports with a budget ceiling of IDR 435,658,116,000. Subsidies are given with an operational subsidy scheme: ship, container, and cargo. These subsidies are categorized as direct subsidies, namely direct transfers of funds through budget expenditures by the government (ITF, 2019).

The territorial coverage of the sea toll program in 2021 covers 80 districts in Indonesia, consisting of 14 districts in Sumatera, 3 districts in Kalimantan, 12 districts in Sulawesi, 7 districts in Nusa Tenggara, 15 districts in the Maluku Islands, and 20 districts in Papua. The coverage is outside the 2 cities in Java as base ports (Jakarta and Surabaya).
The route codes and areas served by the 2021 sea highway have different codes for each region, which can be seen as follows:

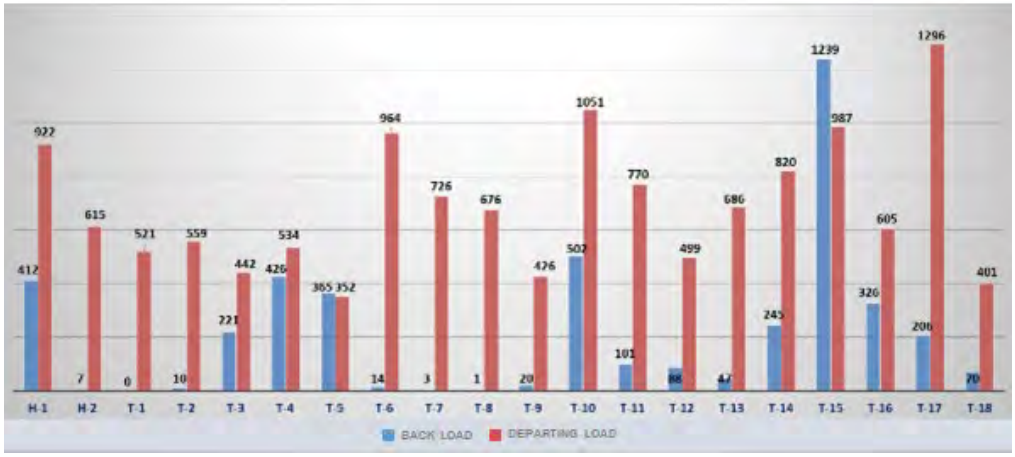
Table 1: Sea toll route network for the fiscal year 2021

No	Route Code	Route Network	Total Distance (Nautical Miles)	Operator
1	H-1	Tanjung Perak – 438 – Makassar (Soekarno Hatta) – 766 – Tahuna – 1071 – Tanjung Perak	2,275	PT Pelni
2	T-3	Tg.Priok – 468 – Deer – 194 – Tarempa – 149 – Pulau Laut – 76 – Selat Lampa – 61 – Subi – 47 – Serasan – 85 – Midai – 576 – Tg. Priok	1,656	PT Pelni
3	T-5	Bitung – 89 – Ulu Siau/Tagulandang – 64 – Tahuna – 105 – Lirung/Melangoane – 97 – Miangas – 83 – Marore – 79 – Tahuna – 64 – Ulu Siau/Tagulandang - 89 Bitung	670	PT Pelni
4	T-10	Tanjung Perak – 1216 – Tidore (Soasio) – 156 – Morotai – 72 – Galela – 144 – Maba/Buli – 139 – Vedas – 1213 – Tanjung Perak	2,940	PT Pelni
5	T-13	Tanjung Perak - 701 – Rote (Ndao)- 63 – Sabu (Biu) - 644 -Tanjung Perak	1,408	PT Pelni
6	T-14	Tanjung Perak - 657 – Lembata (Lewoleba) -34- Tabilota/ Larantuka -641- Tanjung Perak	1,332	PT Pelni
7	T-15	Tanjung Perak – 437 – Makassar (Soekarno Hatta) – 775 – Jailolo – 139 – Morotai (Daruba) – 1256 – Tanjung Perak	2,607	PT Pelni
8	T-18	Tanjung Perak – 334 – Badas – 118 – Bima – 415 – Tanjung Perak	867	PT Pelni
9	T-19	Merauke – 734 – Kokas – 166 – Sorong – 320 – Biak/Korido – 315 Depapre/Jayapura – 626 – Sorong – 886 – Merauke	3,047	PT Pelni
10	H-2	TG. Perak – 438 – Makassar (Soekarno Hatta) – 494 – Bobong (Taliabu) – 117 – Luwuk – 1,100 – Tanjung Perak	2,149	PT Djakarta Lloyd
11	T-6	Bitung – 226 – Luwuk – 138 – Pagimana – 35 – Bunta – 28 – Mantangisi – 21 – Ampana – 107 – Parigi/Tinombo – 132 – Tilamuta – 212 – Bitung	889	PT Djakarta Lloyd
12	T-7	Makassar (Soekarno Hatta) – 358 – Ereke – 89 – Raha – 111 – Sikeli – 116 – Selayar – 106 – Makassar (Soekarno Hatta)	780	PT Djakarta Lloyd
13	T-8	Makassar (Soekarno Hatta) – 501 Bungku – 61 – Kolonodale – 563 – Makasar (Soekarno Hatta)	1,125	PT Djakarta Lloyd
14	T-16	Tanjung Perak – 710 – Wanci – 216 – Namrole (Leksula) – 133 – P.Obi – 1093 – Tanjung Perak	2,152	PT Djakarta Lloyd
15	T-2	Teluk Bayur – 105 – Mentawai(Sikakap) – 243 – Pulau Baai – 432 – Mt. Sitoli – 109 – Sinabang – 339 – Teluk Bayur – 339 – Sinabang – 109 – Mt. Sitoli – 432 – Baai Island – 243 – Mentawai (Sikakap) – 105 – Teluk Bayur	2,456	PT ASDP
16	T-4	Makassar (Soekarno Hatta) – 97 – Barru (Garongkong) – 64 – Polewali (Tanjung Silopo) – 129 – Mamuju – 151 – Balikpapan – 148 – Striped – 581 – Nunukan/Sebatik – 613 – Makassar (Soekarno Hatta)	1,783	PT ASDP
17	T-9	Tanjung Perak – 1835 – Oransbari – 120 – Wasior – 126 – Nabire – 95 – Serui – 23 – Waren – 165 – Sarmi – 1708 – Tanjung Perak	4,072	PT Broad Line
18	T-12	Tanjung Perak –733- Kalabahi -202- Kisar -42- Moa - 249 - Larat –152- Tepa -1074- Tanjung Perak	2,452	PT Pelayaran Tunggal Ika
19	T-1	Tanjung Priok – 997 – Lhokseumawe – 114 – Malahayati – 24 – Sabang – 1107 – Tanjung Priok	2,242	PT Pelayaran Tempuran Mas

No	Route Code	Route Network	Total Distance (Nautical Miles)	Operator
20	H-3	Tanjung Priok – 562 – Teluk Bayur – 562- Tanjung Priok	1,124	PT Meratur Line
21	T-11	Tanjung Perak – 1240 – Fak Fak – 154 – Kaimana – 204 – Timika (Pomako) – 96 – Agats – 335 – Elat - 1261- Tanjung Perak	3,290	PT Pelayaran Tempuran Mas
22	H-5	Tanjung Perak – 1700 – Merauke – 1700 – Tanjung Perak	3,400	PT Pelayaran Tempuran Mas
23	T-17	Tanjung Perak – 1133 – Saumlaki – 231 – Dobo – 1313 – Tanjung Perak	2,677	PT Pelayaran Tempuran Mas
24	T-20	Tanjung Perak – 854 – Tarakan – 83 – Nunukan – 903 – Tanjung Perak	1,840	PT Pelayaran Tempuran Mas
25	T-21	Cape silver – 1038 – Namlea – 1038 – Cape Silver	2,076	PT Pelayaran Tempuran Mas
26	T-23	Merauke (Coconut Lima) – 194 – Kimaam – 18 – Moorish – 40 – Bade (mapi) – 105 – Gantentiri (Bovendigul) – 357 – Merauke (Coconut Lima)	714	PT ASDP
27	T-24	Merauke (Kelapa Lima) – 360 – Atsy – 86 – Agats – 86 – Atsy – 96 – Senggo – 96 – Atsy – 360 – Merauke (Coconut Lima)	1,084	PT ASDP
28	T-22	Biak – 120 – Teba – 60 – Bagusa – 30 – Trimuris – 30 – Kasonaweja – 120 – Teba – 120 – Biak – 22 – Brumsi – 22 – Biak	524	PT ASDP
29	T-25	Timika (Pomako) – 212 – Atsy – 110 – Eci – 110 – Atsy – 212 – Pomako	644	PT ASDP
30	T-26	Timika (Pomako) – 500 – Agats – 66 – Sawaerma – 60 – Mamugu – 126 – Agats – 500 – Timika (Pomako)	1,252	PT ASDP

Source: Directorate of Sea Traffic, Directorate General of Marine Transportation, Ministry of Transportation, 2021

Based on data from the Ministry of Transportation, the realization of voyage and cargo transported in the period January to December 2020 is as follows:



Source: Directorate of Sea Traffic, Directorate General of Marine Transportation, Ministry of Transportation, 2021

Figure 1: Realization of sea toll voyage and cargo in 2020

The figure shows that the payload varies between routes, with a total departing payload of 13,825 TEUs and an entire return payload of 4,303 TEUs. Some of the large departing loads were on the T-17, T-10, T-6, T-15, and H-1, while the large return payload was on

the T-15 route passing through Morotai. However, the smallest departing cargo is on T-5, and the smallest return cargo is on T-1.

The data shows the imbalance of departing and back loads so that the trip becomes inefficient. Various problems are behind this, including (Research and Development Agency of the Ministry of Transportation, 2021):

a. Poor access to ports from production areas,
b. Limited facilities on board for perishable goods, for example, in the form of refrigerated containers,
c. The undeveloped regional commodities that can be transported via sea toll,
d. Technical constraints, such as licensing aspects and limited access to technology in remote areas, thus prevent producers from participating in the sea toll program.

In addition to infrastructure problems, people in the 3TP area also have difficulties developing their local lead commodities, so they are well distributed. These problems include the unavailability of business entities that accommodate the distribution of commodities, lack of socialization among the public about the mechanism for sending commodity products, improving the quality of human resources to develop potential commodities in hinterland areas, absorption of commodities that have not been optimal, the unavailability of equitable access to digital information through internet access to market regional commodity products and even distribution of routes in the 3TP area (Mugen 2022). In developing infrastructure facilities, a study can be carried out on whether the existing transportation infrastructure can serve distribution activities optimally and determine future needs according to the scale of activities (Europlatforms EEIG 2004 on Widodo et al.).

This paper aims to identify the leading commodities in the service areas of the sea toll road so that it is hoped that it will be able to increase the volume of reverse cargo through the sea toll road. In addition, the potential volume of reverse cargo that the sea toll can transport will be calculated based on developing the region's leading commodities.

2. Methodology

The methodology used in the study is through secondary processing data obtained from various sources, including the Ministry of Transportation and the Ministry of Trade. The data processing is supported by a literature review on developing logistics services and essential commodities in the regions. The data source is obtained from the ministry of trade for data on types and volumes of primary commodities. In contrast, data on sea toll routes and volumes of departing and returning cargo are obtained from the transportation ministry. The types and sources of data can be seen as follows:

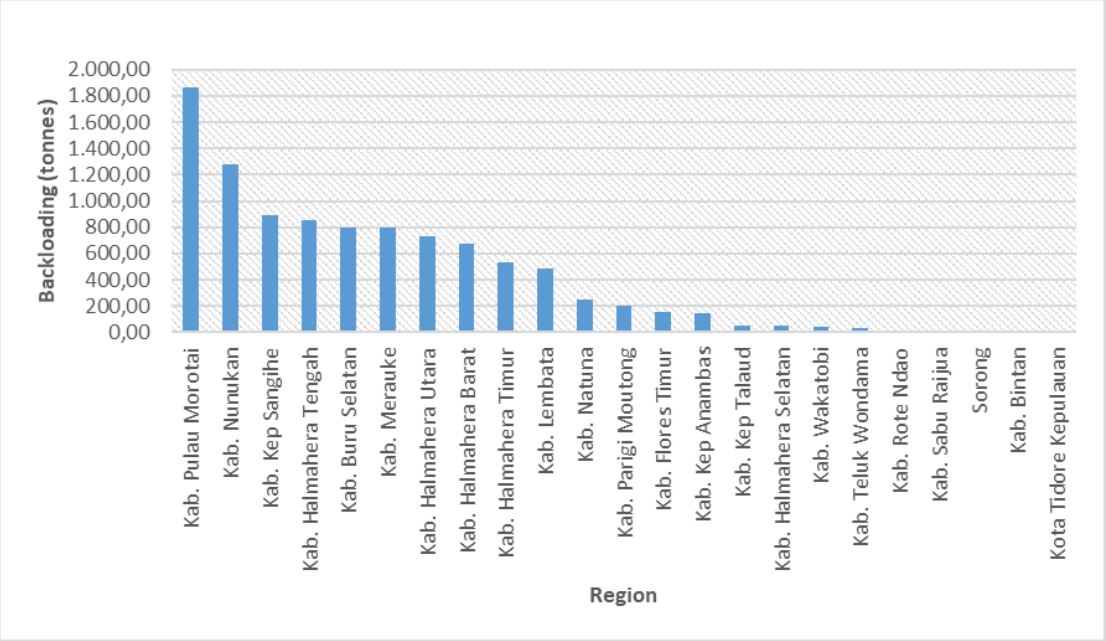
Table 2: Types and sources of data

Data Type	Data source
Main commodity types and volume	Ministry of Trade
Sea toll route	Ministry of Transportation
Departing and back load volume	Ministry of Transportation

3. Results and Discussion

3.1. Data Collection Results

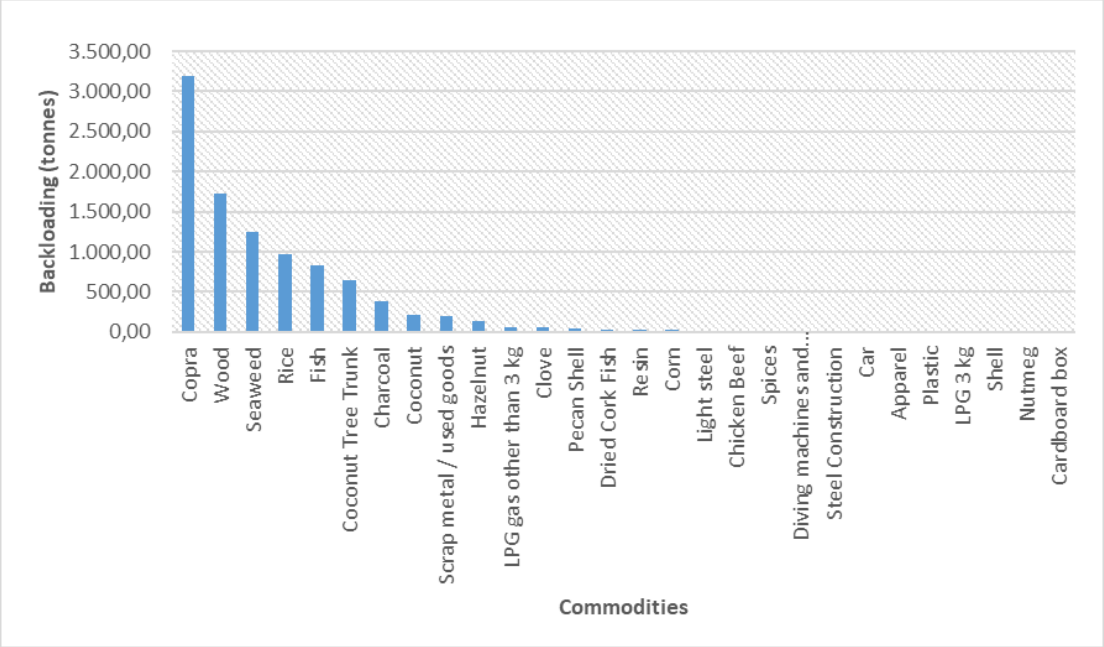
Pulau Morotai Regency has the highest backload, 1,968.47 tons, followed by Nunukan Regency (1,282.01 tons). The data also shows that many areas still do not have adequate countercharges, including Tidore Islands City, Bintan Regency, Sorong, Sabu Raijua, and Rote Ndao, which has absolutely no reverse charge. The volume of backloading per area served by the sea toll is presented in Figure 2.



Source: Directorate of Sea Traffic, Directorate General of Marine Transportation, Ministry of Transportation, 2021

Figure 2: Sea Toll Back Load per Region in 2020

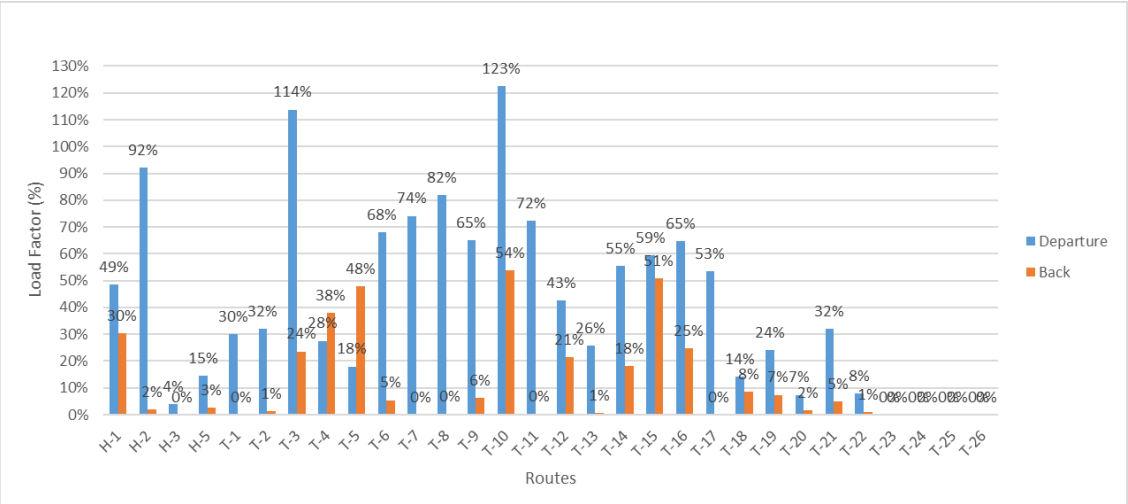
Based on the type of commodity, the profile of sea toll return transportation is dominated by natural products, such as copra, wood, seaweed, rice, fresh fish, and coconut tree trunks. Judging from the types of return commodities transported by sea highways, the majority are essential materials for daily needs consumed by the community, such as rice and fresh fish. In detail, the backload per commodity type is presented in Figure 3.



Source: Directorate of Sea Traffic, Directorate General of Marine Transportation, Ministry of Transportation, 2021

Figure 3: Sea Toll Back Load per Commodity Type in 2020

There is one route that has a combined load factor of back and departing above 70%, namely T-10 (LF 88.1%) serving the Tanjung Perak – Tidore (Soasio) – Morotai – Galela – Maba/ Buli – Veda – Tanjung Perak (see Figure 4). The routes with relatively high departing payloads include H-2, T-3, T-7, T-8, T-10, and T-11, while the route with relatively high back loads is the T-10 route. From this graph, it is also necessary to pay attention to the T-23, T-24, T-25, and T-26 routes, namely Merauke, Biak, and Timika, which are in Papua Province, because they do not have a reverse charge of 0%.



Source: Directorate of Sea Traffic, Directorate General of Marine Transportation, Ministry of Transportation, 2021 (processed)

Figure 4: Realization of Sea Toll Route Load Factor

The potential backload can be identified based on the volume of production of lead commodities in the region. Based on data from the Ministry of Trade, the importance of local lead commodities that will be transported by the sea toll in 2021 is presented in the following table:

Table 3: Volume of Regional Leading Commodities by Province, 2021

No	Route	County/City	Harbor	Commodity Name	Potential (tons/yr)
1	T-1	Aceh Besar	Malahayati	Tuna fish	1,000,000 tons
2	T-1	Aceh Utara	Lhokseumawe	Areca nut	4,320 tons
3	T-12	Alor	Kalabahi	Candlenut	1,761 tons
4	T-22	Asmat	Agats	Nothing	-
5	H-2	Banggai	Luwuk	Coconut	330 tons
6	T-4	Barru	-	-	-
7	T-20	Biak Numfor	Biak	Copra	185.8 tons
8	T-19	Supiori	Korido-Supiori	Copra	864 tons
9	T-3	Bintan	-	-	-
10	T-6	Boalemo	Talimuta	Paddy	1,260 tons
11	T-7	Bombana	Sikeli	Copra	1,740 tons
				Rice	1,690 tons
12	T-21	Boven Digoel	Tg Perak	-	-
13	T-16	Buru	Namlea	Copra	3,680 tons
				Wood	5,180 tons
14	T-7	Buru Selatan	Namrole	Copra	700 tons
15	T-7	Buton Utara	Ereke	Coconut/Copra	1,505 tons
				Cashews	1,374 tons
16	T-11	Fakfak	Fakfak	Seaweed	648 tons
17	T-14	Flores Timur	Larantuka	Skipjack tuna	211.7 tons
				Coconut	409 tons
18	T-15	Halmahera Barat	Matui-Jailolo	Skipjack tuna, Mackerel scad, Cutlass fish, Tuna fish	22,609 tons
				Copra	30,443 tons
19	T-16	Halmahera Selatan	Obi	Clove	724 tons
				Meranti wood	3,000 m^3
20	T-10	Halmahera Tengah	Weda	Coconut	864 tons
21	T-10	Halmahera Timur	Maba	Copra	80 tons
22	-	Halmahera Utara	Galela	Copra	67,303 tons
				Clove	580.2 tons
				Chocolate	996 tons
23		Kabupaten Jayapura	-	-	-
24	T-11	Kaimana	-	-	-
25	T-3	Anambas	Tarempa	Frozen squid	200-300 tons
26		Aru	-	-	-
27	T-2	Mentawai	Mentawai	Clove	60,000 tons
				Copra	84,000 tons
				Areca nut	132,000 tons
28	T-5	Sangihe	Tahuna	Copra	512.3 tons
				Clove	1,495 tons
				Fresh fish	603.2 tons
29	T-7	Selayar	Jampea	Black Copra	9,796.8 tons
				White Copra	14,403.6 tons
				Fish	11,602.68 tons
30	T-5	Siau Tangulandang Biaro	Siau	Copra	3,409.7 tons
31	T-5	Talaud	-	Copra	22,133.44 tons
32	T-17	Tanimbar	Saumlaki	Copra	1,236 tons
	T-12	Tanimbar	Larat	Copra	415 tons
33	T-9	Yapen / Serui	Serui	Seaweed	500,000 tons
				Sawn Timber	1,000,000 tons
				Plywood	1,500,000 tons
34	T-14	Lembata	Lewoleba	Coconut	2,783 tons
35	T-12	Maluku Barat Daya	Kisar	Copra	60 tons

No	Route	County/City	Harbor	Commodity Name	Potential (tons/yr)
	T-12	Maluku Barat Daya	Moa	Copra	85 tons
	T-12	Maluku Barat Daya	Tepa	Copra	34 tons
36	T-17	Maluku Tenggara	Elat	Coconut (Copra)	252.2 tons
37	T-9	Mamberamo Raya	Kasonaweja	Wet fish	24 tons
38	T-4	Mamuju	Belang-Belang	Corn	1,466 tons
				Coconut	768 tons
39	T-9	Manokwari Selatan	Oransbari	Kakao Chocolate	132 tons
40	T-21	Mappi	Mapi	Rubber	2.9 tons
41	T-18	Merauke	Yos Sodarso	Rice	50,250 tons
				Gambier	600 tons
42	T-11	Mimika	Pomako	Sago flour	336 tons
43	T-8	Morowali	Bungku	Coconut seeds (Cover)	20 tons
44	T-8	Morowali Utara	-	-	-
45	T-7	Muna	Raha	Ground corn	360 tons
46	T-9	Nabire	-	-	-
47	T-3	Natuna	Selat Lampa	Coconut	12,179 tons
				Clove	12,923 tons
				Rubber	4,258 tons
48	T-4	Nunukan	Tunon Taka Nunukan	Seaweed	1,006,302 tons
49	T-6	Parigi Moutong	Tinombo	Rice	325,178 tons
				Corn	65,252 tons
50	T-4	Polewali Mandar	Tanjung Silopo	Broiler chicken	360 tons
51	T-15	Morotai	Daruba	Copra	2,535,000 tons
				Block wood	3,045,260 tons
				Wooden logs	3,278,000 tons
				Tuna fish	479,394.6 tons
				Shrimp	70,000 tons
52	H-2	Taliabu	Bobong	Coconut / Copra	671,573 tons
				Clove	2,538.6 tons
				Cacao / Chocolate	345,217 tons
53	T-13	Rote Ndao	Ba'a	Copra	132 tons
54	T-13	Sabu Raijua	Biu	Bulk Salt	10,000 tons
				Seaweed	7,000 tons
55	T-9	Sarmi	-	-	-
56	T-14	Sikka	-	-	-
57	T-2	Simeulue	Cargo Sinabang	Rattan	600 tons
				Sago	576 tons
				Areca nut	600 tons
58	T-13	Sumba Timur	-	-	-
59	T-18	Sumbawa	-	-	-
60	T-9	Wondama	-	-	-
61	T-6	Tojo Una-Una	Mantangisi	Corn	180,866 tons
				Copra	108,000 tons
62	T-16	Wakatobi	Wanci	Seaweed	2,616 tons
63	T-9	Waropen	Waren	Nothing	-
64	T-4	Kota Balikpapan	-	-	-
65	T-2	Kota Bengkulu	-	-	-
66	T-18	Bima	Bima	Red Union	47,900 tons
67	T-2	Gunung Sitoli	Gunung Sitoli	Wet Rubber	2,400 tons
				Dry Rubber	2,400 tons
68		Kota Jayapura	-	-	-
69	T-13	Kota Kupang	-	-	-
70	T-2	Padang	Teluk Bayur	Nothing	-
71		Kota Sabang	-	-	-
72	T-19	Kota Sorong	-	-	-
73	T-20	Kota Tarakan	-	-	-
74	T-10	Tidore	Tidore	Mixed fish	154 tons
				Scrap metal	159,5 tons

Source: Ministry of Trade of the Republic of Indonesia, 2021

3.2. Strategic Issues related to Leading Commodity Development

Based on the results of interviews with operators related to sea toll, strategic issues related to the development of lead commodities in the hinterland areas of marine highways were obtained, including;

Table 4: Strategic Issues Related to Commodities in the Hinterland Area Port Stopover for Sea Toll

No	Aspects of Attention	Strategic Issues	Resources
1	Types of commodities and the continuity of their production	In some hinterland areas, some commodities require special treatment, such as refrigerated containers for products or commodities that are perishable and have the opportunity to continue to increase in production.	INSA
		The types of backloading commodities are generally agricultural, plantation, and fishery products, which are still dependent on the seasons, and not yet leading to industrialization, so in terms of cargo volume, they are not yet economical.	• PT Temas • PT Djakarta Lloyd
		There has been no increase or development of commodities in terms of production volume in the last few years. Still, new regional commodities, such as the Papua region with its forest products and rice, have not been anticipated.	• ALFI • PT Djakarta Lloyd
2	Access to the node on the hinterland side	The problem is the transportation distance from the production site (point of origin) to the node; for example, there is a significant distance between the loading and unloading dock for river transportation and the port, so a connection mode is needed via land/road.	PT Djakarta Lloyd
		The farther the hinterland area is from the port node, the less effective the impact on the issue of reducing price disparities will be.	ALFI
		Limited road transportation modes transport commodities from the location of production/origin.	ALFI
3	Commodity handling facilities at distribution nodes (ports)	Limitations (lack) of adequate loading and unloading facilities (e.g., cranes) at docks, especially in the 3TP area.	PT Pelni
		The speed of loading and unloading of commodities is still low, so it has an impact on ship waiting times.	• PT Meratus • PT Djakarta Lloyd
		Availability/readiness of refrigerated containers (reefer) whenever needed in the field.	• PT Pelni
		The loading and unloading process at 3TP ports mainly relies on local labor and is still manual, takes a long time, and is limited in local working hours, not yet running 24-hour activities every day.	• PT Djakarta Lloyd • PT ASDP
4	Support of related Ministries/ Agencies, Local Governments, and local stakeholders.	The potential lead product has not fully utilized The sea toll due to the lack of the role of the local government.	PT Pelni
		Rumah Kita and Gerai Maritim are still not optimally supporting the counter load consolidation process.	PT Meratus
		Local government support for the industrialization of potential commodity products in the region is minimal, for example, coconut plantation products in Bitung.	• INSA • PT. Djakarta Lloyd
		Large capital holders generally control the prospective downstream industries.	PT. Djakarta Lloyd
		Not all regions (hinterland areas for sea toll destinations) have informed the potential of their local commodities.	ALFI

Source: in-depth interview (2021)

These strategic issues need to be considered in developing local lead commodities in the future.

3.3. Potential Estimation for Filling the Backload Gap

The estimated potential for filling the gap for the return cargo of sea toll vessels is calculated by looking at the current departing and back cargo and the prospect of local products that can be transported.

Table 5 shows that some routes have a significant potential for increased backload. These routes have destinations in Western and Eastern Indonesia, with some having base ports in the regions, such as Makassar and Bitung. This shows potential commodities in the area that can be developed with the sea toll program. The calculation results are as follows:

Table 5: Estimation of Gap Filling Potential for Sea Toll Ships

Route	*Ship Name*	Load (TEUS)		Backload Gap (TEUS)	Local Product Potential (TEUS)*	Potential for Filling The Backload Gap
		Departure	Return			
		(A)	(B)	(C)=(A)-(B)	(D)	
H-1	Logistik Nusantara 1	473	296	177	0	No load
H-2	Kendhaga Nusantara 03	475	10	465	50,983	Full
H-3	Titip Kontainer	10	0	10	0	No load
H-5	Titip Kontainer	50	9	41	0	No load
T-1	Kendhaga Nusantara 12	158	0	158	50,323	Full
T-2	Kendhaga Nusantara 2	134	5	129	14,154	Full
T-3	Logistik Nusantara 4	454	94	360	215	Part
T-4	Kendhaga Nusantara 6	193	265	-72	938.45	Already optimal
T-5	Kendhaga Nusantara 1	153	407	-254	33,629.87	Already optimal
T-6	Kendhaga Nusantara 13	277	22	255	34,046	Full
T-7	Kendhaga Nusantara 4	252	0	252	3,294	Full
T-8	Kendhaga Nusantara 15	557	1	556	1	Part
T-9	Kendhaga Nusantara 9	221	21	200	150,002	Full
T-10	Logistik Nusantara 5	1029	451	578	149	Part
T-11	Titip Kontainer	249	1	248	93	Part
T-12	Kendhaga Nusantara 5	162	81	81	218	Part
T-13	Kendhaga Nusantara 11	139	4	135	1,700	Full
T-14	Kendhaga Nusantara 7	512	167	345	65	Part
T-15	Logistik Nusantara 3	519	445	74	477,118	Full
T-16	Kendhaga Nusantara 10	363	139	224	655	Part
T-17	Titip Kontainer	398	0	398	117	Part
T-18	Kendhaga Nusantara 08	231	138	93	4,952	Full
T-19	KM. Lognus 02	210	65	145	43	Part
T-20	Titip Kontainer	37	8	29	9	Part
T-21	Titip Kontainer	200	31	169	1	Part
T-22	KMP. Membramo Foja	146.2	17	129.2	0	No load
T-23	KMP. Muyu	0	0	0	0	No load
T-24	KMP. Bambit	0	0	0	0	No load
T-25	KMP. Kokonao	0	0	0	0	No load
T-26	KMP. Binar	0	0	0	0	No load

* conversion of potential regional commodities, Ministry of Trade of the Republic of Indonesia, 2021

Table 5 shows that there are 2 routes that have optimally reloaded, namely T-4 and T-5. The table also shows that the potential for adding full backloads so that it is equivalent to departing loads is on route T-9, followed by T-15, H-2, T-1, T-6, T-2, T-18, T- 7 and T-13. Meanwhile, several routes have the potential for additional backloads even though they cannot fill up to the equivalent of the departing payload, namely routes T-3, T-8, T-10, T-

11, T-12, T-14, T-16, T -17, T-19, T-20 and T-21. The routes that have absolutely no potential for backloading are routes H-1, H-3, H-5, T-22, T-23, T-24, T-25 and T-26.

4. Conclusion

The current condition shows an imbalance between the departing and back loads in the sea toll program. As in consequence, the trip becomes inefficient. The problems include infrastructure, facilities, limited local lead commodities, and technical aspects related to licensing and access to technology.

Backloading can be maximized by transporting potential commodities according to the port of origin of the trip in the hinterland area. In addition, to enhance travel, the transportation of items can improve the regional economy and reduce disparities in the price of goods.

Strategic issues related to the development of lead commodities to support the sea toll program include the types of commodities and the continuity of their production, access to nodes on the hinterland side, commodity handling facilities at distribution nodes (ports), and support from related Ministries/Institutions, Local Governments, and local stakeholders.

Some routes have the potential for a significant increase in backloading. These routes have destinations in Western and Eastern Indonesia, with some having base ports in the regions, such as Makassar and Bitung. This shows potential local lead commodities in the area that can be developed with the sea toll program.

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Role of GIS in Study of Smart village

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Abstract

With the rise in population and migration being increased from rural areas to urban areas, smart villages come into play for the development of the nation. India's total population stands at 139 crores, which is equivalent to 17.7% of the world's total population. Altogether, 89.5 crore population is of rural area (2019 Census) as per data of 2019, that is more than 2/3rd of the India's population, as compared to 47.1 crore population living in urban areas. (Census 2021). Presently half the population is below the line of poverty and about 70% of the population are in rural areas. This trending change in urbanization clearly shows that rural population is migrating to urban areas to find better livelihood. The objective behind this research is the development of villages in such a way that village would have all the basic amenities for their proper functioning. The study at Jangal Aurahi was carried out for micro-level development and planning using GIS. (CARTOSAT-I and LISS IV merged and DEIMOS satellite data). GIS helps in development of rural areas and proves to be an effective tool for increasing the educational status, increasing the business & job opportunities thereby strengthening the rural community. Mapping, monitoring, managing existing resources, facilities and infrastructure of the village was the objective so that suitable action plans for soil, land, resource, wastewater and solid waste can be prepared.

Keywords: Smart Village, Migration, GIS, STERM, Sustainable development

Introduction

A village may be defined as a clustered human settlement or community which is larger than hamlet but smaller than a town having a population ranging from hundreds to thousands. When there is a high economic growth in India, it is seen that “Lewisian transition” is taking place. Yearly, around 5 million persons are migrating from rural area, out of which about of which about 3 million per year are coming to urban areas.(Parida, 2019) This rate and estimates, about 843 million population are expected to migrate from rural to urban areas. Lack of opportunities and facilities, leads to unmanageable stress on urban areas(Economic times, 2021) Smart villages today have an important role in society for the development of nation. Technologies need to be implemented in all processes for the upgradation of these villages in the form of smart villages. In this context, GIS, GPS, and Remote sensing would help in identifying areas and prepare maps to make smart villages(Prakash et al., 2017). Today villages have to face infrastructure, health, education, employment, water drainage, waste disposal, water supply, gas, electricity issues which can be solved with the help proper designing of smart village action plan.(Smart Village Pilot Project, 2019). Smart village should be interactive with multi-functional organizations and active participation is required for making bonding among the villagers.(Prakash et al., 2017) GIS is a tool which collects, analyses, and thereby visualizes the geospatial and analytical data either through on-site or from remote sensing or photogrammetry. With the help of using GIS techniques, we collect the primary data which helps researchers in preparation of scientific maps. GIS helps to monitor, gather present condition, infrastructure facilities for various management plans like solid waste, soil & water resource, etc. advanced technology of GIS helps in increasing local -vocal business opportunities, upgrading the educational status and for the development of the nation.

Yuktdhara Geospatial Planning portal is helping to locate planned assets on map for development of plans which further facilitates effective monitoring *(Watershed et al., 2021)*. Smart village can indirectly increase economy since it allows people to interact with outside world. GIS information is now being used by various policy makers by displaying important data’s such as population, area in forms of monographs and tables. The STERM (Science, Technology, Engineering, Regulations and Management) framework can be used to design and build these villages.*(Viswanadham & Vedula, 2010)* Philippines and

India are the only two countries which are implementing GIS for their rural development. Village Jangal Aurahi in Gorakhpur is studied using GIS & GPS techniques and high-resolution satellite data to understand development of rural area. Technology directly or indirectly helps smart villages to grow rapidly. Use of GIS can be of great help in identifying areas facing lack in their basic infrastructure and ensuring their overall development. Generation of maps using GIS technique helps in planning and development purposes. Mapping would involve focussing on infrastructure planning like construction of roads, providing safe and clean water facilities, providing basic education, distribution of electric lines, building of public toilets and residential complexes, telecommunications, drainage, and sewerage facility. It is observed that urban and rural areas still have a huge gap between them in reference to providing amenities and their development. (Centre for Training, 2020)

Jangal Aurahi (Fig.1) is a study area which lies in Gorakhpur of Uttar Pradesh having an area of around 326.711 hectares. Village is surrounded by Gorakhpur Tehsil in South. Local language of area is Hindi, Bhojpuri and Urdu. The headquarter is in Gorakhpur.

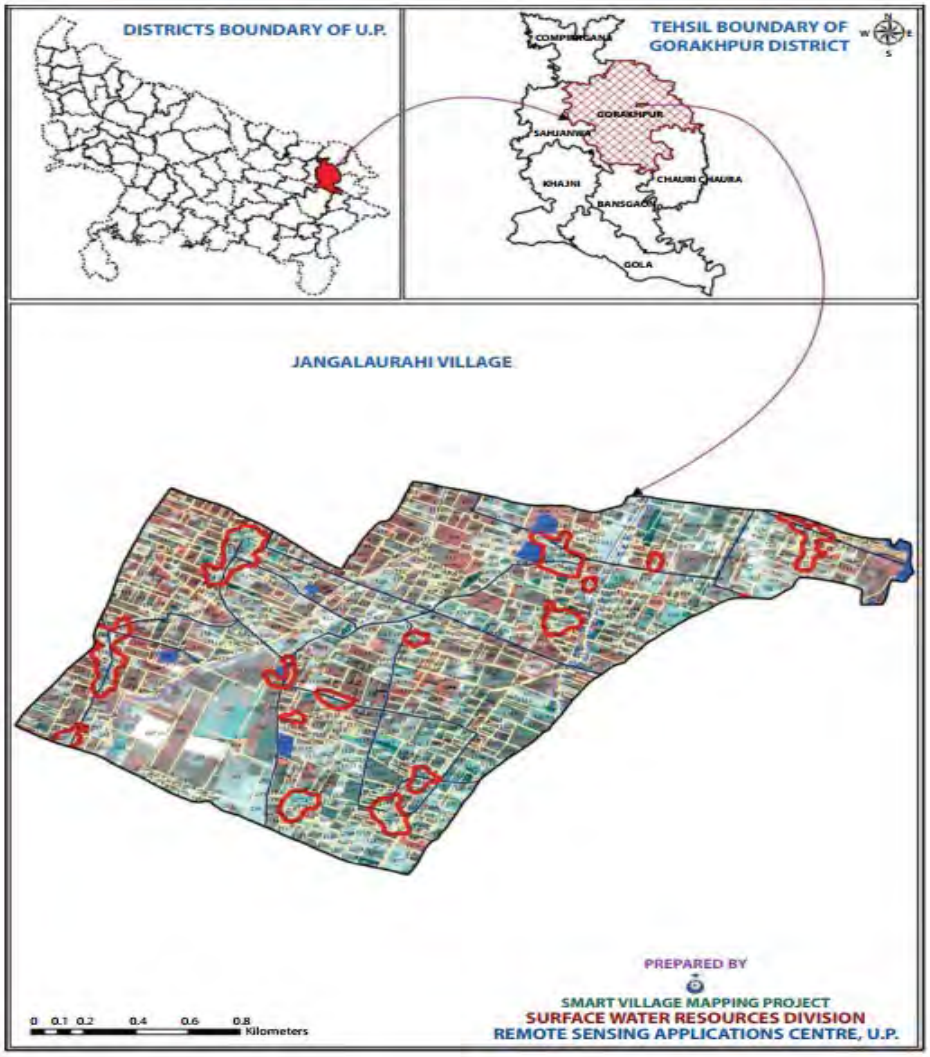

Figure 1: Study area where LISS IV and DEIMOS satellite data were used

OBJECTIVE OF THE STUDY:

1. To improve and nurture the Jangal Aurahi village as a pilot study to inspire various gram panchayats by improving infrastructure planning in a comprehensive way that focusses only on rural community by means of preparation of thematic maps through LU/LC, soil, etc.
2. To improve the livelihood and standard of living of villagers by changing the infrastructure facilities like basic amenities, sewerage, soil and water resources, providing utilities, etc.

DATA USED AND METHODOLOGY

1. **Satellite Data**

   Satellite data is used to get the map with greater accuracy and also it provided infrastructure mapping of an area. The high-resolution satellite data of Cartosat-1 (2.5-m spatial resolution) and IRS LISS-IV (5.8-m spatial resolution) and Sentinel data for the selected villages were used.(Adhikari, n.d.)

2. **Cadastral Data**

   This map is very helpful for planning related works for any kind of village. The cadastral map sheets of Jangal Aurahi were generated by revenue department and it is collected for development works in the form of A1 sheets.

3. **Ground Truth Data**

   For collecting GPS data, The NAVSTAR GPS which is designed, financed, deployed, and operated by U.S. Mapping technology satellite is used. It is a satellite-based radio positioning and time-transfer. It helps in collecting the accurate high-resolution data from the areas which has obstruction or non-visualization through satellite data like electric poles, dug-well, hand pump, transformer, etc.(Lal, n.d.)

4. **Survey of India Toposheet**

   For locating the villages, roads and various topographical features, SOI toposheets on a scale of 1:50000 are used. Jangal Aurahi village of Chirgaon Tehsil, falls in 63N/5.

5. Methodology (Fig.2)

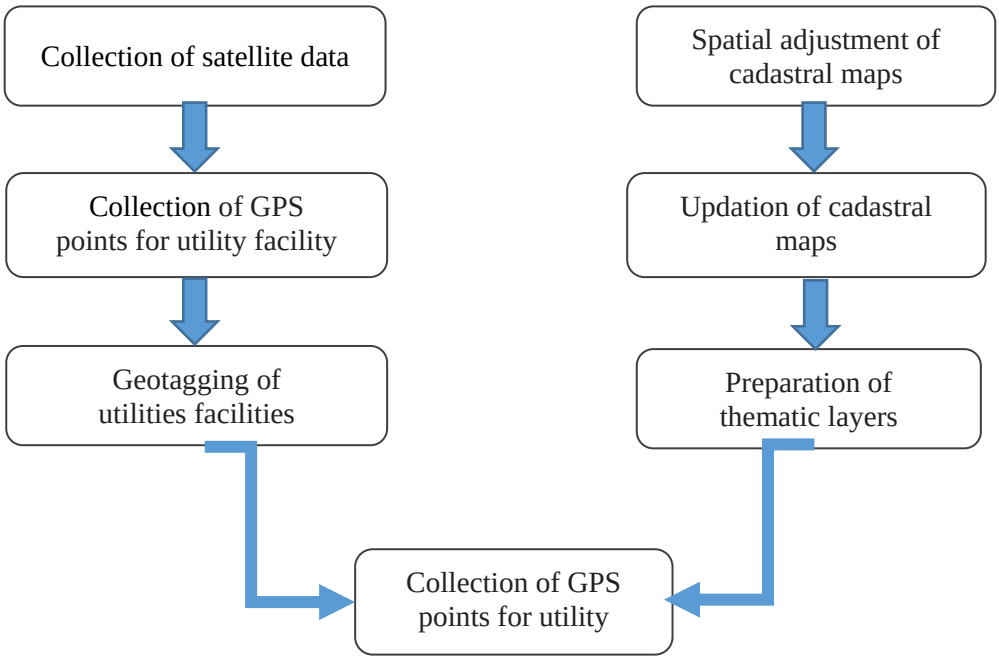

Figure 2: Methodology flow chart for the action plan map preparation

For the detailed study, different thematic maps are prepared using high resolution satellite data.

a) **Infrastructure Map**: Infrastructure Maps helps in mapping the existing infrastructures like water bodies, road, plantations, and their connectivity with the users. Proper road network and connectivity should be developed in Jangal Aurahi. Roads are available with three brick lanes, Kharanja road, CC roads, canals, handpumps, schools were not visualized through satellite data, this GPS data was used for mapping these facilities. (Fig. 3) Accordingly, the collected points were marked in respective sections of roads in x and y coordinates through ArcGIS software. The infrastructure Map is shown in Figure 4.

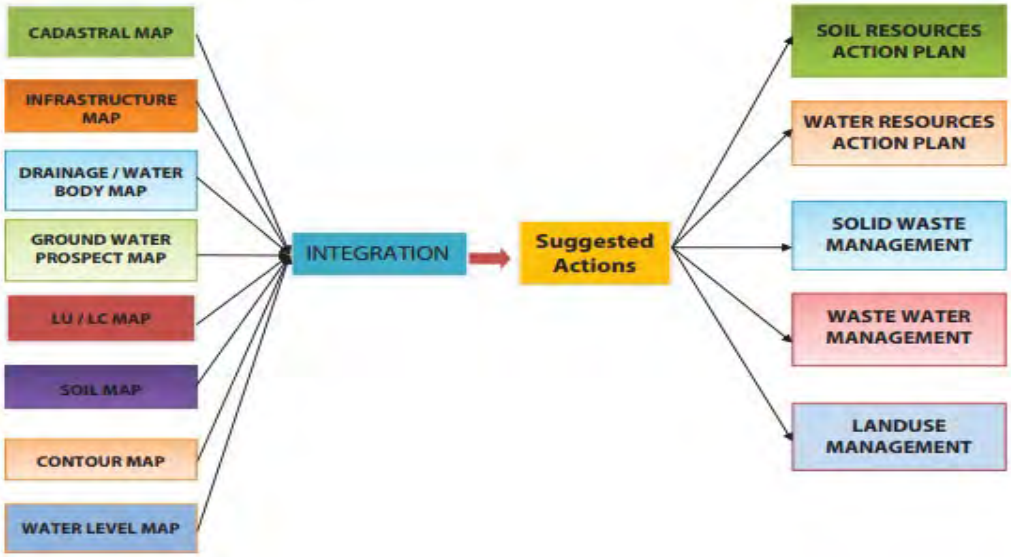

Figure 3: Methodology flow chart for the study

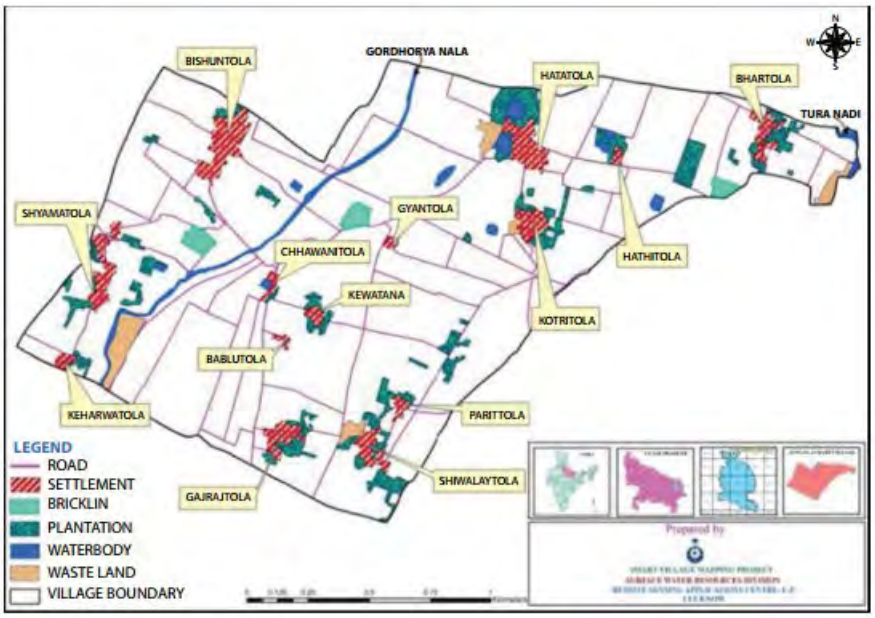

Figure 4: Infrastructure Map

b) **Land Use/Land Cover Map:** This map helps in identifying the purpose for which land is being used. The map of Jangal Aurahi village shows the area is being used for growing kharif & Rabi crops along with settlement, orchid, and water bodies. The LU/LC map is shown in Figure 5.

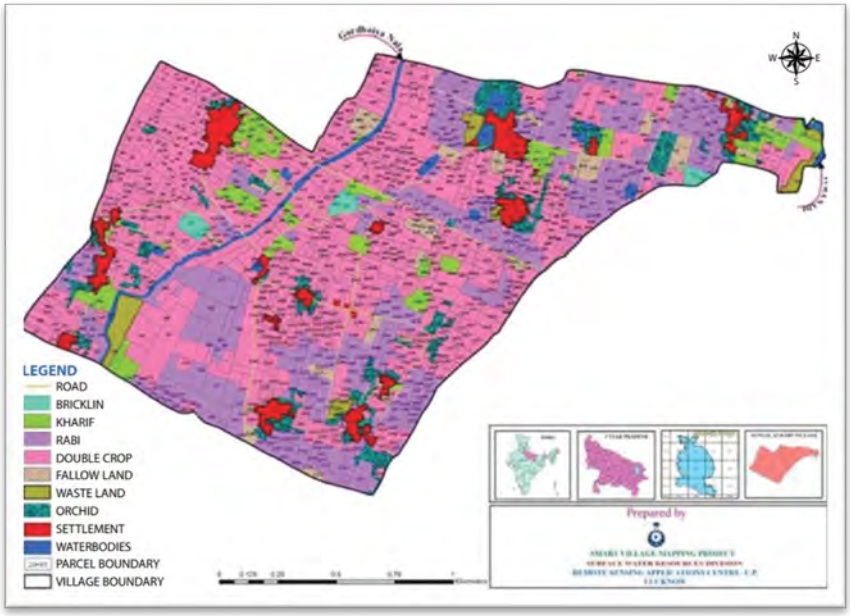

Figure 5: LU/LC Map

c) **Soil Map:** Soil map helps in identifying the soil properties and determining the suitability of a particular crop to grow in that particular area. Soil of Janhal Aurahi is sandy loam to loam and silty loam to silty clay loam. Most of the areas are covered with sandy loam soil. The used soil map is prepared under NRIS (Natural Resources Information System) project. The Soil Map is shown in Figure 6.

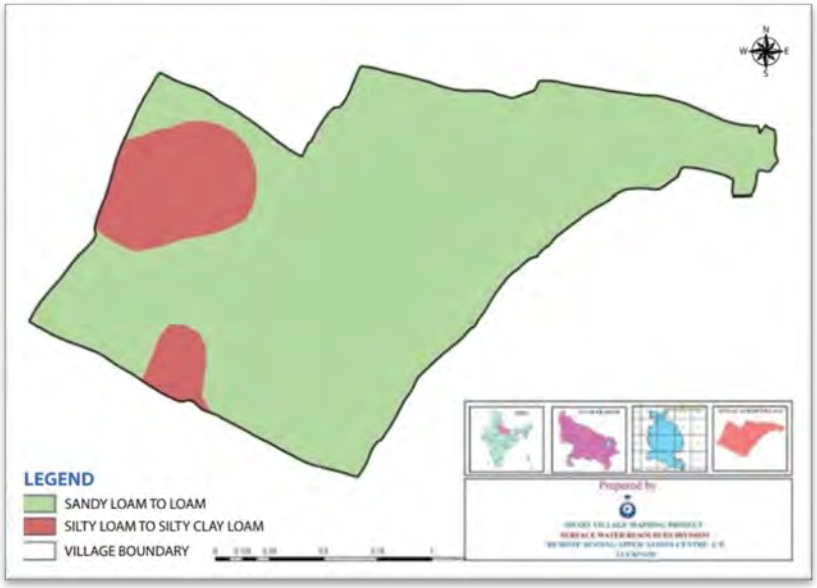

Figure 6: Soil Map

d) **Ground Water Prospect Map**: The groundwater prospect map is prepared under Rajiv Gandhi National Drinking Water Mission-Phase-IV (RGNDWM) is taken into consideration for this project. It is observed through this map that area of the village is under alluvial plain and the extreme east corner of the village comes under flood plain deep due to the flowing of Tura River. The village has excellent groundwater availability with various aquifers.(McBride et al., 2015) (Luchi et al., 1976). The groundwater prospect Map is shown in Figure 7.

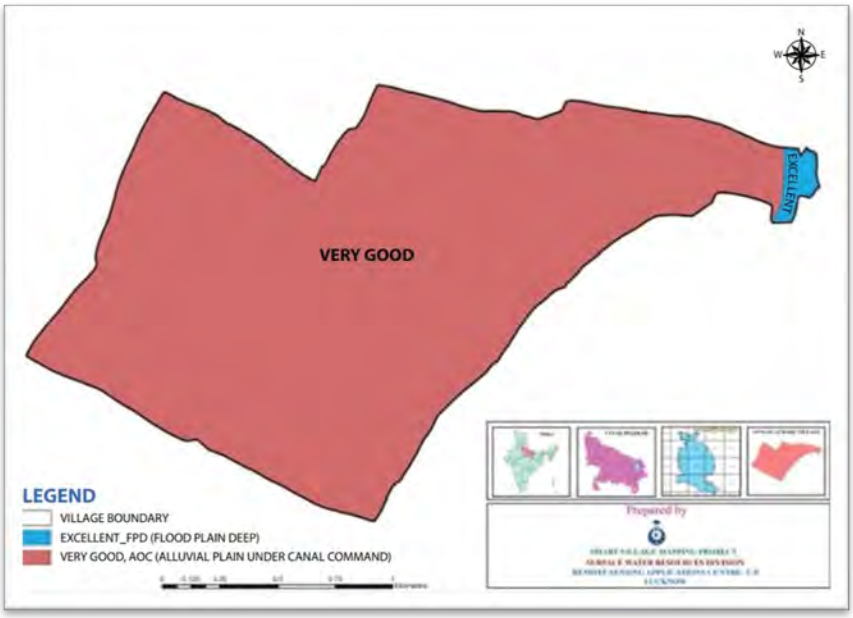

Figure 7: Ground Water Prospect Map

e) **Cadastral Map:** The Cadastral Map provides the data related to change in land holding size. Due to certain socio-economic factors, it is seen there is a change, and it gets updated through high resolution satellite data. The cadastral Map is shown in Figure 8.

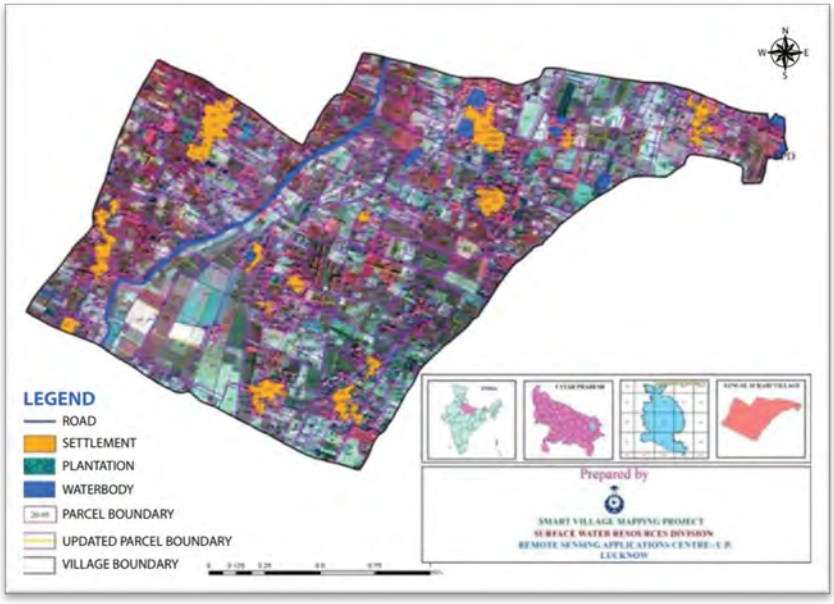

Figure 8: Cadastral Map

f) **Land Capability Classification (LCC) map:** Land capability classification helps for agricultural purposes. Land capability of Jangal Aurahi village is gentle in slope, vey shallow in depth, and has very fine soil texture, the other one comprises of gentle slope, extremely shallow depth and fine textured soil.

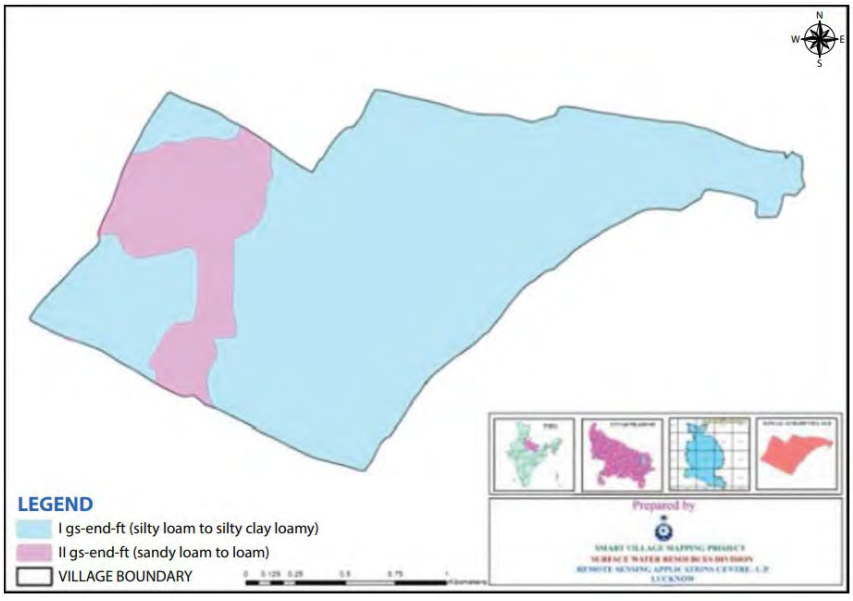

Figure 9: LCC Map

g) **Contour Map:** Topography of the area is shown by Contoured maps. SRTM DEM data is downloaded, and contoured map is prepared. Contour lines are drawn at an interval of 0.5 m to use the concept of slope for an area. By collecting the prints, area is being surveyed physically with the help of contour maps. (Fig. 10)

Figure 10: Contour Map

RESULT AND DISCUSSION

Action Plan Map

Socio-economic development of any area is dependent upon water and land resources. For this, action plan map considering the soil and water resources, Solid wastewater management, solid waste management are prepared. This map would help in sustainable development of the natural resources. It also helps in planning a new innovative mechanism focussing on the development of the whole village population. This action plan map helps in controlling various damages like surface runoff, increase of groundwater recharge, control soil erosion, effect reduction in sediment production, land and water pollution control, helping in safeguarding the downstream areas from floods and droughts, effective use of water and land resources, protection of forests, wastelands and wetlands. It is observed that relating to soil and water resources, solid

waste management, action is needed to maintain the normal condition and sustainable development.

Soil Resources Action Plan

Alternate land use practices like Agro-forestry, Agro-horticulture, and check-road-bund were considered for the preparation of soil resources action plan. It is always recommended and taken care that the existing land use is not disturbed, and land use is technically feasible, economically viable and socially it should be accepted by local farming community.

A brief detail is given below.

(a) Agroforestry: This is a management system of land in which different trees are grown around crops or pastureland. This method is suggested to be used along the roadsides thereby helping to protect the roads from the damages caused by water.

(b) Agro-horticulture: For fallow agriculture land, agro-horticulture is recommended. The fruit trees like custard apple, tamarind, ber, mango, guava, sapota, and teak plantations with pulses like cluster bean, horse gram, etc., are suggested for this system, this helps in revenue generation

(c) Check-road-bunds: the bunds are helpful in preventing the check roads from damage caused by run-off.

Water Resources Action Plan

For the development of water resources of villages, suggestions are made and measured suggested are contour bunds, peripheral bund and desiltation is recommended to improve the ground water conditions which ensured building of new additional lands for irrigation.

(a) Contour bund: This technology helps to control soil erosion, helps in water retention thereby increasing the crop production and is mostly practiced in slopy and hilly areas where soil productivity is low. Surface run-off water can be reduced by this technology in which it is important that contour bunds are available at different levels of contours so that ground water is recharged for agricultural purposes.

(b) Desiltation: This is a process to remove siltation from a water body before the water enters the storage pond with the help of building the desilting pond. After this process, all the dams storage capacity in increased within a few days.
(c) Peripheral Bund: These serve as a fence which protects from water and wind erosion in low rainfall areas and constructed along the field boundaries without considering the contour lines. It helps in maintaining the soil fertility and water infiltration is increased considerably into the soil.

Wastewater Management Action Plan

Discharge of wastewater on the roadside or nala in villages creates inconvenience by raising unhygienic conditions, various diseases, water logging, etc. Different structures are recommended to stop these unhygienic conditions such as:

a) Magic Pit or Soak Pit: A soak pit is walled porous chamber which is directly connected to residential building. This serves as a function by letting the wastewater coming from septic tank to slowly soak into the underlying ground. This should ideally be located far from the source of drinking water.

Solid Waste Management Action Plan

To manage the solid waste from each house, it is necessary to establish a waste collection transport system and dumping yard within the area. The collected waste is segregated into biodegradable and non-biodegradable at each settlement by making two dustbins. (a) Green dustbin: Biodegradable (b) Red dustbin: non-biodegradable. With bio-degradable waste, bio-compost can be prepared, and non-biodegradable wastes are sold to recycles or sent to landfill sites.

Land Use Management Action Plan

This action plan is very helpful in ensuring the long term socio-economic and environmental functions of the land. It helps in maintaining the sustainability of human needs and benefitting the present and future generations (Fig.11). Various recommendations can be made in this respect:

a) Solar plant: This reduces the dependency on fossil fuels, and it helps in deriving the clean and pure energy from the sun. Solar plants are installed in villages mainly of solar panel devices.

b) Health Centre: Health centres should be available in the villages to ensure proper health conditions of the villagers. Villagers need not go far from their villages in search of better healthcare facilities.
c) Market: Market serves as a growth engine in increase of rural economy. To enhance the economic conditions of villagers, marketplaces need to be developed in villages.

Figure 11: Amenities Map

Conclusion

For any nation to develop, it is necessary that overall development is there in villages also. For present nation, rural development is one of the foremost missions for transforming India into a developed Nation. It is the need of the hour to give emphasis on developing the rural areas along with the development of rural communities at micro-level (Pandey & Tripathi, 2020). The present condition in Uttar Pradesh is that there is a huge gap among the urban and rural settlements which needs to be catered effectively for the overall development of a nation as a whole. Mapping of Infrastructure Facilities need to be done like providing drinking water facilities, education facilities, distribution of electricity line, construction of telecommunications, sewage and drainage facilities, road construction, etc. in villages.(Degada et al., 2021)

The research done on Jangal Aurahi village shows that it has good water and surface prospects with good soil quality to support on the agricultural production which would help farmers achieve optimum crop production with the help of innovative technology thereby increasing the economic conditions of villagers. GIS mapping helps in geo-tagging of various amenities which gives clear idea and picture about the present condition and availability, thereby helping policy makers and planners to make decisions for the development.(Pandey & Tripathi, 2020)
The aim involved in the study is to initiate the process which would lead to the comprehensive development of the village by substantially improving the loving and quality of life of all sections of village population by providing basic amenities, improving social and economic status, better educational facilities, better ecological conditions, access to rights and grants, wider social coverage so as to become the pilot project for other villages also. The plot level updation work carried out for the villages with the use of high-resolution satellite data DEIMOS and merged data of Resourcesat and Cartosat for the cadastral level is beneficial to the Revenue Department.

The database once generated using GIS and various satellite information provides a list of benefits like quick access to information, flexible access to data retrieval and analysis, efficient updating of natural resources, and utility facility maps use of generated databases for different user departments like planning departments and departments dealing with ground water quality (Shruti Kanga, Varun Narayan Mishra, n.d.)
It is seen that technology advancement, renewable energy helps to reach rural people and bring in development. Rural areas are adopting smart village model with use of technology, with sustainable development and living from pucca houses with access to basic amenities (Bhattacharya & Sachdev, 2021). This would help migrators to reach again to their villages with smart agriculture, electricity, new jobs. Failure to use GIS in smart villages is not due to lack of funds but due to poor strategy, lack of awareness, unfocused planning and overall monitoring of activities (Patil et al., 2018).

Key findings of this study are described as follows:

1. Land use changes are prominent in certain places, like agricultural land has been converted into settlement which might have occurred due to human or through development.

2. Jangal Aurahi village has good groundwater and surface water resources, good soil quality which helps in agriculture production. For the development of smart villages, it is necessary that emphasis is given on increasing the crop production so as to increase the economic status of farmers and villagers.
3. Through agro-forestry and agro-horticulture, waste lands can be converted into economic producing land thereby reducing soil and land pollution maintain the ecological balance. This would help in better use of land thereby improving the socio - economic conditions of the villagers.
4. It is also observed that electric poles and related infrastructure is available, but the village lacks electric supply.
5. Clean toilets can be seesn in villages which promotes Swachcha Bharat Abhiyan.
6. Some of the suggestive measure for the villages needs to be taken care of:
   a) By establishing better connectivity and transportation in villages, Jangal Aurahi village can be transformed into centre of resources by making centre marketplace.
   b) To reduce the migration from rural to urban areas, there is a need to increase the employment opportunities and better educational systems, by providing MSME (dairy, fisheries, poultry, farming, etc.)
   c) An awareness program needs to be introduced to the villagers so that they can use advanced technologies and schemes by government for increasing their livelihood and agricultural production like Pradhan Mantri Gram Sadak Yojana, Deen Dayal Upadhyay Grameen Kaushalya Yojana, Deendayal Antyodaya Yojana/ National Rural Livelihood Mission, Prime Minister Rural Development Fellowship ,MGNREGA, Sampoorna Grameen Rozgar Yojana, Samagra Siksha Abhiyan, National Social Assistance Programme, Pradhan Mantri Gramin Awaas Yojana, PURA.(Shukla, 2016)

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INTEGRATION OF OCCUPANTS' SENTIMENTS FOR MAXIMISING POSITIVE EXPERIENCE IN HOUSEHOLD DESIGN

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Abstract:

Occupants' sentiments about their domestic environments are holistic, which affects their mental wellbeing. Today, various research methods are used to examine occupants' psychological issues in their domestic settings. The contextual study of occupants' narratives may provide valuable information for integrating their emotions to maximise the positive experience in house design. The study of users' sentiments has many applications in architecture and has grown to be a powerful tool for interpreting others' thoughts. A occupant's narrative has been considered to establish a connection between an inhabitant's experiences and mental wellbeing (i.e., emotional responses or sentiments). This study's primary goal is to analyse the research methods used to evaluate occupants' sentiments in their dwellings. This study's main objective is to understand what domestic settings' occupants need and want and to identify elements in house design models that may improve a satisfying domestic experience. This study has undertaken a relevant literature study to understand the research methodology for analysing user sentiments thoroughly. Semi-structured interviews have been taken into account as data collection techniques for this study at different points. To understand the relationship between occupants' negative and positive emotional experiences according to different household spaces, content analysis has been done using NVivo, a qualitative data analysis computer application. This scientific method of occupant sentiment investigation may also lead to the conception of a domestic "environmental experience design (EXD) framework.

Keywords: *Domestic Environment, Occupants' Experience, Research Methods, Sentiment Analysis*

1. Study Background

In emerging nations like Dhaka, Bangladesh where land is scarce due to the difficulties of horizontal development, the necessity for vertical expansion of high-density urban housing is quickly growing to address the issues. Dhaka's housing market relies heavily on public and private funding (BRAC, 2017, RAJUK, 2015). Most of the housing market is in the private sector. Around 70% of private real estate developers build houses and apartments bigger than 1000 square feet (92 square meters) to appeal to upper-class and higher-income clientele (BRAC, 2017). The public sector only provides 7 to 10 percent of all housing, primarily for government workers employed in the public sector. A scarcity of around 0.5 million housing units is also projected by 2020, in contrast to the 25000 units the private sector generates annually. The housing industry in Dhaka is now changing its target demography from higher and upper-middle-

income groups to lower-middle and middle-income people by creating high-density small-sized apartments. As a result, middle-class families find it more difficult to buy or afford suitable living spaces in large cities like Dhaka (BRAC, 2017; Kamruzzaman & Ogura, 2007). In high-density flats, where physical design elements (such as room numbers, sizes, configurations, and layout) are the main priority in the architectural design process, lower-middle and middle-class families live in claustrophobic or tiny domestic spaces. These cramped quarters are typically crowded, lacking in privacy and convenient environmental facilities which may result in poor living conditions and consequently, adversely affect occupants' mental wellness either directly or indirectly (Chowdhury et al., 2022).

The domestic environment influences the quality of life and psychological problems of inhabitants. Due to socioeconomic limitations, low- and middle-income families are more vulnerable to mental health problems. This is because they have few alternatives to improve or change their present domestic living arrangements (BRAC, 2017; Shams et al., 2014). The limited architectural design considerations for high-density urban housing may not sufficiently address the issue of people's mental welfare in the local context. As a result, domestic environment may affect the feelings/sentiments/emotions of the occupants who live there. Therefore, in a densely populated household setting, assessing and including the inhabitants' sentiments in architectural design and decision-making is necessary which may open up new avenues for environmental experience design (EXD) research (Chowdhury et al., 2020). Through meticulous field observation, this research investigated the occupants' sentiments in a domestic unit among middle-class homes (as an example) in Dhaka, Bangladesh. The findings of this study demonstrate that residents' sentiments directly affect their quality of life or domestic living experiences which may provide new lines of inquiry for EXD research.

2. Sentiment Analysis

Sentiment analysis is a method for data collection from an entity and evaluating any of its subjectivities. Sentiment analysis is a study strategy that examines at the emotions of a sample in order to reveal different points of view by using various research procedures. Whether user-generated content expresses their positive, negative, or neutral feelings will be determined (Saura et al., 2019; Dang et al., 2020). Sentiment may be categorised using three main phases of mining: component or aspect level, sentence level, and document level. It has been shown that sentiment analysis is capable of identifying the emotions, and therefore the thoughts, of product users in terms of understanding how these feelings and opinions influence the users' decision-making. There are several options and strategies for using this technique. Hybrid models, machine learning, and artificial intelligence techniques may all be simulated with the use of specialised software. In addition to machine learning, there are alternative techniques that may improve an algorithm's chances of succeeding depending on the reliability of the information, such as algorithm training using data mining techniques (Saura et al., 2019; Dang et al., 2020). Regardless of whether sentiment analysis is performed using deep learning or more conventional machine learning, text training data must be purified before use to construct the classification. Features- or aspect-based sentiment analysis, polarity sentiment identification, and objective or subjective classification are some of the processes that need to be accomplished. Depending on their context, words and phrases may have differing levels of subjectivity, and subjective sentences can appear in an objective document. Aspect-based sentiment analysis is relevant to sentiment that is focused on certain attributes of entities. Polarity and intensity are two main criteria used to evaluate sentiment analysis. The polarity of the feeling indicates whether it is negative, neutral, or positive. Intensity reveals the relative power of the emotion. Sentiment analysis has been the subject of a significant amount of research in the area of recommender systems. Collaborative filtering (CF), content-based, demographic-based, and hybrid approaches make up the majority of this field's methods, all of which relies on information filtering (Saura et al., 2019; Dang et al., 2020; Kathiravan et al., 2021). Age, gender, nationality, and other user demographic data are used by demographic methods; item and user characteristics can be used by content-based methods; implicit or explicit user preferences are required by CF methods; and hybrid approaches make use of any type of item and user data that can be gleaned from digital networking (actions, preferences, behavior, etc.).

3. Tools and Techniques

In order to gather qualitative (contextual) information regarding the experiences of middle-class residents in certain high-density housing areas of Dhaka, Bangladesh, interviews were conducted. However, during the field data collection period, unanticipated local conditions or restrictions related to the COVID-19 outbreak changed and modified the placement of home examples in Dhaka and data gathering procedures for this study. The University of Melbourne has approved this study's use in human research on an ethical basis (Ethics approval ID 20752). For the purpose of achieving the goals of the research, the inhabitants (also known as respondents) are listened to as they describe their experiences in their homes in light of the various interior spaces, unique preferences, and limitations. The participant initially learned about the research subject and received the go-ahead before the field observation. The collecting of data was unaffected by participants. If they decided not to provide any information during the interview or observation, they were free to remain silent. To contact them once again for study, permission has been obtained. The sentiments of the inhabitants are examined in this research using one interview as an example.

In order to extract the residents' story for this study, NVivo, a qualitative research tool, was used. The analysis of unstructured data is possible using a programme called NVivo. NVivo displays nodes, relationships, and user sentiment coding. It is possible to manually identify attitudes in a way similar to traditional codes by selecting text and manually shifting it to another location. But a great opportunity to swiftly review NVivo's "auto-coding" capability is provided by its sentiment analysis (Pudaruth et al., 2018; Saura et al., 2019). This instrument categorises emotions into four groups: highly positive, slightly positive, somewhat negative, and very positive. It is usual feature to do sentiment analysis by comparing a set of text to a classified definition of keywords marked by "sentiment." To gather certain kinds of data and enhance the findings of sentiment analysis, researchers pre-processed data and components (main attributes). Other data pre-processing options include adding or removing identifying or classifying information—three steps composed the whole procedure by NVivo. First, thematic modeling—a classic built-in model—was used. Second, based on the primary factors influencing the occupants' sentiments, a Sentiment Analysis was done to divide the themes that were identified into three categories: negatively, positively, and neutrally. Third, using the qualitative analytic application, a textual analysis of the results was conducted utilising text data mining techniques (Pudaruth et al., 2018; Bologna and Hayashi, 2018; Saura et al., 2019). All the interface was linked to the Sentiment Analysis and classification until a coverage percentage of >0.1 was reached.

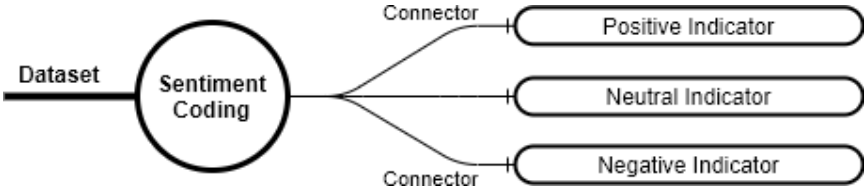

Figure 1. Sentiment coding analysis process *(Illustration: Author)*

4. Occupants' Narratives and Field Notes

Case Study

A middle-class family's Dhaka, Bangladesh, house was chosen for this study. This house has 1200 square feet in size. There are two bedrooms in this house, a master bedroom and a child's bedroom. The master bedroom features a balcony and an attached bathroom. The kitchen is also linked to a portion of this balcony. It should be noted that this home has a study area that is partially located in the child's bedroom. There are separate dining and living areas in the house. A bed that is evidently a guest bed is located next to the sitting area in the drawing room. The drawing room is next to another balcony. There are five inhabitants in this family as a whole. The house under consideration for the case study is situated on the second level of the four-story

building. This house has been inhabited for around 15 years. The housewife of the dwelling was interviewed for this study. The total time of the interview was about 25 minutes. The interview was first audio recorded in Bengali. The interview has been transcribed in English for further study. Below is the schematic floor plan of this house (**Fig. 2**) and various space-related occupants' narrations (**Fig. 3-9**) are described.

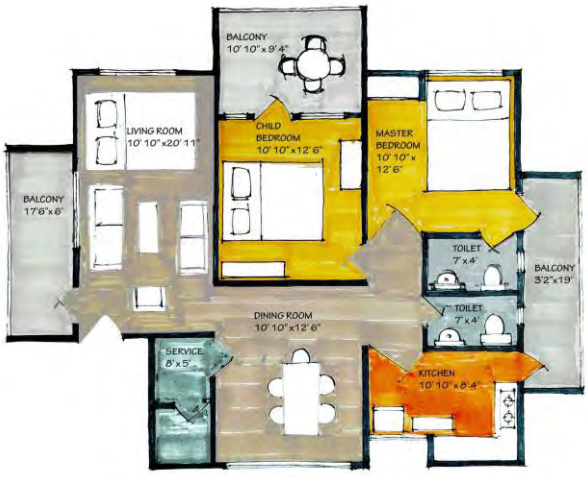

Figure 2. Household plan for case study, Dhaka, Bangladesh *(Illustration: Author)*

Master Bedroom

"… The master bedroom where my mother lives now used to be my grandfather's room. He watched television there. There was a small window in the middle of the wall on the other side of the television. From that window, you can get a view of the dining room. So, in other words, you can watch the television directly from the dining room through this window. So, when my grandfather watched the television, the women inside the house used to sit in front of this window with their work to watch television. This window was made for ventilation but in reality, it was used as a multipurpose window. It is exciting. My mother always tells us stories about her memories of these places. However, I wouldn't say I like the window because it hampers the privacy of the bedroom. The light enters the bedroom through that window. And if someone works in the dining room late at night and another person is sleeping in the bedroom, he will feel irritated with the light coming through this window."

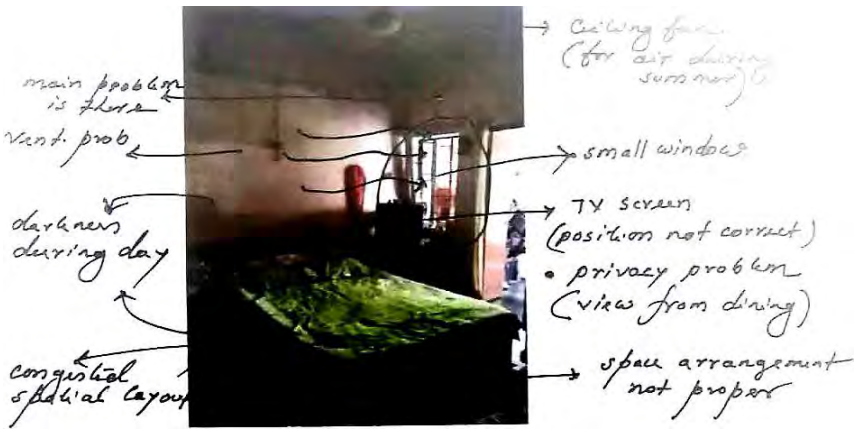

Figure 3. Field notes of a master bedroom

Child Bedroom

"… All the rooms are connected to each other. Although sometimes we face difficulty to placing the furniture correctly. For example, if there are doors and windows on

every side, you do not get any solid walls. So where are you going to keep the furniture? In that case, we must be a little creative, like we use wall cabinets and have made fixed furniture in many places. My room is on the west side—two openings, one door and one window, open to the west balcony. Lots of light and air come from that direction. Every morning i wake up in this room with sunlight. The environment is also suitable for study. Your mind will always be cheerful when there is sunlight."

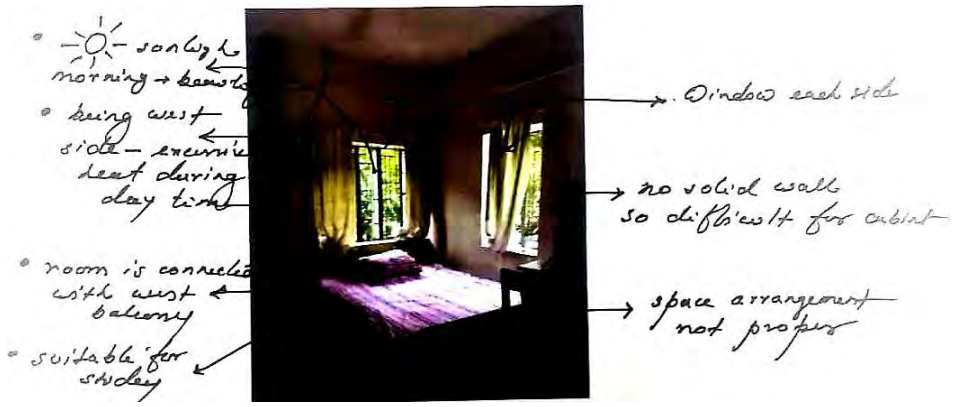

Figure 4. Field notes of a child bedroom

Toilet

"… We do not have a false ceiling above the toilets. So sometimes we feel a little problem with the storage but as the ceiling height is better, we do not face any problem with the ventilation of the toilets. The air flows easily so the ventilation is good."

"… According to the function, I would say there is enough space in the toilets. But the windows are as small as regular toilet windows. So, there is a problem with the ventilation. So, after being in the shower for a long time, it feels frowzy. After coming out of the toilet, you will feel the cold air against your skin. But inside the bathroom, it is very hot and suffocating. It happens because there is no place for the air to go out as there is another building nearby. However, there is no problem with privacy. Usually, the sunshades of toilet windows are very thin. But in our toilets, the sunshades are much bigger, around 1.5-2 ft, giving us better privacy."

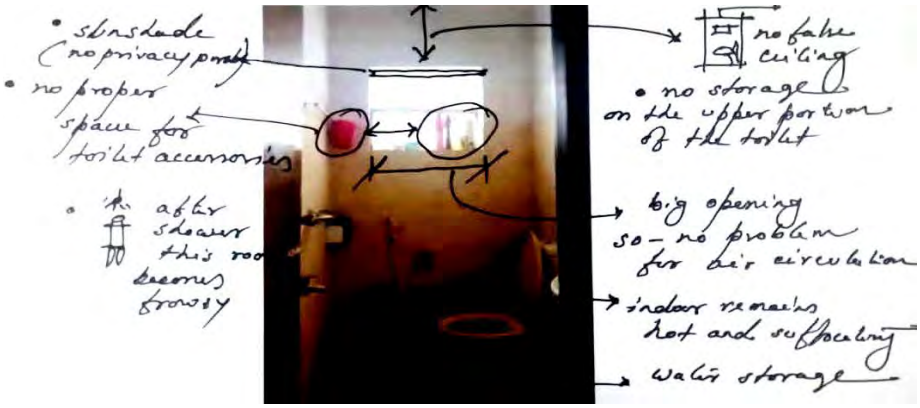

Figure 5. Field notes of a toilet

Drawing

"… Our living room was very large, so we separated a part of that room and used it as a guest room. There is a lot of dust coming from outside. This is very problematic. To avoid this problem, we keep the windows shut or the curtains closed. Also, we must clean them regularly. We often change the furniture arrangement whenever we

have difficulty with the space. For example, we have rearranged the living room recently. We moved my youngest sister's reading table to this room so that the dining room gets more space, and my sister can also study here peacefully. This room is huge; it is being used as a partial reading room. Since guests are not coming due to corona, we are utilizing it differently. The living room of this house used to be my grandmother's room. The room arrangement was different back then. It had a bed on one side and a sofa on the other. This house has two entries. One door is with the living room and the other is with the dining room. The use of this room was completely different back then. Later we changed the space differently. Again, since the pandemic, we are using this room a little differently. Now, this room gives a reading room appearance."

Figure 6. Field notes of a drawing room

Dining

"… In the COVID situation, we saw that not many guests were coming. So, we tried to make the space our own because we stayed home all day. We rearranged it a little so that everyone could use it better. We moved my youngest sister's reading table to this room so that the dining room gets more space, and my sister can also study here peacefully. This house has two entries. One door is with the living room and the other is with the dining room. The master bedroom has a small window in the middle of the wall on the other side of the television. You can watch the television directly from the dining room through this window. This window was made for ventilation but in reality, it was used as a multipurpose window. I do not like the window because it hampers the privacy of the bedroom. The light enters the bedroom through that window. And if someone works in the dining room late at night and another person is sleeping in the bedroom, he will feel irritated with the light coming through this window. The window is still there and we Use a curtain to cover it."

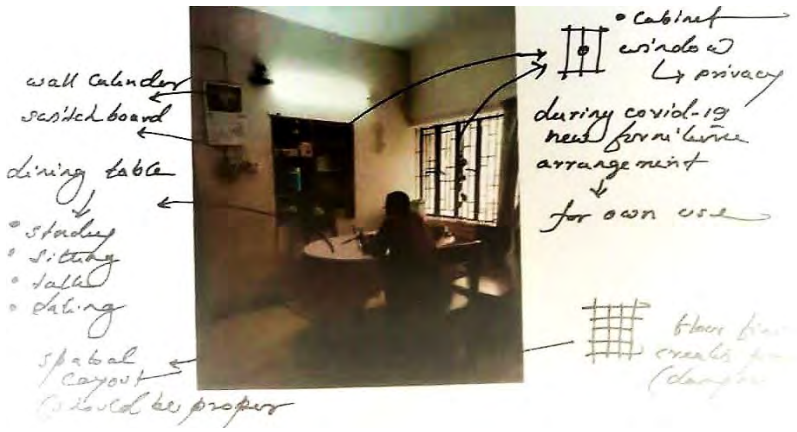

Figure 7. Field notes of a dining space

Kitchen

"… We do not face any problems with our kitchen that people face in apartments. Our house is very old, so our kitchen is big. This type of kitchen is rare. It has also got windows on both sides. The air circulation is perfect. Also, there is sufficient place to work and place furniture properly. So, I would say it is an ideal place for a kitchen. It is one of the best features of our house."

Figure 8. Field notes of a kitchen

Balcony

"… Our living room and the guest room are adjacent to a huge road-facing balcony. But that place has a lot of dust coming from outside. Sometimes the plant on the balcony gets covered with dust if it is not washed daily. This is very problematic. There is a building besides the South balcony, so it gets the shadow of that building. I would say that the balcony on the front side is my other favorite spot with an east view. We use that space for plantations. We have created such an environment that it looks like a forest. My mother takes care of everything and keeps this place neat and beautiful. Also, there are two chairs in this space. We go there and sit for a while. Sometimes we drink our tea there or spend time with a bit of chit-chat. And there is also a structure that is a combination of a planter box and a sitting area. It is built so uniquely that you will not see something like this in any other place. My grandparents designed it like this. This house is a unique feature, and I like it very much."

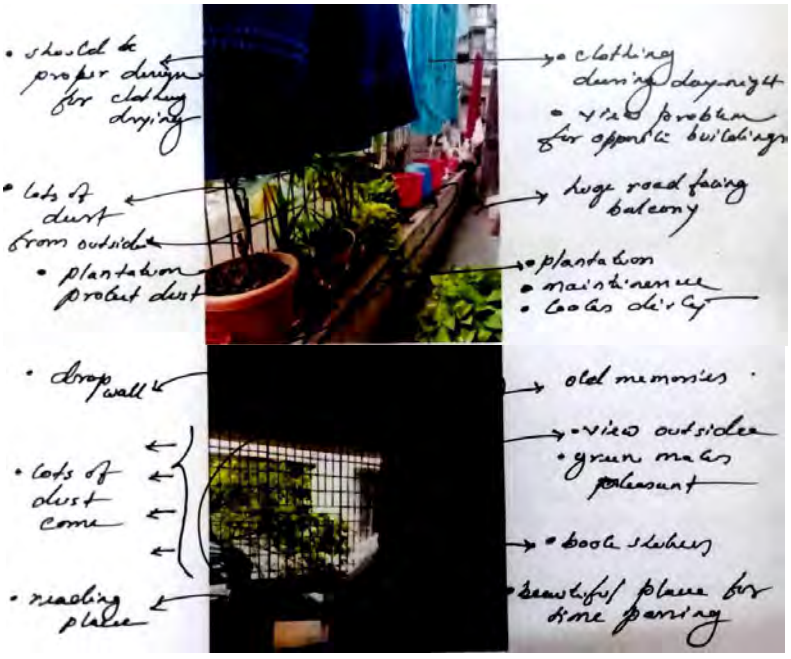

Figure 9. Field notes of a balcony

5. Occupants' Sentiments in Domestic Setting

According to the contextual analysis, the inhabitant feels two very positively and three very negatively experiences about his/her home's living conditions. A total of nine experiences have been classified as having moderately good feelings, as shown in **Table 1**, whereas six of the sentiments are classified as being moderately negative.

Table 1: Occupants' sentiments classification

A: Very Negative	B: Moderately Negative	C: Moderately Positive	D: Very Positive
3	6	9	2

This investigation has shown that negative feelings are the most prevalent of all attitudes with a percentage coverage of 13.02 percent, compared to a percentage coverage of 12.49 percent for positive sentiments. **Fig. 9** and the following sections show the percentage coverage scenario of the occupants' sentiments.

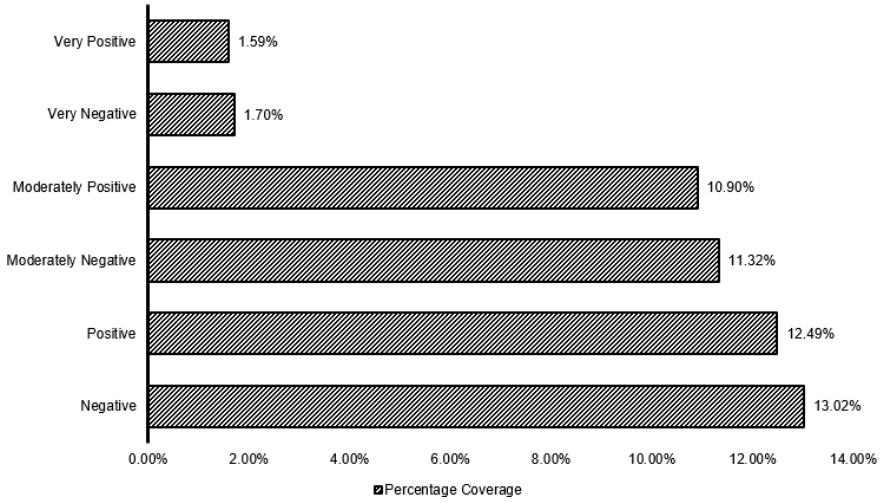

Figure 10. Occupants' sentiments analysis by NVivo

Positive Sentiments

- *… My room is on the west side—two openings, one door and one window, open to the west balcony. Lots of light and air come from that direction. Every morning i wake up in this room with sunlight. The environment is also suitable for study. Your mind will always be cheerful when there is sunlight.*
- *… we do not face any problem with the ventilation of the toilets. The air flows easily so the ventilation is good.*
- *… However, there is no problem with privacy. (Toilet)*
- *… We moved my youngest sister's reading table to this room so that the dining room gets more space, and my sister can also study here peacefully.*
- *… We do not face any problems with our kitchen that people face in apartments. Our house is very old, so our kitchen is big. This type of kitchen is rare. It has also got windows on both sides. The air circulation is perfect. Also, there is sufficient place to work and place furniture properly. So, I would say it is an ideal place for a kitchen. It is one of the best features of our house.*
- *… I would say that the balcony on the front side is my other favorite spot with an east view.*

- *… I would say that the balcony on the front side is my other favorite spot with an east view. We use that space for plantations. We have created such an environment that it looks like a forest. My mother takes care of everything and keeps this place neat and beautiful.*
- *… It is built so uniquely that you will not see something like this in any other place. My grandparents designed it like this. This house is a unique feature, and I like it very much.*

Very Positive Sentiments

- *… My room is on the west side—two openings, one door and one window, open to the west balcony. Lots of light and air come from that direction. Every morning i wake up in this room with sunlight. The environment is also suitable for study. Your mind will always be cheerful when there is sunlight.*
- *… However, there is no problem with privacy. (Toilet)*

Negative Sentiments

- *… And if someone works in the dining room late at night and another person is sleeping in the bedroom, he will feel irritated with the light coming through this window.*
- *… So sometimes we feel a little problem with the storage but as the ceiling height is better, we do not face any problem with the ventilation of the toilets.*
- *… But inside the bathroom, it is very hot and suffocating.*
- *We often change the furniture arrangement whenever we have difficulty with the space.*
- *… Again, since the pandemic, we are using this room a little differently. Now, this room gives a reading room appearance.*
- *… In the COVID situation, we saw that not many guests were coming. So, we tried to make the space our own because we stayed home all day. We rearranged it a little so that everyone could use it better.*
- *… There is a lot of dust coming from outside. This is very problematic.*

Very Negative Sentiments

- *… But inside the bathroom, it is very hot and suffocating.*
- *… There is a lot of dust coming from outside. This is very problematic.*

According to the data shown above, the wide window that provides easy access to light and air is the feature that inhabitants love most. After that, it's more crucial for one of the walls in the home or room to be solid, which means there mustn't be any windows or holes in them so that residents may place a large cabinet there. However, when it comes to how they arrange their spaces, they like spaces that are spacious enough for them to effortlessly shift any furniture about to fit their requirements and tastes. It should be emphasised that how a space is organised or functions matters to the user.

Furthermore, Tenant makes some valid concerns about toilet ceilings. For instance, residents may utilise the excess space above the toilet ceiling as storage. Additionally, the room orientation has been highlighted as a unique consideration. If there aren't enough windows in the toilet, it becomes too unhygenic to use for too long. But in this instance, their right to privacy is equally crucial. The location of the window ought to respect residents' privacy. In household situations, adding a sizable balcony is essential. However, the most significant thing to consider is how to utilise the balcony correctly and how to keep it clean. They can appropriately conduct plantations and other everyday activities, especially if the bedroom and dining/drawing room are joined by a balcony. Occupants' preferences for household design is illustrated in **Fig. 11**.

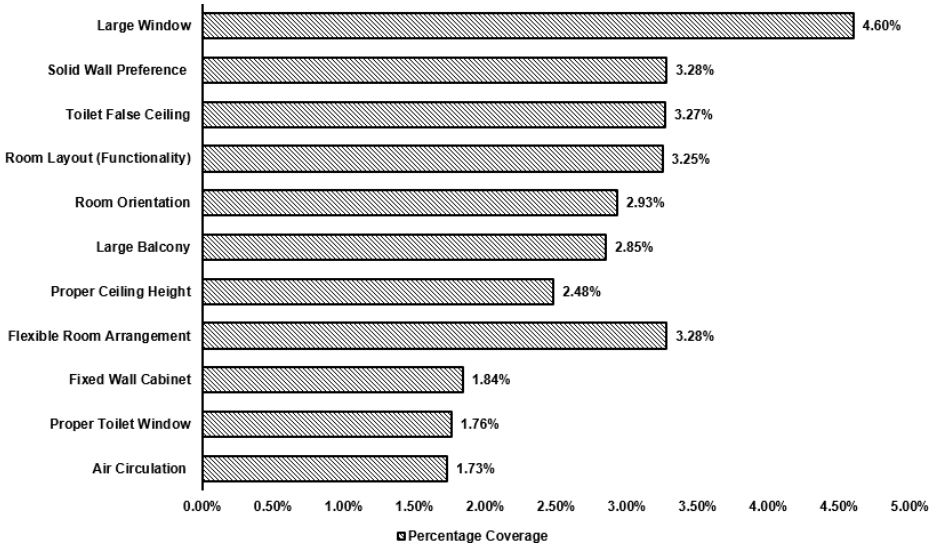

Figure 11. Occupants' preferences for household design

6. Integration into Architectural Design Process

According to the explanation above, people who live in various spaces within a domestic environment have diverse sentiments about spatial and environmental factors. Most people's time is spent inside, usually in domestic settings. Every aspect of a person's everyday life is different when they live in a domestic environment. There are several preferences regarding occupants' wants and requirements in their household situations. Each element of a home's atmosphere affects its residents' sentiments. These aspects in their living situations stimulate the mediative abilities of individuals. As a result, owing to various social and cultural features, contextual influences impact occupant behaviour and perception.

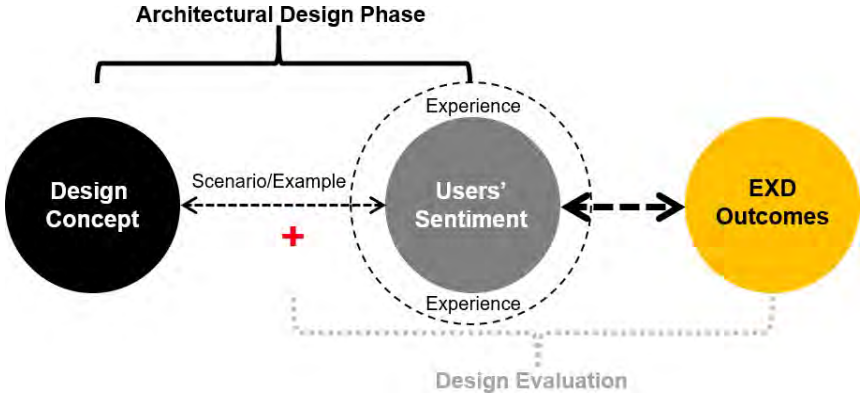

Figure 12. Integration of occupants' sentiments into EXD

Consequently, examining their emotional impressions of their living conditions is essential to improving occupants' mental wellbeing. Integrating thorough psychological perceptions and sentiments related to occupant experiences may enhance the notion of household design. According to the literature, a research gap exists between users' context and the current architectural design process. In the current architectural environmental experience design (EXD) process, the breadth of a description of user experiences is relatively constrained (Chowdhury et al., 2020, 2022). In light of this, user experience includes how residents feel. Therefore, a design strategy for architecture may include users' sentiments together with spatial and environmental preferences, which may enhance the mental wellness of occupants in their households (**Fig. 12**).

7. Future Research Direction and Conclusion

Occupants have holistic sentiments about their living spaces, which has an impact on mental wellbeing. The contextual analysis of occupants' narratives provide some insightful data for incorporating their emotions to maximise the pleasurable experience in household design. A resident's perspective has been taken into account to develop a connection between their experiences and sentiments (i.e., negative and positive emotional responses). At several stages during this work, semi-structured interviews have been considered as a method of gathering data. Content analysis has been carried out utilising NVivo, a qualitative data analysis software programme, to comprehend the relationship between occupants' negative and positive emotional experiences in a domestic setting. A domestic "environmental experience design (EXD) framework might be created using this empirical approach to occupant sentiment assessment.

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CULTURE AND BUILT ENVIRONMENT RELATIONSHIP IN SOCIAL HOUSING OF MANIPUR

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Abstract: *Housing is a system which gives both physical as well as psychological protection. Over time, it has evolved as an expression of culture and society. However, the meaning of housing is reducing merely to a physical construct. Rapid urbanisation and the rising demand of housing especially in the social housing segment have further skewed this definition. The meaning of a house according to some researches has five functions such as shelter which is the most basic function of home and neighbourhood, utilitarian function, domain function, social function and symbolic or cultural function further attesting the fact that the meaning of housing is more complex that just physical shelter. One of the key observations by some researchers in the field of affordable housing segment is the compromise on the quality of life especially the culture and traditions of the society which often gets the least priority. Reduction of the cost till date is the only concern in this segment of housing since the demand is very high and supply very less with social housing mostly left in the hands of public funding. The study of housing will remain incomplete without the understanding of culture, evolution, and society as a whole. Housing and its society often considered as living heritage is an important element of culture and takes forward a crucial aspect of the culture to the future generation. With globalization and in the wake of meeting the rising demands in many sectors, priorities have shifted, often giving culture the least priority. The paper explores the importance of culture in housing and its key role in planning and implementation of social housing schemes for better acceptability and sustenance in Manipur in Northeast India which offers a diverse background of geography, culture, and ethnicity.*

Keywords: *Social Housing, Culture, Northeast India, Affordability, Living Heritage.*

1 Introduction

Housing is a system which gives both physical as well as psychological protection. According to Blauw, the meaning of a house has five functions (a) shelter-the most basic function of home and neighbourhood (b) utilitarian function (c) domain function (d) social function (e) symbolic or cultural function (Blauw,1994) further attesting the fact that the meaning of housing is more complex than just physical infrastructure. Housing over time has evolved as a reflection of culture and time, however with growing needs and demands of the society; housing is reducing to a mere physical construct. A number of researchers in the affordable housing segment have also observed that quality of life in terms of culture and traditions get the least priority while reduction of cost gets the highest priority.

Housing is an important factor that is also considered to assess the economic development of cities. Quality of urban life is mostly explained with the relationship of one's satisfaction with houses, neighbourhood, and town (Senlier, Yildiz and Salihoglu, 2013). Access to basic housing is considered to enhance the economic performance and place competitiveness (Centre for Research and Market Intelligence, 2008). A number of policy makers and researchers have started considering housing as an important barometer. Access to right kind of affordable housing has been considered essential in attracting and maintaining skilled workers which further encourages inward investment (Centre for Research and Market Intelligence, 2008).

Development has posed a serious threat to traditional architecture of the region and has further led to disparity between modern and traditional ways. While those who can afford are moving towards a modern home, those at the hands of government schemes are left with the minimum. Apart from this, it is often left to rural area to keep culture and tradition alive. The pressure of rising demand of housing has led to prioritization to meet numbers while upliftment and preservation of culture and understanding the importance of traditional built form has taken a backseat

India is facing a challenge with the availability and provisioning of housing with rapid urbanization and rising economic disparity. Apart from this there is migration of rural to urban areas further leading to more pressure in housing. While urban India struggles with meeting the demand of housing, rural India struggles with the condition of the physical structure, poor sanitary condition, and basic infrastructure. In this scenario, the priority in housing is given to finding solution to existing issues. However, the issue of culture and traditions if not taken up now will become an issue in future with focus only to solution finding and not innovation.

2 Culture and Development Worldview

Development has always been associated with swanky high rises and modern infrastructure in almost all parts of the world. Cultural and traditional imprints on the other hand were treated as a thing of the past. It was not considered an integral part of development process. Built form was not seen as a reflection of the society but as a mere service for communal life (Emeka Ebuz & Ebere Donatus, 2018). More so, the advent of International style of architecture saw a disconnect with culture. Some of the characteristics of the international style of architecture listed by Emeka Ebus & Ebere

Donatus in the paper, “How International was International style of Architecture” includes (i) rectilinear plans with free plan and free façade; (ii) substation of pitched and protruding roofs with flat roofs with parapet; (iii) avoidance of over embellishment on walls and surfaces; (iv) minimum impact on the physical terrain; (v) democratic spaces that can be changed or modified when needed; (vi) considered anti-climate; (vii) standardization became a norm; (viii) building hierarchy was disregarded (Emeka & Ebere, 2018). International style of architecture can thus be defined as that style of architecture that is devoid of “any political, cultural, religious or geographical undertones”. (Emeka & Ebere, 2018). International style of architecture was criticized by many too. The seclusion of culture and traditions in architectural decisions were highly criticized. George Baired considered as an anti-modernist, criticized it as “architecture without feelings”. The modern housing solution has suffered an irreversible loss of culture and traditions.

However, many organizations both at international and local level are recognizing the relevance of culture in the development process. On the other hand, sustainability which is defined as “development that meets the need of the present without compromising the ability of future generations to meet their own needs” ((Søfting & Wijkman, 1998)) is being looked with a fresh perspective. It has also been stated by many researchers that the three pillars of sustainability i.e. environment, economy and society is incomplete without culture and hence culture as the fourth pillar is a theme that is being explored in the research related to sustainable development and adopted by various organizations including UNESCO. The reason for this decision can be traced to recognizing the fact that, “culture ultimately shapes any kind of development and determines how people act in the world” (UNESCO et all).

Sustainable Development Goals-2030 (SDG-2030) which is the global agenda for till the year 2030 adopted by the General Assembly of the United Nations in September 2015 includes 17 sustainable development goals and 169 specific targets. SDG-2030 has inched itself forward in taking steps in consideration of cultural aspects. Although there is nothing specific to culture, some of the targets such as Target 4.7. 8.3, 8.9 and 12.b and 11.4 finds mention of culture.

United Cities and Local governments (UCLG) which is a global network of governments and associations at various scales is working “to represent, defend, and amplify the voices of local and regional governments to leave no-one and no place behind”. UCLG is working towards ensuring that local government to: (i) integrate culture into all their development policies; (ii) work on developing a strong cultural policy; (iii) every public policy to include a cultural dimension and; (iv) promote the idea of culture. While at the national level, it is calling on governments to include culture in national development plan as a whole by establishing clear objectives and actions in areas of education, economy, communication, and environment etc. UCLG is also drawing the attention of international organizations, development agencies, and United Nations to integrate culture in sustainable development and to promote debate at international platform on the importance of including culture as the fourth pillar of development (UCLG, 2016).

The Agenda 21 for Culture of the UCLG was approved in May 2004 with a commitment to “human rights, cultural diversity, sustainability, participatory democracy and the creations of the conditions for peace”. This document is the first document with a mission

to prepare groundwork for cities and local government across the globe for cultural development. A number of cities and local government across the world has adopted the Agenda 21.

3 Culture and Housing

Culture manifest in various forms, in the way we dress, the food we eat, the way we interact and the houses we live in. Housing and its society often considered as living heritage is an important element of culture. There are many definitions of culture that has been developed over time. Culture is something that influences everything people do in their society because of their ideas, values, attitudes, and normative or expected patterns of behaviour ((BELSHEK, n.d.). According to Hofstede (1980) and Belshek (2006) Culture is the collective programming of the mind which distinguishes the members of one group from another, which is then passed on from one generation to another (Gladwin & Hofstede, 1981). Culture is also an important driving force in the process of economic development (Songjei, et.all 2011).

Amos Rapoport takes a conceptual approach with a broad theory of Environment-Behaviour Relations (EBR) through a framework based on culture. He raises three important questions (i) what biosocial, psychological, and cultural characteristics of human beings influence which characteristics of the built environment; (ii) what effects do which aspects of which environment have on which group of people under what circumstances and why; (iii) given these two-way interactions between people and environments, there must be a mechanism linking them, what are these mechanisms (Rapoport, 2001). In the article published in 2000, Rapoport writes that culture may or may not directly impact the built environment (which is organization of space, time, meaning, and communication, a system of settings, cultural landscape and made up of fixed, semi-fixed, and non-fixed features), however culture which influences kinship, family structure, roles, social network, status, identity and institutions etc. in turn influences the built environment (Rapoport, 2000).

Culture however is slowly becoming a thing of the past and is often left to the hands of the government and monument protection law to be preserved, as it is believed to be an identity of the nation. Identity is also often associated as a mere representation of the nation to the outside world. At this point what is important is to realise that cultural heritage is an important part in the study of sustainable development too.

While trying to understand the context of culture and housing, Oliver (1987) poses an important question regarding housing: why, when considered historically and cross-culturally there are so many different forms of housing in such different settlement types wherein the general answer was cultural differences (Oliver, 1987). The article brings forth an important aspect of the study of culture and housing and how it is linked through a figure called Dismantling of culture and relating its expressions to the built environment. The article gives a strong base for further research for housing and culture.

4 Housing in Manipur: System of settings

Northeast (NE) India consists of 8 states in the eastern most corner of India and is home to about 45.5 million people (Census 2011). A number of cities including rural areas are developing owing to rising population, increase in economic activities and improved

connectivity. Other than the state of Assam which has seen various formats of development in the residential sector, other parts of Northeast's housing development are still mostly individual units. Government led housing schemes like other parts of the country have been providing financial assistance to people of Northeast India too. Pradhan Mantri Awas Yojana (PMAY) is the most recent one which has been able to reach many households both in rural as well as urban areas.

Housing in Manipur is still limited to independent house barring some in the core of the Imphal city which are either built to rent out or owing to growing family members. Whether located in urban or rural setting, cultural and traditional practices are very strongly seen. Families and extended families form societies and live within the same locality similar to a joint family. Traditional houses can widely be seen in rural areas of Manipur.

The traditional layout of a Manipuri Meitei (people of the valley) is still more or less followed even with the upgrade and change in building material. As documented by R. Brown in 1873 in the book, "Native State of Manipur, The Hill Territory under its rule" the houses are constructed with bamboo or wood framing with walls of dried reeds plastered with a mixture of mud and cow-dung while the roof were thatched with grass. As shown in Figure 1, all houses face towards the east which is flanked by a large open veranda. The veranda is an active social space used for seating, entertaining guest, daily household activities as well as for some religious and traditional rituals. The sleeping space for men and women are separate. The fireplace or the kitchen where cooking is undertaken is located in the north-west corner (*which is still followed in all Manipuri Meitei household as a norm in both new as well as old construction*). The start of construction of the house is fixed by an astrologer and on this particular day the first post known as "*jatra*" is erected. The first post (or column in new construction) is bound by cloth at the top along with a wreath of leaves and flowers while a mixture of milk, sugarcane juice and ghee (clarified butter) is poured in the ground dug for the first pole. This tradition is still followed by all new construction till date which highlights the importance of culture and traditions to the people of Manipur.

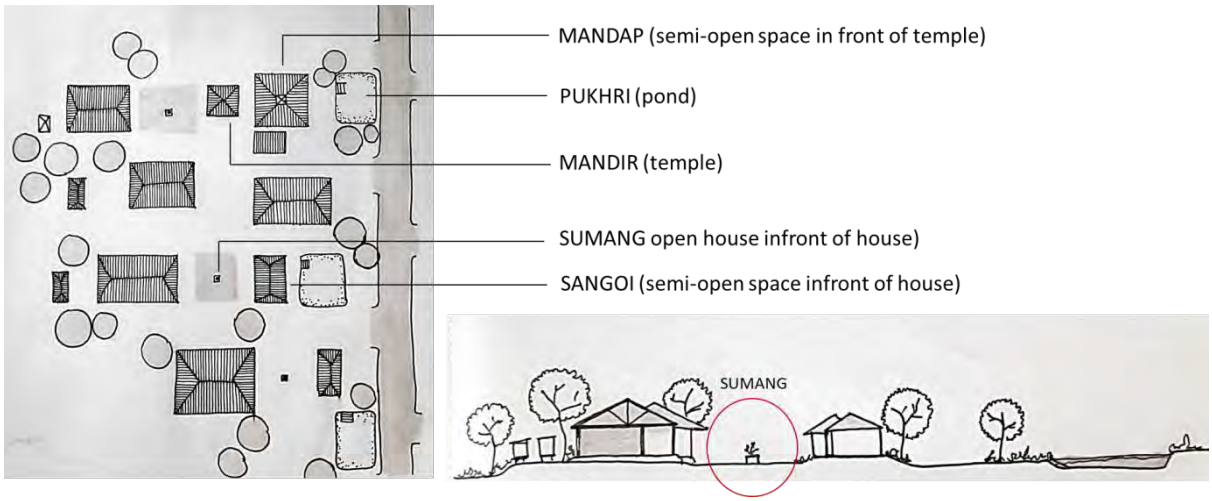

Figure 1: Meitei community cultural and social fabric. Source: Author

In terms of the settlement fabric, a hierarchy of open spaces such as household, neighbourhood and community level is prevalent (highlighted in Figure 1). The household level open space known as "*sumang"* in urban areas is now disappearing to make way for new houses with growing family size. *Sumang* is an open space in front of a house where many festivals are celebrated and rituals are performed such as marriage, death, and birth etc. "Sangoi" is a semi-open space which is used for varied activities such as weaving by women folks. "Mandap", a semi-open space mostly associated with a temple is unique to some community and is used for both families as well as community level functions. On the other hand, community level open spaces are used for larger gathering and community level celebration both religious as well as other occasions. The community level space is more or less preserved both at urban as well as rural areas. In urban areas, the previously open ground has now been converted to semi-open community hall with a roof to be able to use under all weather conditions.

Though the houses are built and operated independently as a family unit, the community level participation is still very prevalent both in urban as well as rural areas. However, in terms of built environment, the new construction is seen to disrupt this social fabric which is strongly observed in the urban areas. It has thus become important to take corrective actions.

5 PMAY-G Housing Typology Disconnect

Post-Independence in 1947, housing and rehabilitation of refugees arriving from Pakistan was a major challenge and focus area of the Government. However, rural housing as an independent program came to the fore only after the launch of Indira Awas Yojana (IAY) in January 1996. Although considered as a successful programme certain gaps were identified in IAY by Controller and Auditor General of India in the year 2014. Lack of clear data of housing shortage, non-transparent beneficiary selection process, decreased housing quality and technical supervision, and issues related to loan availability were some of the few gaps in IAY implementation.

With an aim to solve the above identified issues and to align this program to *Housing for All 2022* Mission, IAY was restructured into Pradhan Mantri Awas Yojana-Gramin (PMAY-G) wef to 1st April 2016. The aim of PMAY-G is to provide "a pucca house each with basic facilities to all houseless households and to those household still living in kutcha and dilapidated houses by 2022". The immediate objective was "to construct and handover one crore houses to households living in kutcha/dilapidated houses in three years (2016-2019)".

Prakriti Hunar Lokvidya (PAHAL) was a study conducted under the PMAY scheme to capture the traditional and local construction techniques across India. Based on the study conducted on ground, a number of typologies were developed which could be referred to by the beneficiary to build their house under this scheme. These typologies which were divided more on the basis of geographical location were affordable but to how much it is appropriate culturally and socially (Katharpi & Doloi, 2018, 619-626) needs to be examined in more detail. Katharpi and Doloi (2018) in the Assamese housing design study in their review found that many families that had moved out of traditional homes to newer construction were not favourable in terms of their socio-cultural aspect and its traditional landscape (Katharpi & Doloi, 2018, 619-626).

Under PAHAL, Manipur has been divided into three zones namely ZONE A (the valley areas and adjoining hills comprising of Imphal west and east, Bishnupur and Thoubal districts), Zone B (higher altitude hill areas comprising Tamenglong, Senapati and Ukhrul districts), and Zone C (lower altitude hill areas comprising of Churachandpur and Chandel districts). Zone A has two typologies while Zone B and Zone C have one typology each.

While geographically it may be appropriate to divide Manipur into these zones, however the origin of the inhabitants can be long traced to very early times each with their own unique identities and culture as highlighted in Figure 2. In terms of geography and for ease of study Manipur were broadly divided into the Hills and the Valley but with time and understanding of the relevance of cultural fabric, this divide needs to be re-looked at. The Valley was mostly inhabited by the ***Meiteis*** (along with ***Meitei Pangal***) and some tribal population while the Hill is majorly inhabited by various tribes which broadly falls under ***Naga***, ***Kuki*** and ***Maring***. Each tribal group has their own belief system and myth associated with their origin. The origin of the ***Meiteis*** has certain contradictory explanations ranging from that originating from a Tartar Colony from China, an original race based on Mahabharata or the Shang Kingdom of Pong, China. The *Naga* is believed to have come from the North from the Kachar district of Assam. This is further attested by the fact that Naga tribe has attachments for the site in which their village is situated in contrast to the migratory nature of other tribes; the *Kuki* tribe on the other hand is believed to have originated from the South and the East of Manipur. The *Maring* is believed to be from the East since they closely resemble the Burmese, while the *Meitei Pangal* (Muslims) is believed to be brought as battle captives.

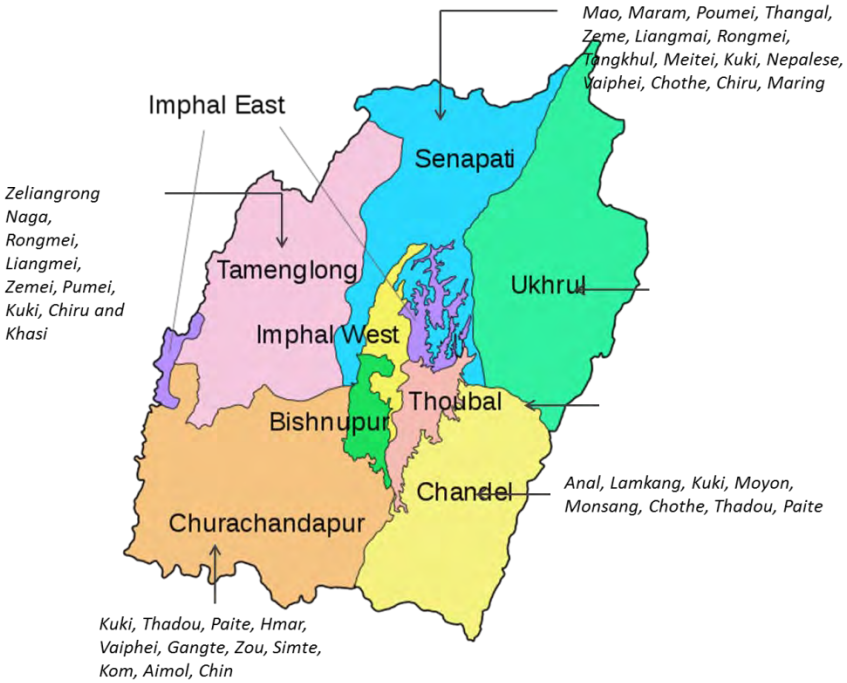

Figure 2: Erstwhile District Map of Manipur showing various tribes. Source: Redrawn from Maps of India

The primary focus of PAHAL is local material and construction technology, “vetted for both structural and resilience to the vagaries of local climatic conditions” (PAHAL-Volume II). The housing typology proposed for Zone A as shown in Figure 3 has attempted to stick to the traditional construction technique and inclusion of a veranda in the front but has no reference to culture or arrangement of spaces based on local traditions. Any housing project cannot be also looked at in an isolated manner. The relation of the outside and the inside along the built and the un-built needs equal attention. It must also be highlighted that culture and family structure changes as much as how climate and the environment is changing. To simply adopt a traditional typology without understanding of these angles would be inappropriate.

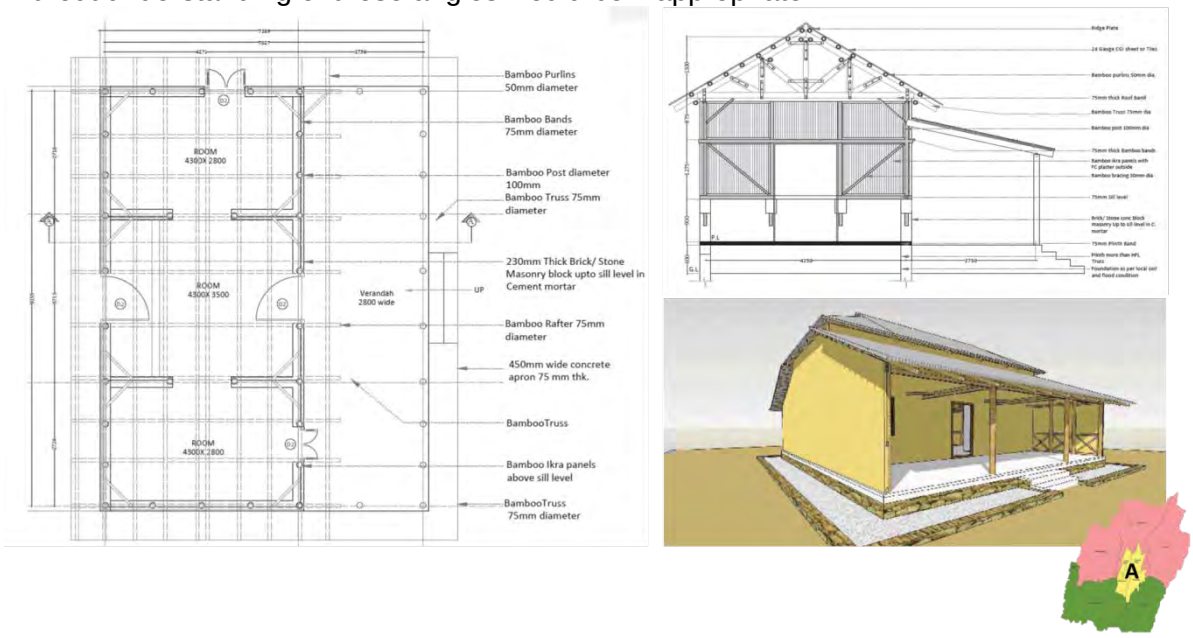

Figure 3: PAHAL House Typology Design. Source: PAHAL, Prakriti Hunar Lokvidya, PMAY-G, Ministry of Rural Development, Government of India

It can also be highlighted that neighborhood planning and design in most of our policy documents related to housing is not given due consideration. The focus of most social housing schemes are related to affordability, construction technology and achieving targets due to rising demand. As mentioned earlier in the paper, quality of life is mostly explained with the relationship of one’s satisfaction with houses, neighbourhood, and town (Senlier, Yildiz and Salihoglu, 2013).This approach to housing has led to a congested and meaningless urban fabric.

The open space outside a house (used for a number of activities including household cottage industries) which is not taken into consideration leaving the decision to mostly the land owner needs to be revisited. The design of a house does not mention any particular direction nor has an alternative suggestion if the plot or available land is not line with the suggested design. This may not seem like a major issue when one is dealing with a fairly large plot or uncongested neighborhood. On the other hand a typology needs a proper setback highlighted or designed so as to ensure proper light, ventilation and space hierarchy. What we need to realize is that cross-reference of

different policies such as building byelaws, UDPFI guidelines becomes cumbersome for a project of this scale.

6 Conclusion

Housing is a settlement process and a way of people to communicate with the surrounding. The concept of “Housing as a verb and a process”-(Turner and Ward, 2017) needs due attention in all housing study. Many nations and organizations have recognised that culture and heritage plays an important role in the development of the nation and has included various aspects of culture in their policies. Inclusion of culture however should not end in just policy documents but needs to be seen through till the end.

For a community to be sustainable, culture should become a core aspect for promoting cohesion, conviviality, and citizenship (UCLG, 2016). Culture creates an identity and a sense of belonging which in turn enables the community as a whole to actively participate into the upliftment and preservation of the society as whole. Traditions, rituals, and culture are an important heritage that needs to be conserved. Many times solutions to a number of issues are found in local knowledge. Traditionally all societies have been inclusive ensuring each members are taken care of. It was also a thread that was keeping the community together.

An attempt has been made in addressing locally available building material and construction technology in policies concerning social housing but when it comes to prioritizing between reduction in the construction cost and others, cost becomes the first and only priority. A society is shaped cultural and traditional practices but social housing is still addressed as a unit but not as a part of the larger whole. Social housing schemes in developing cities of India are grappling with rising demand and shortage in supply, with authorities turning a blind eye towards other aspects of housing. It has does become important to look as social housing in rural areas with a fresh perspective before rural India goes into the same path as urban India.

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