

Proceedings of The 1st International Conference on Smart Villages and Rural Development COSVARD 2018

12-14 December 2018
Assam Administrative Staff College
Guwahati, Assam, India

Editors:

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The University of Melbourne
Victoria 3010, Australia



Smart Villages Lab
Culture • Construction • Capacity • Community

1st International Conference on Smart Villages and Rural Development (COSVARD 2018) hosted by the Smart Villages Lab (SVL) of the Faculty of Architecture, Building and Planning of the University of Melbourne.

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Preface

A very warm welcome from the conference Convenor and the Chair to all the attendees and stakeholders of COSVARD 2018 conference.

In 2018, for the first time the International Conference on Smart Villages and Rural Development (COSVARD) has been set up to run as an annual conference. The 1st International Conference on Smart Villages and Rural Development (COSVARD 2018) was hosted by the Smart Villages Lab (SVL) of the Faculty of Architecture, Building and Planning in the beautiful city of Guwahati of the North East Indian state of Assam. The conference was held in the premier venue of Assam Administrative Staff College, Khanapara on 12-14 December 2018. The local partner for COSVARD 2018 was the premier technical institute of Assam, Assam Engineering College, located in Jalukbari, Guwahati.

With over 40% of the world's population now living in rural areas, there is a global interest in research associated with the creation of "Smart Villages" to address the ever growing urban-rural divide. Smart Villages 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.

COSVARD was created for serving two clear purposes. First, resulting from the current Smart Villages project funded by the State Government of Assam, the conference is considered as an important milestone in the ongoing partnership between the University of Melbourne and the Government of Assam for developing shared capacity. Second, because Smart Villages and Rural Development is an emerging area of research, COSVARD becomes a gateway for imparting intellectual discourse among the communities of practitioners, academia, policy-makers and students facilitated by the Smart Villages Lab (SVL) at the University of Melbourne. The research and development initiatives at SVL aim to narrow the gap between urban and rural communities. It is our intention that the conference becomes a regular occurrence 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. Having developed a critical mass in the Smart Villages context, teaching activities such as specialised classes and traveling studios will eventually be introduced to broaden the interdisciplinary education curriculum at the University of Melbourne and beyond.

The scope of COSVARD 2018 conference was within five broad themes, 'Rural Housing', 'Rural Infrastructure', 'Rural Economy', 'Sustainability' and 'Smart Governance'.

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.

Finally, 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.

The research papers received from broad audience across all five themes were accepted for COSVARD 2018 following the double-blind review process. The scientific committee of the conference comprised over 28 experts from diverse disciplinary background recruited globally. Five selected keynotes were presented by five distinguished academics in the field. The keynotes presenters were Prof Atul Bora, Principal Assam Engineering College; Prof Anu Gokhale from the University of Illinois, USA; Prof Koshy Varghese from Indian Institute of Technology Madras, India; Prof K C Iyer from Indian Institute of Technology Delhi, India and Prof Sunil Singal from Indian Institute of Technology Roorkee, India.

Last but not least, I sincerely appreciate the support, dedication and commitment of every single member of the scientific committee and a few other distinguished colleagues in reviewing the papers for the conference. Without their selfless support and good wishes, COSVARD 2018 would not have been possible.

With warm regards



Dr Hemanta Doloi,
Convenor and Chair
Director (Smart Villages Lab)

Message from Co-Chair

At the outset, I wish to thank everyone involved in organising COSVARD-2018 in a grand manner.

Assam Engineering College, being the local organising partner, involved in collaboration with University of Melbourne for this 1st International Conference on Smart Villages and Rural Development (COSVARD), which is one of the key by-products of the ongoing collaborative research project geared towards upgradation of skills in construction sector of the state. The construction sector has a strong multiplier effect on all other sectors of economy and therefore attempt has been made to engage all stakeholders to make the collaborative venture a grand success.

This conference is organized with a vision for sharing intellectual knowledge and wisdom of experts committed for upgradation of skills in the construction sector of the places of high need such as the state of Assam, and states in India and abroad and to disseminate the information to all stakeholders involved in construction sector with a focus to facilitate creation of smart and sustainable villages and cities.

As Skills in Construction, Information Communication and Technology (ICT), Smart and Sustainable Village and Cities, Sustainable human settlements are embedded to each other, the theme of this annual conference is chosen to continue a healthy debate among the participating experts and stakeholders of diverge background.

Our message is clear. 'Smart Village' will never happen without 'Sustainable Construction Practices'. Therefore, improvement of capacity in this sector is taken up to create smart and sustainable villages, cities and towns in the state as well as in the world.

I wish the COSVARD will become a truly international event with the above stated mission in years to come.

With warm regards to all the delegates participated in COSVARD 2018.



Dr Atul Bora
Conference Co-Chair
Principal, Assam Engineering College

Committees and Partners

Organising Committee:

Dr Hemanta Doloi (Chair), The University of Melbourne
Dr Atul Bora AEC (Co-Chair), Assam Engineering College
Dr Sally Donovan, The University of Melbourne
Mr Geoff Kimm, The University of Melbourne
Prof Ray Green, The University of Melbourne
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COSVARD 2018 – 1st International Conference on Smart Villages and Rural Development

Venue: Assam Administrative Staff College, Khanapara, Guwahati
Date: 12-14 December 2018

Tentative Program Schedule

1st International Conference in Smart Villages and Rural Development (COSVARD 2018)

Agenda for Opening Ceremony and Inauguration

**Wednesday 12 December 2018
Assam Administrative Staff College**

10.00-10.10 am:	Chorus by students of AEC members
10.10-10.15 am:	Felicitation of Guests
10.15-10.20 am:	Welcome Speech [context and purpose] Dr Atul Bora [Principal, Assam Engineering College]
10.20-10.30 am:	Introductory Remarks, Project briefing and introduction of the project team [Dr H. Doloi, The University of Melbourne]
10.30-11.15 am:	Inaugural Address [International Conference in Smart Villages and Rural Development] Sri Siddhartha Bhattacharya Hon'able Minister, Education, GDD, Law & Justice Government of Assam
11.15-11.25 am:	Project Insights [Prof Mark Burry, The University of Melbourne]
11.25-11.35 am:	Project Insights [Prof Ray Green, The University of Melbourne]
11.35-11.45 am:	Address by Shri Maninder Singh, IAS Principal Secretary, Higher Education, Government of Assam
11.45-11.50 am:	Vote of Thanks [Dr Sally Donovan, The University of Melbourne]
11:50am:	High Tea

Technical Session starts at 1:30pm

Time	Wednesday 12th	
1.30 pm	Keynote: Smart Village as the Basic Building Block of a Sustainable World (A. Bora, Principal, AEC)	
2.10 pm	Keynote: Smart Technologies and their role in rural development (A. Gokhale, Illinois State University, USA)	
2.30 pm	Afternoon Tea	
3.30 pm	Session 1: Housing	
	Chair: Prof Ray Green	Authors
	Paper 1 – Housing typology as development indicator	Dr S. Donovan, University of Melbourne
	Paper 12 – Studying rural housing for Smart Villages, Assam: Case Selection Strategy	V. Katharpi and H Doloi, University of Melbourne
	Paper 19 – A novel approach of constructing ferrocement wall for cost-effective housing	M. Goswami, S. M. Dhar, B. Swargiary, R. Boro, Central Institute of Technology, Kokrajhar; V. Varma School of Planning and Architecture, Delhi
	Paper 29 – Reinventing patterns and traditional elements in vernacular settlements in rural India	S. Bantanur, BMS School of Architecture, Bangaluru
5.00 pm	End of day	

Time	Thursday 13th	
9.00 am	Keynote: Rural Governance (K. Varghese, IIT Madras)	
10.30 am	Morning Tea	
11.00 am	Session 2: Governance	
	Chair: Dr Sally Donovan	Authors
	Paper 6 - A conceptual model framework of Smart Village for Sustainable Development	Dr A. Chakraborty, TPI; R. Pawani, GIMT; Dr S. K. Deb Assam Engineering College
	Paper 25 - ICT4D for Smart Governance of Rural Development	G. Kimm, Swinburne University of Technology; H. Doloi, University of Melbourne
	Paper 28 - The new Assam smart village dwelling: meeting the challenge of absorbing new technologies	X. Huang, V. Katharpi, University of Melbourne; M. Burry, Swinburne University of Technology
	Paper 31 – Towards the Environmentally Sustainable Smart Village	R. Crawford, The University of Melbourne
12.30 pm	Lunch	
1.30 pm	Keynote: Small hydro in rural development (S. K. Singhal, IIT Roorkee)	
3.00 pm	Afternoon Tea	

3.30 pm	Session 3: Infrastructure	
	Chair: A/Prof Robert Crawford	Authors
	Paper 9 - Computer Aided Design of a Multipurpose Wheelchair for Rural Areas of Assam	M. Bhuyan, R. Rahman, S.K. Deb, Assam Engineering College; H. Doloi, University of Melbourne
	Paper 23 - Collaborative governance structure for maintenance of rural roads	A. Panda, L. Boeing, IIT Guwahati
	Paper 24 – Implementation of Power Modulator Circuits in Smart Village Bus Architectures	S. Bharadwaj, J. Pathak ² , U. R. Kalita ³ , P. Sarma, S.R. Baruah, A. Thomas - ^{2,3} Assam Don Bosco University and Indian Institute of Information Technology.
	Paper 30 – Creating a Self-Help Parametric Digital Workbench Prototype for Assam Village Development	G. Kimm and M. Burry, Swinburne University
5.00 pm	End of day	
Evening Activity (Optional)	Al Fresco Grand dinner cruise on the Brahmaputra River with traditional Assamese folk dancing and live music	

Time	Friday 14th	
9.00 am	Keynote: Infrastructure Funding (K. C. Iyer, IIT Delhi)	
10.30 am	Morning Tea	
11.00 am	Session 4: Finance/ Employment	
	Chair: Prof Koshy Varghese	Authors
	Paper 4 - Employee engagement as a tool for rural development: an empirical study on rural retail banking sector	P. P. Mishra, P. K. Biswal, Xavier University; S. K. Ghosh, Indian Institute for Production Management
	Paper 8 - Is JAM enough to ensure financial inclusion in rural economy?	A. Chetia, Jawaharlal Nehru University
	Paper 17 - Rural development through ecotourism, nature conservation and environmentally sustainable design (ESD)	R. Green, University of Melbourne
	Paper 27 - Reviewing organisational buying decision-making and mass custom design mechanisms for sustainable housing delivery	M. Noguchi, University of Melbourne
12.30 pm	End of Conference	

Keynotes Speakers and topics

1. Prof Atul Bora, Principal, Assam Engineering College, Guwahati, India
 - *Smart Village as the Basic Building Block of a Sustainable World*
2. Prof Anu Gokhale, Illinois State University, USA
 - *Engaged Learning for Rural Development*
3. Prof Koshy Varghese, Indian Institute of Technology Madras, India
 - *Rural Governance and Community Participation - participatory modelling by rural stakeholders in Village development*
4. Prof K C Iyer, Indian Institute of Technology Delhi, India
 - *Rural infrastructure financing – drivers and impediments from an Indian context*
5. Prof Sunil Singal, Indian Institute of Technology Roorkee, India
 - *Small Hydro in Rural Development*

Housing and development indicators in Majuli

Sally Donovan¹

¹ Smart Villages Lab, University of Melbourne, Australia, donovan.s@unimelb.edu.au

Abstract: We asked residents of Majuli District in Assam to classify their house into one of five categories: mud, bamboo/timber, raw-bricked, Assam-type or concrete. We explore whether these housing classifications are purely based on building materials, or whether there is some socio-economic component. We found that a more detailed analysis of the building materials shows a lot of overlap between the classifications likely due to most houses being built from a mix of different materials. Using income and electricity access as development indicators we found that there was some indication of status in the classifications in that RCC and Assam-type houses tended to be wealthier and more likely to have electricity than the other types. There was not a huge distinction between the other classifications. Overall around 20 per cent of households do not have electricity in the region. Combining these results with results of research into international electrification projects, we recommend that if the government wants to improve development in the region through electrification, a key component of the scheme must be a training programme to raise awareness of ways electricity can be used to improve livelihoods.

Keywords: Smart Villages, Housing, Sustainable Development Goals, Energy access.

1 Introduction

Since 2000 the United Nations Millennium Development Goals (MDGs) have catalysed the implementation of many developmental policy interventions. These have led to significant improvement in the livelihoods of many of the world's poorest residents. However, these improvements were disproportionately targeted to urban areas, leaving rural communities behind and increasing the urban-rural divide. One of the lessons learnt in the implementation of these goals is that a bottom-up approach – where local residents are consulted throughout the policy-formulation process – often lead to more successful outcomes than top-down approaches, where policies are formed between governments and academics only. This is especially true for rural areas, where traditional lifestyles are far removed from those of politicians and academics who often reside in modern urban environments.

In 2015 the expansion of the MDGs into Sustainable Development Goals (SDG) has provided a more detailed series of objectives for policy-makers to improve the quality of life of people in developing economies (United Nations, 2018a). Building on the assertion that consultation with local residents will lead to more successful policy interventions for rural communities The Government of Assam have commissioned a team of researchers from the University of Melbourne to conduct a long-term research project into Assam, where over 80 per cent of the population reside in rural areas. The initial phase of the research programme is focusing on the Majuli District as a case study area, as described in section 2. The first phase of our project was to engage with local residents through a face-to-face household survey. The survey methodology will be described section 3.

One of the aims of this survey was to establish the current status of Majuli residents. We want to understand whether the type of house that a resident lives-in provides an indication of their development status, and thereby indications of which households need to be targeted for developmental improvements. In section 4 of this paper we explore the housing classification options collected through the survey. These were largely based on building materials and we look at how distinctive these classifications are in relation to this attribute. We then look at other attributes of each housing classification including the number of household members, number of rooms and size of the house. We compare how these values vary both within and across housing classification.

Having established the physical attributes of the 10-0-m housing classifications from the survey, in section 5 we look at the relationship between housing classification and two key development indicators: household income and access to electricity. Finally, in section 6 we give an example of how we combine the survey results with our research into development policy interventions from around the world to development policy recommendations for in need residents of Majuli.

2 Case study area

Majuli is an island in the Brahmaputra River, which became an independent district of Assam on the 8th of September 2017 (Karmakar, 2016). It is considered the largest river island in the world by the Guinness World Records, stealing the title from Marajo, Brazil in 2016 (India Today, 2016). However, due to erosion caused by frequent flooding in the region, the island is shrinking and is reported to have lost more than 50 per cent of its land mass (Down to Earth, 2016). It is an entirely rural district comprised of 12 official villages and approximately 2300 households. The precise number of households is difficult to determine as the most recent census was in 2011, nearly 7 years ago, and the

frequent flooding means that many houses are lost annually. The scale of this loss and subsequent rebuilding is not well documented. For our survey we collected data from 2154 households, with representatives from all 12 official villages.

3 Survey

3.1 Development of questions

The survey questions were developed using previous censuses and other NGO surveys. The initial set of questions was distributed to seven experts for review and the final survey incorporated all their feedback as far as possible. The total number of questions varied depending on the household as some questions were targeted to each household member, therefore the total number of these depended on the number of occupants. Table 1 lists the topics covered in the survey and a sample of the type of questions covered within each broad topic area.

Table 1: Topics covered in Majuli survey

<i>Main Topics</i>	<i>Example sub-topics</i>
Housing	Building materials, size, number of occupants, age
Household demographics	Income, education, occupation, age, gender, potential
Energy use	Electricity availability, appliances used, cooking fuels
Agriculture	Size of land, crops, livestock, income generated
Skill level	Current skills, desire to gain new skills, willingness to pay for skills development
Infrastructure priorities	Roads and maintenance, healthcare provision, education etc.

3.2 Implementation

The surveys were collected between mid-2017 until the end of August 2018. Students from Rangachahi College, a school located in Rangachahi, the central and largest village on Majuli, were trained to collect the surveys. Local people were used to collect the survey data to avoid any potential language or other cultural barriers. It also helped us to engage closely with the local community and provide some interesting and potentially useful work experience to young people in the region. It also avoided the difficulties associated with accessing this isolated location for people residing in other locations.

The surveys were collected via an app on four ipads supplied to the Rangachahi College by the University of Melbourne. Figure 3-1 illustrates the survey interface. As can be seen it was fairly easy to navigate, containing a mix of drop down box selection, multiple choice and input answers. Collection via the app also meant that the data were instantly uploaded to a cloud and accessible by researchers for analysis.

Figure 3-1: Screengrab of survey interface

Each survey collector was also provided with a handheld GPS device and a digital camera allowing them to accurately note the longitude and latitude of each household and to take a photograph for documentation.

4 Results

4.1 Housing

Housing is a major issue in Majuli. As in most parts of the world there are housing shortages. Resilience of housing is also a big issue as Majuli is prone to both flooding and earthquakes. Designing affordable housing that can withstand these phenomena presents a challenge for any housing scheme. In Assam, the cost of land is relatively cheap, while construction is very expensive. In a secluded region like Majuli, the cost and availability of building materials is limited by many factors not least of which is lack of transport infrastructure making it difficult to transport building materials to the island. As a result, many houses are built in a piecemeal fashion, with people building as much as they can afford initially and then adding to their house over time.

Previously the Government of Assam instigated an initiative entitled “Housing for all” where people were provided with housing of one of five designs. The designs were derived from a very high level academic approach that only considered the physical and geographic characteristics of the regions. As a result, the housing failed to meet community expectations and the scheme was not entirely successful. For example, the scheme failed to consider the occupational needs of the community. As Majuli is a very rural region, the majority of its residents are engaged in agricultural activities. Therefore, they may require areas in their home for storing grain after a harvest, or for livestock, particularly during the wet season when there is much flooding; bringing livestock indoors may become essential.

Another important point to note is that Assam is very culturally diverse. There are 115 different recorded ethnic groups in the region (Wikipedia, 2018) with diverse cultural and religious practises. For example, some religions require segregated areas for male and female household members. These are examples of the essential functionality within households that was not accounted for by the housing for all scheme. One of the aims of our Majuli survey was to establish the current state of housing in the region in detail as well as determining the housing aspirations of the villagers.

4.2 Building Materials

The survey asked residents to classify their house according to one of five typologies: mud, bamboo/timber, raw-bricked, Assam-type or RCC. The pie chart in Figure 4-1 shows the distribution of results. As can be seen 50 per cent of the houses were classified as mud, indicating the majority are built from locally available natural building materials. The second most common is the Assam-type house, followed by raw bricked, bamboo/timber. The least common is RCC at only 3 per cent, likely due to this being the most expensive house type making it unaffordable for the average resident of Majuli.

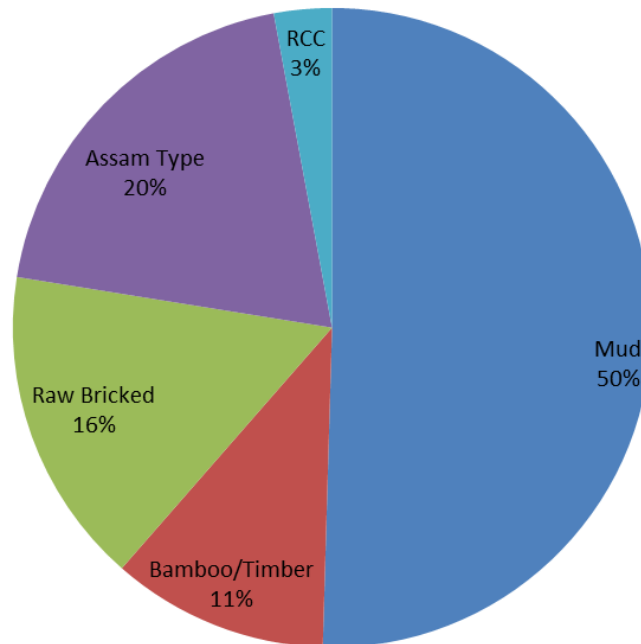


Figure 4-1: Distribution of housing typologies on Majuli Island

Due to the piecemeal fashion in which houses are often built in the region, it is likely there is some overlap between these categories as many houses may have sections built from different materials. To get a clearer picture of housing we therefore asked for the primary building material of each of the main sections of the house.

Figure 4-2 shows the distribution of primary roofing material by housing type. As can be seen the predominant roof material across all housing types is tin, mainly as dual sheets (tin dui Sali) with only a few as single sheets (tin ek Sali). RCC is the main roofing material in RCC houses. Other categories of locally available natural materials such as bamboo and thatch are surprisingly uncommon.

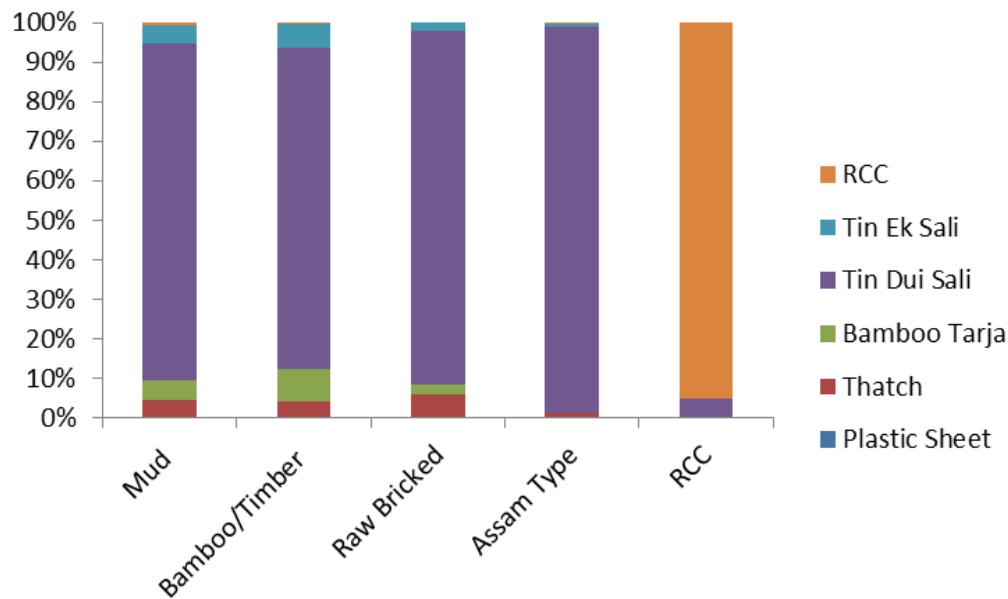


Figure 4-2: Predominant roof building materials by housing type

Figure 4-3 shows the distribution of primary wall building materials. Bamboo tarja (bamboo woven into sheets) is the most common material over all, and found most frequently in mud, bamboo/timber and raw-bricked houses. However, there are a significant number of Assam type houses with bamboo as the predominant wall building material, illustrating the overlap between the housing typologies and difficulty in making clear classifications with this limited number of options. For the Assam type and RCC house full-brick is the most common response to the predominant wall material as expected although interestingly there are some houses in the other categories coming up as full or half brick.

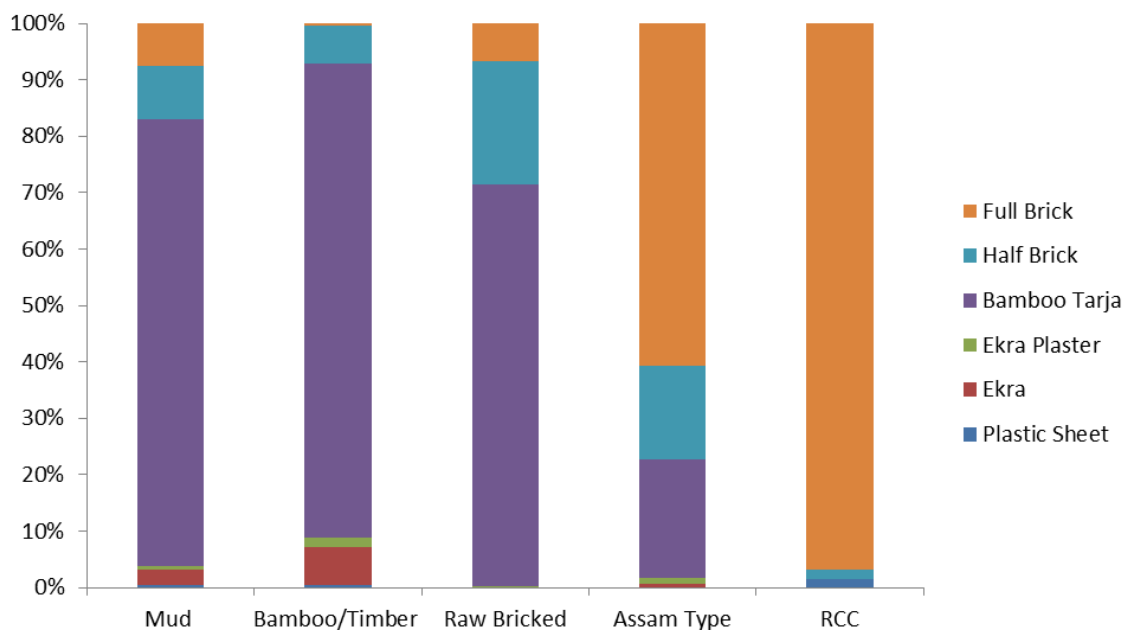


Figure 4-3: Predominant wall building materials by housing type

Figure 4-4 shows the predominant floor building materials. Earthen floor is the most common response across all housing types, and especially in mud, bamboo/timber and raw bricked categories. In RCC houses cement and tiles are the most common flooring materials. Brick soling features in every housing category but is not very common. Marble and granite are very rare in the region, likely due to the higher cost and lower availability of these materials.

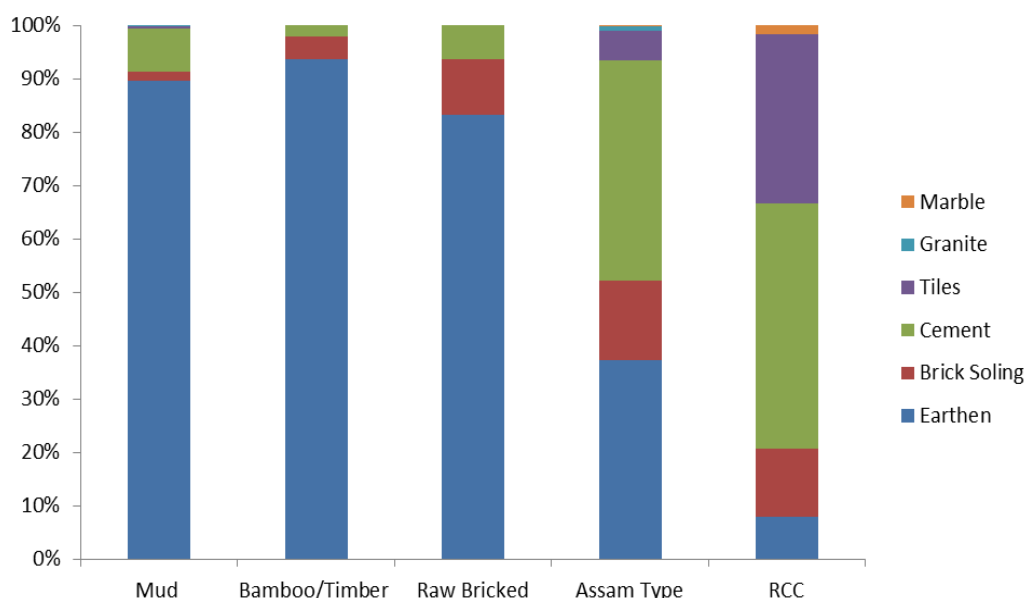


Figure 4-4: Predominant flooring building materials by housing type

These results show that, with the exception of RCC, a house in any of the classifications could be primarily composed of a tin roof, bamboo walls and earthen flooring. Thus, we expect that the decision to classify their house as one type or another may also have a socio-economic component, where mud indicates the poorest, least developed households while RCC indicates the wealthiest and most developed, with the other categories falling in between.

4.2.1 Housing size characteristics

Table 2: Housing size characteristics

	Occupants	Rooms	Area (sqft)
Mud House	4.4 ± 1.8	3.3 ± 1.5	927 ± 658
Bamboo/Timber House	4.2 ± 1.9	3.1 ± 1.1	740 ± 680
Raw Bricked House	4.4 ± 1.7	3.3 ± 1.3	698 ± 701
Assam Type	4.7 ± 2.1	4.4 ± 1.7	1148 ± 871
RCC	4.6 ± 1.7	5.5 ± 2.0	1456 ± 783

In order to determine appropriate housing design for the region it was also important to develop a clear understanding of the size and arrangement of housing in the region. Table 2 shows some of the key housing size and arrangement results. Firstly, it shows the number of occupants per household. The mean number of occupants per household is between 4 and 5, independent of housing type. Thus, number of occupants is consistent on Majuli and shows no relationship with housing typology. The breakdown of this is a male head of household with a wife, and two to three children.

The number of rooms per house is consistently around 3 for mud, bamboo/timber and raw bricked houses. Assam-type houses are around 4 on average while RCC houses have the most rooms at 5.5 on average. This is likely a reflection of the fact that Assam type and RCC houses are more likely to have an indoor bathroom, and separate bedrooms for different family members than other housing types.

Finally, the table shows total area in square feet. The mean size of an RCC house is significantly bigger than all other housing types at nearly 1500 square feet. The second biggest is the Assam type at well over 1000 square feet. Interestingly, mud houses are on average bigger than bamboo/timber and raw bricked houses. However, it is worth noting that the standard deviations for all housing types are very large indicating the size of houses is highly variable within each housing typology as well as across. Therefore, it may simply be that there is not a strong correlation between housing classification and area.

5 Development Indicators

5.1 Incomes

We hypothesised that the housing classifications would indicate socio-economic status in that mud houses would be the poorest, least developed households and RCC would be the wealthiest most developed households with the other categories falling in between. To test this hypothesis, we look at housing classification by income. Each household member was asked to indicate their monthly income from a list of ranges: less than ₹30,000; between ₹30 and 70,000; between ₹70 and 100,000; or more than ₹100,000. Therefore, the results for each household can include a potentially large combination of these income categories depending on the number of occupants earning income. In the following we show only those categories that contain a significant proportion of results for clarity.

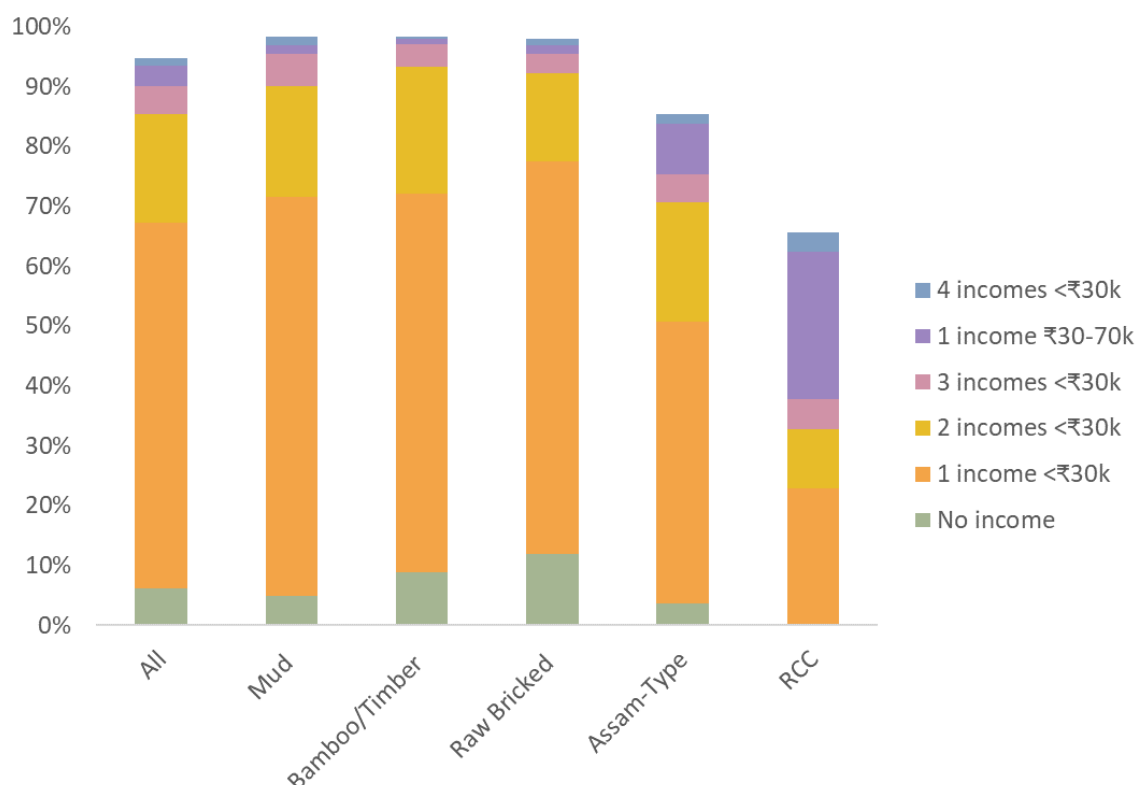


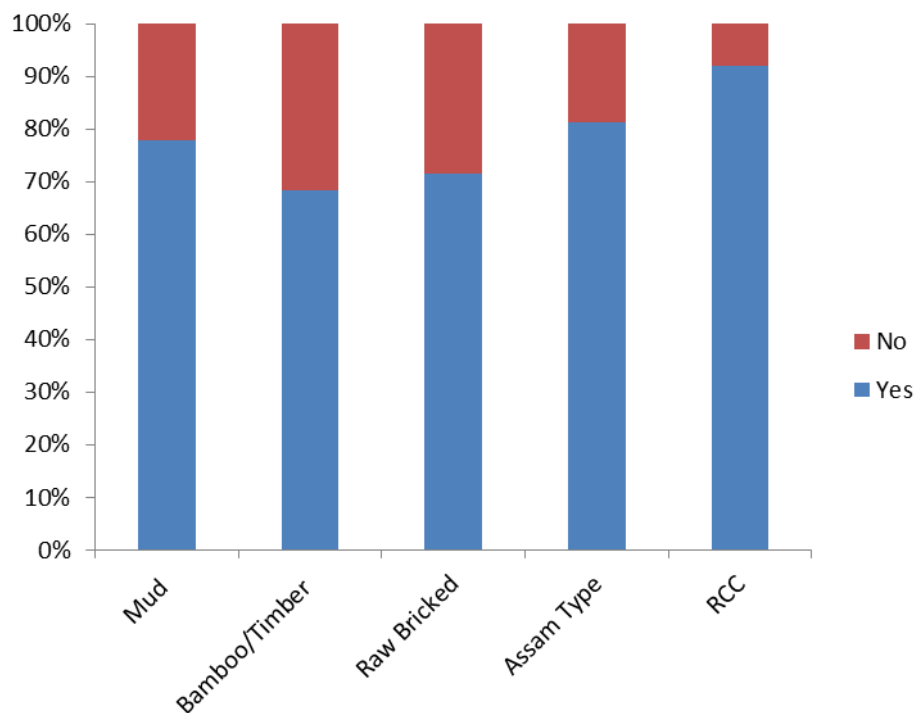
Figure 5-1: Income category combinations by housing type

The first column in Figure 5-1 shows the percentage of households in each combination of income categories, while the remaining columns show the result for each of the housing classifications. The RCC column has no households earning no income, and only 25 per cent earning a single income in the lowest income category. The remaining 75 per cent are either earning multiple incomes per month or in the higher income categories. Compared to the other housing types they are definitely earning the highest incomes on average. Assam-type houses were expected to be the second wealthiest, and these results also fit with that assertion with only 2.4 per cent listed as having no income and around 50 per cent earning multiple incomes or in the higher income categories. Raw-bricked households were expected to be third in terms of wealth, however, this category has the highest percentage of households earning no income or a single income in the lowest income category indicating they are the poorest on average. For mud and bamboo/timber houses the percentage of households earning no income or a single income in the lowest category are both approximately 72 per cent, indicating these housing types are similar in terms of wealth.

5.2 Electricity Access

The further explore the relationship between housing classification and development level we look at energy use. The seventh United Nations Sustainable Development Goal states: *Ensure access to affordable, reliable, sustainable, and modern energy for all* (United Nations, 2018b). The first key indicator of this development goal is: *The*

proportion of the population with access to electricity. The responses to the question do you have electricity access? For Majuli residents is shown in Figure 5-2. There is some indication that residents in mud, bamboo/timber and raw-bricked houses are slightly less likely to have access to electricity than Assam-type and RCC houses. In fact, in the RCC category only 3 houses responded no to this question. Thus, our assumption that RCC houses are the wealthiest and most developed holds in relation to this development indicator. The percentage of Assam-type houses with no electricity is 18.7, which is the second lowest result, but similar to the result for mud houses which is 22.2 per cent. Bamboo/timber and raw-bricked houses have 31.6 and 28.5 per cent with no electricity indicating these are the least developed. Overall around 20 per cent or 200 households on Majuli lack access to electricity.



access.

Figure 5-2: Electricity access by housing type

Majuli is connected to the national grid, therefore from an infrastructure perspective there is no reason for households not to have electricity access. We hypothesised that affordability is likely to be the main inhibitor. To explore this, we looked at the relationship between electricity access and household income. The results are shown in Figure 5-3.

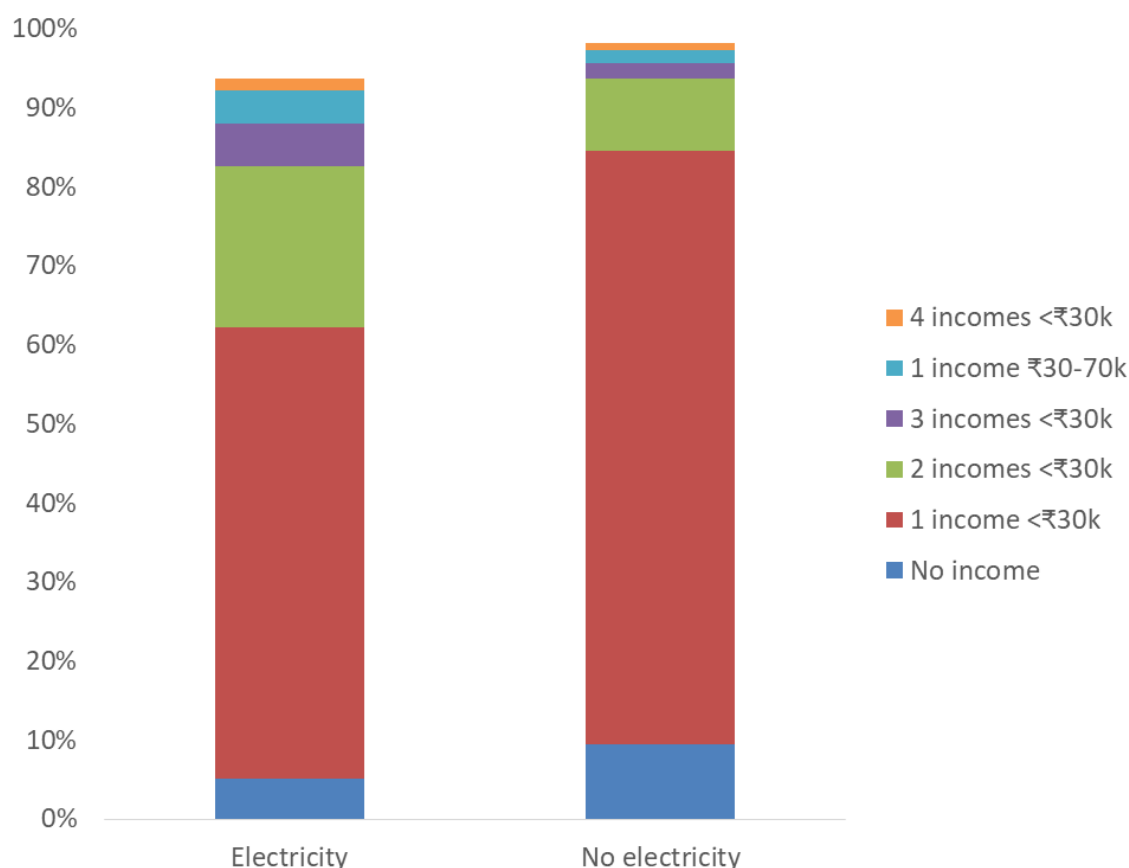


Figure 5-3: Income category by electricity access

6 Discussion

It may seem counterintuitive to provide electricity to a poor rural household, due to the monthly tariff costs adding more regular expenses to already overstretched budgets. In reality, accessing electricity usually leads to an increase in monthly income for households. First of all, most non-electrified households use kerosene lamps for lighting during the evenings. Kerosene is expensive and often requires travel to purchase (aside from the fact that indoor burning of kerosene is a potential fire hazard and has been shown to cause health problems). On Majuli, this would likely require travel across the river to Jorhat via ferry. Electricity tariffs are usually found to be the same as or even cheaper than typical monthly kerosene expenditure.

Secondly, the automation of manual labour will give people more time to perform other income generating activities or pursue education. Post-implementation analysis of rural electrification projects in Nepal for example found that on average women were saving 155 hours per year, while men were saving around 85 hours per year (Legros, 2011).

To illustrate this, consider the processing of rice. Rice is one of the most commonly grown crops in both Nepal and India, therefore it is a relevant consideration. To separate the edible part of rice from the rest of the plant, it has to be milled. In many poor rural areas this is done by hand using a pestle and mortar. Replacing this laborious and time-consuming task with an electric mill was one of the main time-saving activities from the

Nepalese study mentioned earlier. On top of this, the quality of rice obtained from an electric mill is better than that derived from manual milling. Manually milled rice is usually only used for the grower's consumption, or else is sold at a low price to make either rice wine or rice flour. Electrically milled rice on the other hand, is of premium quality and can therefore be sold at a higher price.

Thus, the provision of an electric rice mill has multiple livelihood benefits: it frees up time for people to pursue other, more effective income generating activities, or to improve their educational attainment. It also improves the quality of the rice product allowing it to be sold at a higher price.

As another example, a tailor living in a house with no electricity would be restricted to working during daylight hours, as the light from kerosene lamps or other lighting options is not bright enough for this kind of work. Therefore, electric lighting would increase the hours in a day they would be able to work, allowing them to increase their throughput. The increased income will allow the tailor to save up money and over time they may be able to purchase an electric sewing machine which in turn will further increase their productivity and consequently their income.

It is important to note however that the link between electrification and increased incomes is not instantaneous. People in rural areas are likely to be unaware of the opportunities electricity access can lead to. Therefore, any government led initiative to improve electricity access would need to be accompanied with a training programme to raise awareness among residents of ways to maximise the benefits electricity can provide to their livelihoods. As a precedent a scheme in Nepal electrified a selection of remote rural villages. Some were also offered training in ways to use electricity for income generation. Subsequent analysis of mean household incomes of the villages several years after the scheme found that those villages whose electricity provision had been accompanied by training programmes had increased their incomes more substantially than the villages that were provided with electricity only (Doloi et al., 2019).

Therefore, our policy recommendation would that the government initiate a training scheme to raise awareness of how electricity can be used to improve household's incomes, accompanied by a discounted or payback (i.e. the government covers all or part of the cost of initial electrification, but then this can be paid back over time as part of the monthly tariff. Compared to a government scheme that simply connects people to the electricity grid for free, the training scheme is more likely to lead to real changes in people's livelihoods.

7 Conclusion

The classification of houses in Majuli district into mud, bamboo/timber, raw-bricked, Assam-type and RCC was expected to provide an indication of wealth and development level, in that order from poorest and least developed to wealthiest and most developed. The results of our survey indicated that RCC households were wealthiest, based on monthly incomes, and most developed, based on access to electricity. Assam-type houses were second wealthiest based on their incomes, however, their development level based on electricity access was only marginally different from mud houses. Raw-bricked houses had the lowest incomes on average, and their electricity access was similar to bamboo/timber houses. Bamboo/timber houses had the second lowest income results, and the highest proportion of household without electricity access indicating they were the least developed. Mud houses had nearly identical income results to

bamboo/timber houses, but a higher proportion of households with electricity access, most similar to Assam-type houses.

Therefore, although these results have provided some indication of the development level of households in the regions based on their classifications, further research incorporating other development indicators is necessary to establish which households are most in need of development.

As an example of a policy recommendation resulting from this analysis, while provision of electricity is key in achieving sustainable development goals, a more important government intervention would be providing training to show people how to use electricity to improve their livelihoods.

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STUDYING RURAL HOUSING FOR SMART VILLAGES, ASSAM: CASE SELECTION STRATEGY

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Abstract: *The concept of cultural ecology has been significant in understanding the possible factors of cultural evolution. The cultural evolution of a community is understood to have consequences on the architecture of houses, temples and other institutional buildings. This research intends to understand the architectural evolution of rural Assam as a way of providing the rural community with appropriate and affordable housing suited to their cultural needs and values. This paper aims to define a case selection criterion which will facilitate the selection of appropriate representative cases. This paper will describe of the case selection strategy determined from a review of the literature. In this research, culture has been defined as the product of a cultural ecology that is the intersection of environment, community and interactions. In terms of environment, Assam is separated into five zones based on the physio-graphical characteristics of the state which would indicate/ensure the design of a house that may or may not be suitable to a certain geographical. Designing socially appropriate housing is more difficult as Assam is home to more than 100 ethnic groups, with diverse cultural backgrounds. Whereas different interactions are the result of how a certain community may use and regard a space compared to another. Thus, the selection criteria have been developed based on the age of the village, socio-cultural factors, religion, population and proximity to the nearest urban centre.*

Keywords: *Cultural Ecology, Cultural Evolution, Case Studies, Selection Criteria, Rural Assam.*

1. Introduction

This paper aligns with research aimed at designing and developing a rural housing program that is culturally sensitive and suitable for Assam. This aim is to understand the architectural design of rural housing as a material expression and tangible aspect of the culture of rural communities. It will demonstrate the necessity to define a focus area and reduce the number of variables through definition of a selection criteria to conduct case studies. It will expand on the implications of concept of cultural ecology (Steward, 1972) along with the emancipatory research paradigm (Groat & Wang, 2002) with respect to studying rural communities in the hill areas of Assam. A case selection criterion is defined based on the typical case strategy and diverse case strategy, both of which define a representative case for the research.

Culture has been defined to be specific to place as well as people, indicating that the culture of each village is different (Steward, 1972; Velázquez, 1978). This is due to the geographic, political, socio-economic and religious context with respect to urbanisation and cultural assimilation of the village. This theory implies that it is necessary to understand each village individually, which is unrealistic. However, we can devise a methodology to ethnologically study a village to understand the culture and facilitate appropriate rural housing suggestions. For the formulation of this methodology, four villages will be selected to represent the region to be ethnographically studied and analysed.

Despite Assam having a varied identity of different cultures and over 100 ethnic communities (Ahmad & Raza, 1993), only 17 out of 11366 villages, from 10 out of 32 districts have been studied (UNDP India, 2016). Over 17 prominent ethnic communities including other minor communities are living in the hill areas of Assam within the districts of Dima Hasao, Karbi Anglong and West Karbi Anglong (india.gov.in, n.d; india.gov.in & Janasanyog). However, only three villages, one each from Amri development block from West Karbi Anglong, Bokajan development block in Karbi Anglong and Maibang development block in Dima Hasao, were chosen for the field research conducted by UNDP India for “Appropriate and affordable” rural housing for all (UNDP India, 2016). Only one house design has been proposed as documented in the Pahal-compendium of rural housing typologies as a result of their exercise (IIT, CBRI, & UNDP India, 2016).

The research methodology employed by the exercise was studied and understood that indicated the degree of generalisation in the results as well as the methodology adopted itself. This paper uses the concept of cultural ecology and the emancipatory research paradigm to discuss and reason with the factors that influence the decision-making that enables the research to choose appropriate case study villages for field-research.

1.1. Background research: Diversity in Assam.

In the context of sustainable development, Jon Hawkes (2001) posits that culture should be considered the fourth pillar of Sustainability. He affirms the need of a cultural framework within sustainable development policies. To confirm this perspective, a comparative study was conducted between the Pahal proposed rural housing design and a traditional rural house, followed by a critical analysis of the methodology that resulted in the house design proposed by Pahal (Katharpi & Doloi, 2017). The study highlighted the need for a culturally sensitive approach in the research methodology. Further literature review indicated the necessity of an ethnological methodology to understand the culture of the community. This identified a knowledge gap in the research which indicated that rural housing needed to be sensitive and suitable to the cultural context of the rural community of Assam.

Assam is home to 115 ethnic groups (People of India project). As shown in the figure below 79 (69 percent) identify themselves regionally, that is belonging to the northeast region, 22 (19 percent) locally, that is belonging to the state of Assam, and 3 trans-nationally, that is languages that are spoken in India as well as other neighbouring countries ("2011 Census Population Enumeration," 2011; Planning Commission, 2012). To design and develop a rural housing program that is culturally inclusive, it is necessary to choose representative cases for the diverse community of Assam.

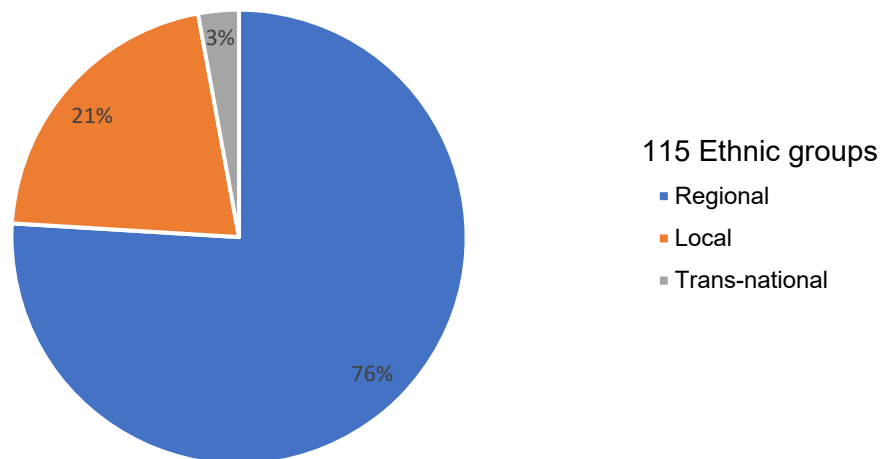


Figure 1: Ethnic Groups in Assam("2011 Census Population Enumeration," 2011; Planning Commission, 2012)

Cultural ecology, an ethnological approach to understanding culture, defines culture as the result of cultural adaptation of a community to the environment (Steward, 1972). Hence, culture can be defined as specific to both community and environment. Therefore, due to the variability in the physiography of the state along with the diversity in ethnic communities, the research would require selecting representative cases that include the variables brought in by the definition of culture as community and place specific. However, time and budget constraints prohibit such a broad analysis of the cultural diversity in Assam.

The research begins by narrowing down the focus area to the hill regions of Assam as shown in **Figure 2** based on the physiographical zoning divided (UNDPIndia, 2016) for the 'appropriate and affordable rural housing for all' under the Pradhan Mantri Gramin Awaas Yojna(PMGAY) scheme. However, this criteria of case selection still includes over 17 prominent ethnic communities including other minor communities living in the hill areas of Assam within the districts of Dima Hasao, Karbi Anglong and West Karbi Anglong(india.gov.in, n.d; india.gov.in & Janasanyog). Hence, this paper aims to define a case selection criterion for determining a smaller sample of representative case studies.

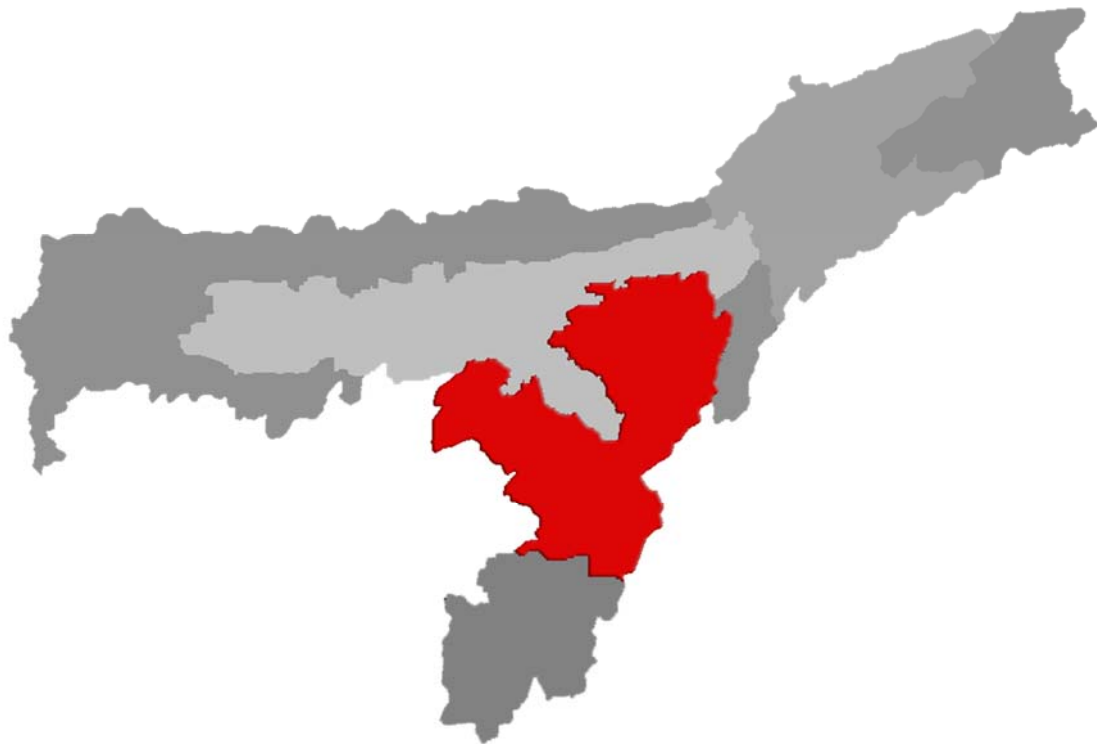


Figure 2: Topographically zoned map

2. Methodology: Case selection as research strategy

Nine case selection strategies have been defined by Gerring (2009): typical, diverse, extreme, deviant, influential, crucial, pathway, most-similar, and most-different. Among the nine, typical, diverse and extreme case selection strategies are most representative of cases critical to this research. All case studies seek representative samples, they are all in search of a typical case or cases (Gerring, 2007). The methodology for the case selection is based on the typical case strategy in combination with the diverse case strategy.

Both strategies facilitate selection of cases that are representative for case study inferences (Seawright & Gerring, 2008). The typical case strategy directs the criteria to define the description of the community to be studied, while the diverse case strategy directs the criteria to choose representative cases that belong to different ethnic communities of the region. In the context of the paper and the methodology adopted for the paper, the villages to be selected for conducting a comparative case study analysis will be referred as 'case' or 'cases'.

In using case study research as a strategy, it is important that the theory and concepts that define the goals guide the case study research and hence define the goals of the case selection. Hence, in this paper, the concept of cultural ecology and the emancipatory research paradigm will guide the methodology of the case selection strategy.

2.1. Cultural ecology

Each community goes through a set of processes that facilitate evolution and development. The processes are unilinear when the evolution process is defined by a set of steps and changes adapted by the community. The processes are multilinear when the evolutionary

process is not defined by the steps and changes, as one community may experience the result of the changes differently from another. The multilineal theory of evolution facilitates the cultural differences among communities, whereas unilinear facilitates the understanding of generalisation of cultural evolution (Steward, 1972).

Ecology is defined as “adaptation to environment” and this process in relation to culture of a community is termed cultural ecology (Steward, 1972). Julian H. Steward (1972) proposed the concept of cultural ecology by arguing that culture explains the nature of humans rather than the genetic potential for adaptation, accommodation and survival. He argues that explanation of the nature of human communities will be found using cultural historical concepts and methods rather than biological concepts.

Hence, the definition of culture is place specific as it is defined by the social habits and activities that are the result of the environment, community and interactions, in which environment includes the climate, geography, politics, resources, history etc.; community will refer to the people, families and households; and interactions would refer to any activity, interactions, events and functions that take place within the environment of the village.

Steward demonstrates the effects of the multilineal evolution of culture that is manifested differently among four rural communities in Puerto Rico (Steward, 1986). He indicated that different levels of cultural adaptation took place through different levels of social integration.

For this research, which focuses on the cultural differences that result in distinct architecture of rural housing, the multilineal theory is assumed. This theory further produces a concept of understanding culture through cultural ecology. The research requires an ethnological understanding of culture which is aided by the understanding and use of cultural ecology as a framework for ethnographic and ethnological study of the communities of the region.

2.2. *Emancipatory research paradigm*

The emancipatory research paradigm confirms the significance of the historical and cultural roles in the case selection criteria, along with the influence of urbanisation on the levels of socio-cultural integration of the cases. It is an inclusive approach which considers and includes multiple ‘realities’ (contexts) shaped by various factors that influence the relation of actors and variables within a frame of a case study (Groat & Wang, 2002). This encourages the inclusion demographics such as number of people, number of households and sex ratio. They are factors that play a prominent role in influencing the cultural ecology of the villages, such as, the distance from the closest town or city and historical context of the region, as demonstrated among the four Puerto Rican communities by Julian Steward (Velázquez, 1978).

The distance of a village from a town or city indicates the degree of inclination or vulnerability to cultural assimilation by urbanisation through social integration of the communities with the more globally perceived community of the town or city. Historical context of the region will indicate the earliest settlers of the region and indicate the dominance of one culture over another.

Being aware of the ethnicity of a village is relevant to the ethnographic and ethnological study of the villages as it provides a frame of reference for the research. In addition, the cases, where the research is to be carried out, are within districts that are classified under the sixth schedule of the constitution which means that they are under the council of autonomous districts of Karbi Anglong and Dima Hasao. This persuades the research to

include the Karbi and Dimasa tribes who are among the dominant tribes in the area. Their close cultural and historical relations with the matrilineal tribes of Garo, Jaintia and Khasi of Meghalaya can provide a different perspective on how matrilineal societies have interacted and co-existed with patriarchal societies. Further, including an ethnic community that originally does not belong to the hilly areas of Karbi Anglong and Dima Hasao, can offer a parallel to the cultural ecologies under the lens of ethnological research.

3. Criteria

With support from the typical and diverse case selection strategies, this paper defines the case selection criteria needed to select the most representative cases. The concept of cultural ecology and emancipatory research paradigm support and define the description of the criteria that play a significant role in studying the typical and diverse case representatives. This paper discusses the preparation process before selecting a case study village. Based on typical case and diverse case selection strategy, the following criteria for case study were developed.

According to the theory of multilinear evolution of culture, the history of a community influences human nature and lifestyle choices that affect culture. In an ethnological study, the dominant community in the region, in terms of population, history and politics will influence the sharing and dissemination of culture in both tangible resources and intangible values. Out of the 100-plus ethnic groups in Assam, 17 are recognised by their respective autonomous councils to reside in the Hilly regions of Assam, namely: Dimasa, Bodo, Kuki, Tiwa, Garo, Man-tai, Khasi, Chakma, Rengma-Naga, Jeme-Naga, Hmar, Biate, Khelma, Jaintia, Vaiphei, Hrangkhoh and Karbi (Anglong; india.gov.in, n.d; india.gov.in & Janasanyog, n.d.; Janasanyog).

The criteria were based on demographic census data, such as population, sex ratio, literacy rate and village size, both geographic and population. This criterion reduces the number of samples from which to choose the cases. Setting an age limit ensures the inclusion of cultural observations that existed before the independence of India due to change in politics and government.

Ensuring diversity in the selected cases will ensure representation of the ethnic diversity of the state. Including a matrilineal community among the cases helps to represent the matrilineal influences on the socio-cultural characteristics of the community. The presence of a religion will ensure a holistic understanding of how the community relates to the spiritual and inanimate elements in their environment, and how the values of spirituality are reflected in their culture.

3.1. Age limit

The age of the settlement affects the research as it gives the historical data on the community and indicates the trend of cultural change in the community due to historical events that took place in the region. Prior to independence, due to the distinct nature of the environment and people living the North-eastern region of India, the British considered a separate form of governance for the region. By 1835, the then government of India enumerated the region as excluded (current Nagaland, Manipur, Tripura, Mizoram) and partially excluded areas (current Meghalaya, Dima Hasao, East and West Karbi Anglong) under the Indian constitution Act of 1835 (Reid, 1944). During the British occupation the tribes could practice their own customary laws within their region, however post-independence, a national culture tended to be imposed on the regions through the nature of administration and governance that was being adopted in rest of India. This change in

administration systems and the structure of governance increased the rate of cultural change.

Post-independence, Assam included the partially excluded areas, Arunachal Pradesh, Nagaland and Mizoram within its jurisdiction (Barpujari, 1998). Without any state borders in place, people of different communities would have inter-mingled and interacted more freely. This borderless intermingling and interaction would have led to more socio-cultural integration among the ethnic communities of a then-united Assam. This criterion takes into consideration the partition of the state of Assam into Meghalaya (1972), Nagaland (1963), Mizoram (1971) and Arunachal Pradesh (1972) since the independence of India.

Immigration from Bangladesh, (formerly East Pakistan), to India is and has been continuing since the split of the two countries until independence of Bangladesh. Many Bangladeshis immigrated into Assam and still have continued to till date (Barpujari, 1998). However, the Assam Accord of 1985 was supposed to negate the migration into Assam through the National Registration for Citizens (NRC). The NRC deadline for immigrants having entered Assam during the creation of Bangladesh was the 24th March 1971. However, it has been difficult for migrants to prove their residency. This criterion indicates the degree of un-surety created with regards to the historical belongingness of the community to the region due to the post-independence immigration and border disputes.

Technological advances increased over the past 50 years since the renaissance when civilisations started to move out of the agrarian way of life. Exponential growth in the use of technology has led to rapid urbanisation and development. The advancement of technology has influenced the economic, religious, environmental and social behaviours and impacted people's behaviour and responsibility to society and the environment ("The impact of information and communication technology on family carers of older people and professionals in Sweden," 2005; Rivera, 2014; Sobotka, 2017; Younes & Al-Zoubi, 2015).

This specification ensures that the villages studied will either have a traditionally built house or older people with knowledge regarding traditionally built houses that are specific to the culture of the village community.

3.2. Socio-cultural factors

The districts that fall under the Zone C classification in Assam are Dima Hasao, Karbi Anglong and West Karbi Anglong. As these districts are considered Tribal areas, or Sixth schedule areas, under the Sixth schedule of the Constitution of India, they are administrated under the autonomous district council of Dima Hasao and the autonomous state council of Karbi Anglong, for both Karbi Anglong district and West Karbi Anglong district (india.gov.in, n.d; india.gov.in & Janasanyog, n.d.; Janasanyog; Ministry of Home Affairs, 2011). The major tribes in these districts are Dimasa and Karbi, hence two of the cases selected will be representative of these tribes. The other two cases will be representative of the neighbouring states Meghalaya to the west and Nagaland to the east.

The emancipatory research paradigm encourages the inclusion of gender as a factor that influences the social construct of a community (Groat & Wang, 2002). The concept of cultural ecology encourages consideration of human behaviour of genders that create differences in the socio-cultural and socio-economic contexts are evident in matrilineal communities and patrilineal communities (Hoffman, Gneezy, & List, 2010; Steward, 1986; Velázquez, 1978)

The cases belonging to different communities living in the different districts within the hill regions of the state, however, for the best representativeness of a case, the major tribes among the residing tribes should be considered. The different districts are under separate administrative systems, this would offer a different view on influence of socio-political scenery of the region. Selecting villages belonging to different ethnic communities also plays a part in understanding the socio-cultural factors that determine the way a village thrives or decays as the effects of urbanisation of the district headquarters.

3.3. Religion

Religion is one of the elements of a community that defines and demonstrates the social norms, practices and values. The values that are reflected in the cultural and spiritual beliefs held by the community will be better reflected by a community that has retained its original cultural religion as opposed to a community that may have been converted to either Hinduism or Christianity. This distinction in demonstration of values is evident in the design of the church (Giedion, 1964).

As observed in the basic form and the details of the Ziggurats and Pyramids, demonstrated the distinction in the reasons and values attached to the architecture of the monuments (Giedion, 1964). The difference in how the Sumerian and Egyptian civilizations expressed their ideas per their cultural beliefs, and how these expressions of ideas were experimented, refined and perfected over time indicated the role played by the cultural perspective on religion and spirituality.

3.4. Population

According to the census data of 2011, rural Assam has an average village population of 1057 individuals, within 214 households. This indicates that there are about 4-5 people in each household. Dima Hasao has 224 individuals within 43 houses per village and Karbi Anglong has 311 individuals in 57 households, indicating that the average village population in these districts are lower than the state average; while the household size is bigger of 5-6 people per household.

The information obtained from the census data is required and used for government planning and statistically represent the national population. In this case, having a uniform number of participants from each case, defines a typicality of the case. It obtains a degree of constancy to the variability that each set of people can provide. Having a small-n case alongside a large-n case will tend to negate the results in the data collection due to the contrasting majority and minority of the numbers.

3.5. Proximity to Urbanisation

The distance of the case will be within a specified radius from the district headquarters. This criterion reduces the coverage area of all the districts to the development blocks, or tehsil, that are in the jurisdiction of the district headquarter. These are Haflong development block for Dima Hasao district, Donka tehsil for West Karbi Anglong, and Diphu tehsil for Karbi Anglong district.

The proximity of a case to urbanisation or a community of a different ethnic background will demonstrate a degree of cultural assimilation that will indicate the level of socio-cultural integration of the cases. The connectivity and accessibility of the village to as inaccessibility could delay the research.

4. Results

A set of criteria were developed base on the discussions of characteristics that define a typical case. Case selection will be finalised before commencing field research based on the on-ground information. A preliminary assessment of the villages around the District headquarters of the Districts in Zone C will be conducted to define the case or cases that fit the definition of a typical case defined by the criteria below in

Criteria	Description
Cultural	Should be more than 75 years old. The cases should belong to different ethnic communities. At least one should be a matrilineal community. Presence of religion.
Population	200-400 individuals in each case 40-70 households in each case
Connectivity	Within a 20 km radius of the district headquarter.

Table 1: Case selection criteria

Criteria	Description
Cultural	Should be more than 75 years old. The cases should belong to different ethnic communities. At least one should be a matrilineal community. Presence of religion.
Population	200-400 individuals in each case 40-70 households in each case
Connectivity	Within a 20 km radius of the district headquarter.

The cultural typicality of the cases is defined by the age limit and religion. The significance of including a matrilineal community among the different ethnic communities is to add diversity in the typical cases to represent the ethnic diversity of Assam. This encourages the case selection criteria to include a Matrilineal community. Either Jaintia, Khasi or Garo, which constitutionally belong to the neighbouring state of Meghalaya, may be selected (Ahmad & Raza, 1993; india.gov.in, n.d; Taher, 1993). The fourth representative case will be based on the next major tribe population after the Karbi and Dimasa, living in the region that is constitutionally belonging to the neighbouring state of Nagaland (Ahmad & Raza, 1993; india.gov.in, n.d; Taher, 1993)

The population of the cases define the number of observations that can be obtained from a single case. Restricting the size of the case does not ensure a reduced number of observations; however, it is one of the criteria that indicate the typicality of the case. To further add the typicality of the cases, they will be selected within a limited distance around the district headquarters to ensure a degree of socio-economic and socio-cultural

integration of cultures due to the proximity to urbanisation. This criterion also acts as a diversity characteristic as there are three district headquarters, hence, different levels of influences of urbanisation depending on the district.

Based on these criteria, cases that have not been assimilated or have been assimilated to a lesser degree will reflect older versions of cultural evolution. In studying these typical cases, the research will be enriched by learning the cultural mechanisms that direct the community to evolve and thrive within their environment.

5. Conclusion

The ethnic and cultural diversity of hill regions of Assam confirms the need to design a methodology that is culturally aware and sensitive to the diversity within the region. This methodology is based on comparative case study analysis research. Knowing which villages are representative of the region's rural communities requires a set of case selection criterion. The intent of this paper is to develop a case selection criterion for the case study analysis. A strategy required to be put in place that enabled selection of cases that are representative of the ethnic diversity of people living in the hill regions of Assam.

This required us to develop a set of pre-decided notions of how a representative case could be described. Using a combination of typical and diverse selection strategy, the criteria were defined. The concept of cultural ecology indicated the necessity of including historical, cultural and religious aspects, along with a defined radius from the district headquarter for each case selection. The emancipatory research paradigm indicated the inclusion of women and matriarchy and religion in the cultural characteristics of the villages. The census data indicated typical sample sizes of a case, in terms of average village population and average household size, in the criteria development.

The typicality of the cases is based on the history, culture, demographics and distance from the district headquarters. To lend diversity to the case selection, the villages were selected from different ethnic communities following different social constructs and belonging to different districts. For better accessibility and to observe the influence of the nearest town which would be the district headquarter in each case, villages around Hamren, Diphu and Haflong were considered. One village from both West Karbi Anglong and Dima Hasao and two villages from East Karbi Anglong that fit the criteria defined by this research will be selected.

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A NOVEL APPROACH OF CONSTRUCTING FERROCEMENT WALL FOR COST-EFFECTIVE HOUSING

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Abstract: The advent of the “smart villages” initiative for “off-grid communities”, the increasing thrusts of the governments in many developing countries to provide affordable housing for sheltering large sections of populations, and the increasing trend of people living in villages and semi-urban areas to build houses akin to their urban neighbourhoods have given impetus to the development of methodologies for constructing houses that are cost-effective, and simultaneously more durable, more convenient to build and use, and more efficient in meeting functional requirements in comparison with the traditional alternatives. Noting that the cost of walls and roof, together with that of doors and windows, typically constitutes about 70% of the total cost of constructing a house, and that the cost of materials typically comprises about 60-70% of that total cost, a novel approach of constructing cost-effective walls was developed in this study. Ferrocement in alternative forms of cement-sand and cement-flyash-sand mortars on reinforcing layer of chicken-wire hexagonal mesh was considered, and various construction wastes were reused for facilitating the fitting of the mesh in panels and placing of mortar on the mesh. Both prefabricated and cast-in-situ panels were considered. A comparison of the cost of a double-sided cavity-type ferrocement wall of half-brick thickness with that made of traditional bricks revealed economy of the order of 36%. The dead weight was found to be about 20% lighter in the case of ferrocement wall in comparison with the wall made of traditional bricks. Further, it was found by a non-destructive test that the strength of the ferrocement wall was comparable to that of traditional brick wall. Overall, the methodology was found as being cost-effective, environment-friendly, energy-efficient and easy-to-develop. With considerable advantages, this methodology has great potential of application in cost-effective housing schemes.

Keywords: Cost-effective housing, Ferrocement, chicken-wire mesh, cavity wall.

1 Introduction

Housing is a basic necessity that provides shelter, safety, security, privacy and comfort. However, worldwide, many cities and human settlements are faced with the crisis of inadequate housing due to growing population and accelerating urbanization. This had prompted the United Nations to adopt the making of cities and communities “inclusive, safe, resilient and sustainable” as one of the 17 Sustainable Development Goals (SDGs) of the ‘2030 Agenda for Sustainable Development’ (United Nations 2017). The commitment towards meeting this SDG has accentuated the need for cost-effective and functionally-efficient housing in many developing nations. “Rurbanisation” that makes “styles of life and the standard of living” in “rural socio- geographic spaces” (Parsons 1964) resemble those in urban proximate is another driver that has given impetus to the development of methodologies for cost-effective and functionally-efficient housing. Further, with the advent of “Smart Villages” initiatives, the need for cost-effective and functionally-efficient houses akin to those in urban landscapes has been growing even in remote villages.

A cost-effective house is generally expected to be strong and durable, sustainable in the choice of materials and technology, convenient to build and use, and efficient in meeting functional requirements while costing less in comparison with a typical traditional or urban house fulfilling the above requirements. In “Guidance for House Builders” published by the Building Materials & Technology Promotion Council (BMTPC) of the Government of India, the cost of materials is indicated as being about 73% of constructing a house, the remaining 27% being that of labour. A research on the break-up of cost of construction of a standardized housing project at two urban centres in each of 15 developing countries in Africa conducted in 2015-16 (CAHF) revealed that the cost of materials varied from 41% in Cameroon to 84% in Liberia, the labour cost varied from 8% in Liberia to 41% in Nigeria, and the indirect cost varied from 8% in Liberia to 31% in Zambia. It is therefore imperative that achieving economy in the cost of materials is key to the construction of a cost-effective house. Element wise, the BMTPC publication indicated that the cost of wall would typically comprise about 30% of the cost of construction followed by 25% for roof, 15% for doors and windows, and 10% each for foundation, flooring and finishing. Although such break-up for other developing countries could not be readily obtained, the values are expected to be comparable. The above observations directed the focus on considering walls as one of the major building components through the choice of appropriate materials and techniques for attaining economy.

Walls can be made up of either traditional or unconventional materials, built as either cast-in situ or pre-cast panels, designed as either load-bearing or partition-wall, and formed into either solid or cavity type. Reddy and Sarma 1970: 38-39 provided details of rammed in-situ stabilized mud walls, soil-cement block walls, concrete hollow block walls, and walls with precast steel mesh reinforced concrete panels and in-situ reinforced concrete pillars, and compared their costs with walls of traditional types, i.e. mud walls with or without bamboo reinforcement, brick masonry walls and stone masonry walls. Vargas *et al.* 1986: 253 studied the seismic strength of adobe walls made from earth and other organic materials by using different types of reinforcement using rural materials and different additives. In describing prefabrication techniques for low cost housing in Assam, Deka *et al.*, 2017 referred the use of bamboo supported biomass wall cladding for wall panels and showed the feasibility of using jute for wall panel construction. Ganesan *et al.* 2018 and Puri, *et al.* 2017 analysed the strength characteristics of bamboo reinforced cement concrete prefabricated panels for wall construction. Focussing on partial replacement of cement by adding different supplementary cementitious materials and on substitution of

brick in order to reduce carbon footprint, increase sustainability, achieve economy while enhancing the strength characteristics of walls, researchers explored the use of materials, such as flyash, waste rice husk, sugarcane bagasse, saw dust, quarry dust, waste glass sludge, waste marble sludge, other agro and industrial wastes, etc., which otherwise pose the problem of disposal and pollute the environment. Interested readers may refer Masuka *et al.* 2018, Kazmi *et al.* 2017; Kazmi *et al.* 2016, Sumathi and Mohan 2015, and the citations therein. In respect of flyash, Rai, *et al.* 2014 observed that it acts like fine aggregate, i.e. filler, in the early ages of application and its pozzolanic property causes considerable improvement of strength at later ages. Noting that the consumption of appropriately designed content of flyash in building construction would i) reduce the problems of its disposal and acquisition of agricultural or other usable land for constructing ash pond, ii) reduce the requirement of cement without affecting the strength characteristics, which in turn would iii) result in saving of raw materials such as limestone, coal, gypsum etc. and emitting of lesser amount of greenhouse gases in the atmosphere, suitability of using flyash for constructing walls for cost-effective housing was explored in the study described herein.

Performance of ferrocement, particularly in making wall panels, had also attracted the attention of researchers. Grija *et al.* 2014 studied the strength, weight and cost of ferrocement wall panels and found these to possess high strength-to weight ratio, and costing 78.2% less than brick masonry wall. Earlier, Cheah and Ramli 2012, Waleed *et al.* 2010, Fahmy *et al.* 2005, Hago *et al.* 2005 and Mohamad *et al.* 2005 amongst others found good structural performance of ferrocement slab panels. In the study described in this paper, the performance and suitability of ferrocement walls were assessed.

Further, construction wastes amount to a considerable percentage of the cost of any construction project. Recycling and reuse of these wastes would result in lesser procurement of materials that involve energy-intensive processes for their production and would enhance sustainability while reducing the cost of construction. Ramaswamy and Satyanarayana 2009 estimated from the study of six building projects in India that the total cost of waste from 5.4-14.70% of the project cost. Skoyles 1976 found from a study in the UK that material wastes varied from 2-15% of the weight of the materials determined from design. Bossink and Brouwers 1996 estimated that material waste in the Netherlands amounted to 1-10% of the weight of purchased materials. From two empirical studies of building projects in Brazil, Formoso *et al.* 2002 estimated the cost of waste as being 5.1-11.6% of the project cost. Garas *et al.* 2001 found that timber frameworks with an average waste of 13% and sand with an average 9% showed the highest percentages of waste among all materials studied. In order to contribute to economy, sustainability and reduction in carbon footprint, the feasibility of recycling selected construction wastes for making ferrocement walls of cavity type for both pre-cast and cast-in-situ construction was explored and made the primary focus of the study reported herein. For brevity, the strength characteristics and the economy of constructing ferrocement cavity wall was described with reference to a small selection of materials and compositions.

2 Selection of location and materials

For experimenting with the construction of ferrocement wall, ten openings between fin-walls above existing half-brick wall of about 1.5 m from the floor in the academic block II of the Central Institute of Technology Kokrajhar in Assam were selected. The openings of width 0.4 m were required to be blocked by 0.6 m high wall.

Amongst materials, Ordinary Portland Cement that is widely used in the region was considered for developing the methodology and analysing the cost. Coarse river sand

was used for constructing ferrocement layers, hereinafter, referred as base-course, whereas fine river sand was used as 'finishing course' for plastering the walls. In one set of tests, cement-sand mortars in 1:4, 1:6 and 1:8 proportions by weight were selected for preparing the base-course and 1:4 cement-sand mortar was adopted for the finishing course for all tests.

Dry flyash, available in abundance as industrial waste from 500 MW coal-based Bongaigaon Thermal Power Plant of the National Thermal Power Corporation located about 13 km from Kokrajhar, was collected for experimenting with the addition of flyash as supplementary Cementous material. As second set of tests in this study, ferrocement walls with base-course made up of cement-flyash-sand mortar in the proportions of 1:1:5 and 1:1:6 by weight and finishing course with 1:4 cement-sand mortar were considered.

Hexagonal chicken-wire-mesh, readily available in local markets for making pens and coops, was used as reinforcement for preparing the base-course of the wall-panels. For holding chicken-wire-mesh across the panels, frames were prepared by using i) pieces of waste timber formworks such as battens and planks of varying cross-sections and lengths and ii) scrap reinforcing bars (rebars) of different diameters and lengths, these being collected from disposal yards of construction sites. For the ferrocement technology devised in the present study, single layer of solid wall or the layer on one face of double-skinned cavity wall would not require permanent back-support; however, the layer on the other face across the cavity would require back-support. Emptied gunny bags and discarded cardboard sheets procured from construction sites were used for providing back-support that would be left permanently inside the cavity wall. The photographs showing different materials used for construction are provided in Figure 1.



Figure 1: Materials for construction of ferrocement wall: a. Timber beign collected from construction wastes, b. Chicken Wire Mesh, c. Cardboard from construction wastes, d. Cement, e Sand, f. Fly Ash, g. Rebars from construction wastes

3 Methodology of construction

Considering thickness of about 15-20 mm for the base-course of ferrocement wall, the total thickness of a solid wall panel with 12-15 mm plaster on either side of the wall would be about 40-50 mm. For cavity wall, the width of the gap between the two skin-walls may be varied for obtaining the desired thickness of the finished wall. For the present study, the construction of cavity wall with finished thickness equal to that of the finished half-brick wall below, i.e. 140 mm, was considered.

3.1 Construction of pre-cast panels:

Timber battens and planks were prepared by suitably cutting into sizes and joining by nails to make frame of size 600 mm x 400 mm (Figure 2a and 2b). The cross-sectional dimensions of the timber pieces forming the frame were such that the dimension perpendicular to the plane of the wall would be the finished wall thickness less twice the thickness of plaster on either face of the wall, whereas the dimension parallel to the plane of the wall could vary depending on the availability of the timber pieces from disposal wastes.

Chicken wire-mesh was cut according to the dimension of the frame and fixed to the timber members with nails such that the outer surfaces of the timber members perpendicular to the plane of the wall would be wrapped by wire-mesh (Figure 2c). The wire-mesh on these surfaces would facilitate bonding between the panel and the members holding the panel when fixed with mortar or concrete in the opening for the wall. The wire-mesh in the area within the frame was tightened by stretching with a manual wire tie twister.



Figure 2: Materials for construction: a. preparation of timber pieces for making frame, b. making frame, c. fixing wire-mesh on the frame, d. applying mortar on wire-mesh for the base-course, e. competed base-course of the panel.

By estimating the quantity of materials required for the base-course for one face of the cavity wall, mortar of desired composition and workability was first prepared. Using a 'Masonry Trowel', mortar was applied on the chicken wire-mesh by holding the frame vertical. In order to prevent the dropping of mortar by passage through the openings of the wire-mesh and by rebound, a mason's 'timber finishing trowel' or a 'plaster trowel' or a 'float trowel' or a polished timber board was held as back-support against the wire-mesh on the inner side of the wall (Figure 2d). After each application of mortar by masonry trowel by pressing the mortar against the back-support, the latter was slowly slid so as not to disturb the bond between the wire-mesh and the green mortar and withdrawn by leaving the mortar in place that filled the mesh-openings and covered the lath of the wire-mesh. The application of mortar by using trowels was continued until the entire surface of the panel on one face of the frame got covered. As expected, there would be unevenness in the base-course thus prepared (Figure 2e). The base-course was cured by sprinkling water from the second day for about two days.

After the base-course on one of the two faces of the cavity wall was set, cardboard panel or gunny bag was fitted to the frame on the other face of the wall by securing with nails. This layer of cardboard or stretched gunny bag would serve as back-support for the base-course on the second face as it would not be possible to hold a trowel in the cavity as a back-support for placing the base-course. Chicken wire-mesh was fitted over the back-support by nailing the mesh in the timber frame on the periphery of the panel. The wire-mesh was tightened by using manual wire tie twister. Base-course for this face was then cast by placing cement mortar on vertically held frame using masonry trowel and by lightly pressing the mortar against the back-support. The base-course of this second face was subsequently cured by sprinkling water.

After setting of the base-course on both faces of the cavity wall, 12-15 mm thick plaster was applied over the base-course as the finishing layer of the panel. After curing of the finishing layer, the panel was ready for being fitted in the selected opening for constructing the wall. At the selected site, the plaster on the sides of the fin-walls were stripped, and the concrete surface was chipped off so as to make a niche of about 20 mm depth in the fin-wall on either side of the opening. Similar niche was also made at the bottom by stripping the plaster on the top of the brick masonry wall at the bottom of the opening. Cement-sand mortar of 1:3 proportion was applied after cleaning and putting cement slurry on the stripped surfaces. The panel was then shoved into the opening and stroked lightly so that the cement mortar and the laths of the wire-mesh on the external surfaces of the frame could bond. A layer of 15 mm thick cement concrete of 1:2:4 ratio with 6 mm down coarse aggregate was laid at the top of the panel. Two lines of Scrap rebars were suitably lapped and was placed over the concrete layer thus laid. The bars were secured on the sides of the fin-walls by making small holes in the concrete and inserting the ends of the rebars therein. A few pieces of cross bars were also tied with the rebars. A further layer of cement concrete of 1:2:4 proportion 25 mm thick was laid over the rebars thereby forming a tie-band. The tie-band together with the niches would prevent the panel being tumbled out of the opening of the wall. The joints between the pre-cast panel and the existing surfaces of the fin-walls, tie-band and the wall at the bottom were finally plastered for making the cavity wall ready for painting or colour washing.

In the case of constructing a large wall, one alternative would be to construct stub columns of small cross section with the dimension perpendicular to the surface of the wall equal to the thickness of the wall. Dowels of scrap rebars could be left at the levels of tie-bands based on the sizes of the panels. These dowels would be joined to rebars for making tie-bands above each panel to be placed for making the wall. The panels could then be fixed one after another and the wall could be finished by the same procedure as described

above. The other alternative would be to divide the large opening into segments by timber battens so that the area of each segment would be equal to that of the pre-cast panels. The timber members of the pre-cast panels would then be fixed in place by nailing with the timber members of the wall segments. Chicken wire-mesh could be fitted on the exposed surfaces of the timber members of the wall segments for laths to hold the mortar of plaster for finishing the wall. The sizes of the panels for either alternative would be such that the maximum weight of a finished panel would be about 35 to 40 kg so that two labourers could handle and put the panel in place without difficulty.

3.2 Construction of cast-in-situ panels:

In the first alternative, a timber frame of the size of the panel was made by fixing timber battens to the existing concrete or brick surfaces by iron nails. For securing the nails, small holes were first made at selected locations of the existing surfaces and cement mortar was placed in those holes for holding the nails before erecting and fitting the frame. For this purpose, timber members of suitable size and length were prepared from discarded pieces sourced from disposal yards. Rest of the procedures, namely fixing and tightening the chicken wire-mesh, placing the mortar on the wire-mesh by using trowels and back-supports, curing the base-course, making the tie-band, and plastering the outer surfaces of the wall are similar to those in the case of pre-cast panels as described above.

Noting that collecting suitable sizes of timber pieces, making sections of desired widths, cutting the pieces into desired lengths, and making frames by nailing could involve considerable labour and time, a second alternative was devised. In this alternative, the frame was made up of scrap rebars of available diameters and lengths by suitable lapping, securing and tying with steel wires. The securing was achieved by inserting the ends of the rebars into holes made in the existing surfaces of concrete or brick on the edges of the panels (Figure 3a).



Figure 3: Construction of cast-in-situ wall panels using a. scrap rebars for making frame, b. Cardboard back-support behind wire-mesh, c. Mortar for base-course, and d. Placing of mortar on wire-mesh against back support.

For cavity wall, two layers of rebars were fitted on each side and cross bars were tied for stiffness and strength. Since, the size of the panel for the current study was small (400 mm x 600 mm), hence vertical and horizontal bars were not used for spanning across the opening of the panel; however, such bars at suitable spacing, such as 500 mm centre-to-centre, would have to be tied to divide a large panel into smaller areas for stiffness and strength. Chicken wire-mesh was fitted on the frame thus made of scrap rebars by using steel wires, wire-cutters, manual wire tie twister etc. Having fixed the wire-mesh, the placing of mortar on the wire-mesh by using trowels and back-supports, the curing of the base-course, the making of the tie-band, and the plastering of the outer surfaces of the wall were accomplished by the same procedure as described in the preceding section for pre-cast panels (Figure 3b, 3c and 3d).

The photographs of the site for erecting wall panels before construction, the base-course applied on the panels, and the plastered surfaces of the finished panels are exhibited in Figures 4 (a), (b) and (c) respectively.

For estimating the amount of labour required, semi-skilled and unskilled labourers were employed to execute repetitive works after having explained the mode of construction to them. Initially, the labourers appeared to be confused and not at ease in executing the work that was unconventional. However, after demonstration, they could carry out the tasks at ease spending considerably less time.

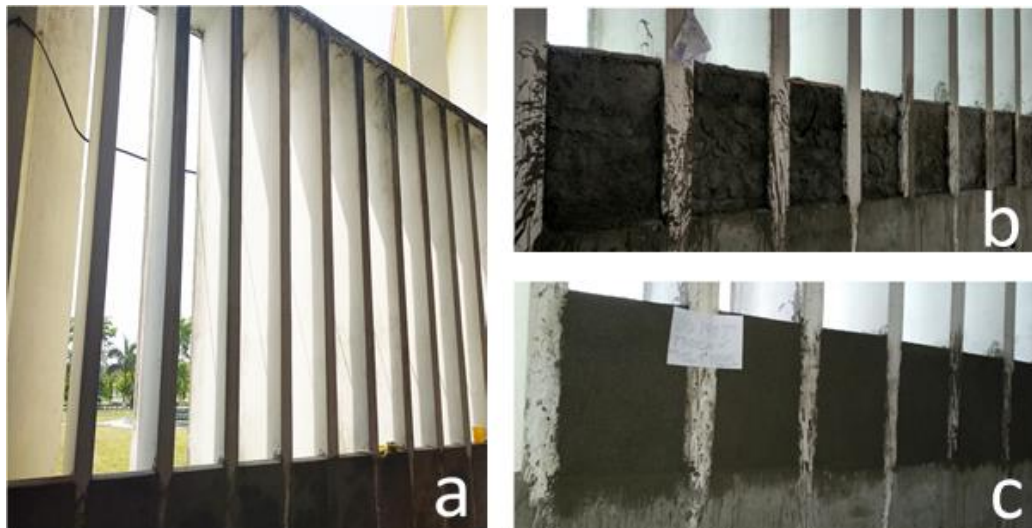


Figure 4: a. The site for erecting wall panels before construction, b. Base-course applied on panels, c. Plastered surfaces of the finished panels

The comparison of weight revealed that, the dead weight of cavity walls constructed by the technique devised in this study would be almost 20% less than that of a half-brick thick wall made up of traditional bricks, hereinafter referred as 'conventional wall'. This would imply a reduction in the cost of the supporting components, such as beams, columns and foundation, of the structure and improvement in the performance of the whole structure during earthquake.

4 Assessment of functionality and strength

From visual assessment of the cavity-wall constructed in the site selected for the study, it was perceived that the wall would meet all functional requirements that a conventional wall is expected to meet. For assessing strength, rebound hammer was used. Although

rebound hammer test was originally intended for predicting the compressive strength of concrete on site, it was found to correlate well with strength of masonry and to be useful for evaluating the uniformity of material properties throughout the structure (Puri, *et al.* 2017; Noland *et al.* 1988). For the current study, rebound hammer was horizontally applied at six points in each panel and the average of the values of strength corresponding to rebound numbers was estimated for the panel (Figure 5). For conversion from rebound number to 14-56 days strength in MPa (Mega Pascal), as was applicable, table of values supplied by the manufacturer were used. For comparison, the strength for the conventional wall was also estimated. The average values of the indicative strength of the panels with different compositions of the base course and that of the conventional wall are provided in Table 1.



Figure 5: Rebound hammer test on ferrocement panels of cavity wall

Table 1: Comparison of indicative strengths of ferrocement walls

Particulars	Strength (Mpa)	Strength as % of that of conventional wall
Cavity wall of base course with 1:4 cement-sand mortar	26.2	87%
Cavity wall of base course with 1:6 cement-sand mortar	23.0	76%
Cavity wall of base course with 1:8 cement-sand mortar	21.1	70%
Cavity wall of base course with 1:1:5 cement-flyash-sand mortar	24.8	82%
Cavity wall of base course with 1:1:6 cement-flyash-sand mortar	22.5	75%
Conventional half-brick thick wall with traditional brick	30.1	–

The values in Table 1 shows the reduction of strength in the case of ferrocement wall by about 13% with 1:4 cement-sand mortar and 18% with 1:1:5 cement-flyash-sand mortar in comparison with the conventional alternative. With leaner proportion with or without the addition of flyash, the strength was found to decrease by more than 20%. It may be noted here that the wall panels tested for this study had the top edge unconstrained (Fig. 4b and 4c). This had caused reductions in rebound of the elastic mass of the hammer and hence relatively low values of strength at two top corners of each panel. The average strength of a panel restrained at all edges would be expected to be higher than that noted in this study. It is however proposed that further tests would be undertaken for assessing the strength characteristics of large-sized panels and the behaviour in regard to moisture absorption, sound and thermal insulation, impact loading etc. for ferrocement walls constructed by adopting the methodology described herein.

5 Estimation of cost

Quantities of different types of construction materials used for cost-effective wall-panels were estimated by considering the sizes and thicknesses adopted. The amount of labour required was assessed from the actual hours employed for accomplishing the works and observing the need for skilled, semi-skilled and unskilled labourers. Rate analysis was carried out by following standard procedures and adopting the rates for items available in the Schedule of Rates of the Public Works Department of the Government of Assam. For some items, such as scrap materials from disposal yards, chicken wire-mesh etc., market rates were used. For comparative assessment, the rate of work for constructing conventional wall was also analysed. For all cases, 1:4 cement-sand mortar was considered for finishing course or plaster. The Cost in Indian Rupees (INR) per square metre and the reduction in cost of ferrocement cavity wall constructed by following the procedure devised in this study in comparison with conventional wall are presented in Table 2. It may be found from this table that, amongst the composition of materials tested as base-course of ferrocement cavity wall, the cost with 1:4 cement-sand and 1:1:5 cement-flyash-sand mortars would respectively be 66% and 62% of the cost of a conventional wall.

Table 2: Comparison of cost of selected types of ferrocement walls

Particulars	Cost per sqm (INR)	Reduction of cost compared to conventional wall
Cavity wall of base course with 1:4 cement-sand mortar	447	34%
Cavity wall of base course with 1:6 cement-sand mortar	432	37%
Cavity wall of base course with 1:8 cement-sand mortar	423	39%
Cavity wall of base course with 1:1:5 cement-flyash-sand mortar	428	38 %
Cavity wall of base course with 1:1:6 cement-flyash-sand mortar	421	39%
Conventional half-brick thick wall with traditional brick	686	–

6 Conclusion and recommendation

From the application of the methodology devised for constructing ferrocement cavity walls, and from the analysis of strength and cost of selected compositions of materials for constructing the walls, it was found that the methodology could be adopted for cost-effective housing without requiring skilled labourer and costly tools and equipment. From the consideration of strength, the panels of ferrocement cavity walls having top edge unrestrained and made up of base-course with 1:4 cement-sand mortar and 1:1:5 cement-flyash-sand mortar were found to yield respectively 87.0% and 82.0% of the strength of conventional half-brick thick wall with traditional brick. In respect of cost, savings in the range of 34-39% could be achieved in the case of cavity walls with different composition of materials in comparison with the cost of the conventional wall. Further there would be reduction of cost in the overall construction of a house with the adoption of this methodology because of the reduction of dead weight of walls by about 20% as compared to conventional wall and hence reduction of the cost of supporting members and foundation. Some reduction in the overall cost would also be through the utilization of scrap materials from the disposal yards which would otherwise be highly depreciated. Additional advantage in the construction of cavity wall by the methodology devised in this study is the improved performance of the structure that could be expected under seismic load due to reduction in dead weight and incorporation of shear-resisting members in the form of tie bands to be used for holding wall panels in place. Because of not using bricks and because of the reduction in the overall usage of cement and steel that would be

expected due to the reduction in dead weight of the structure, the carbon foot-print of a house incorporating ferrocement cavity wall as described in this paper would be less. Because of insulation provided by the air gap within the cavity wall, the constructed walls would be energy efficient throughout the year under different climatic conditions. In the case of pre-cast panels, quality control at casting yard would be easier.

Based on the above, the methodology as devised for constructing ferrocement cavity wall is recommended for adoption for cost-effective housing in urban, 'rurban' and 'rural' areas and in 'Smart Villages' for sustainability, functionality, and cost-reduction. Further studies are recommended for objective assessment of the strength characteristics, the behaviour in regard to moisture absorption, sound and thermal insulation, impact loading etc. and the advantages as indicated above in adopting the methodology of constructing ferrocement wall for cost-effective housing.

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“Reinventing Patterns and Traditional Elements in Vernacular Settlements of Rural India”

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Abstract:

Rural settlements are the role models that derived from socio-cultural and traditional practices. Each village is unique in its own way based on the traditional practices. The paper highlights case studies of four Indian villages, namely; Raghurajpur Orissa, Sawantawadi Maharastra, Mattur, and Shirva from Karnataka. Visual surveys were conducted and selected vernacular houses were documented. Socio-cultural surveys were conducted to understand their influence on the built environment. Settlement patterns with traditional elements were listed and analyzed. It was noticed that each settlement is unique and traditional elements are reflected in their own way.

Keywords: Vernacular Housing, Settlement patterns, traditional architecture,

1 Introduction

Vernacular Houses depicts socio-economic rituals that are reflected in traditional as well as constructional practices. Traditional practices are always expressed through built spaces, forms, and functions. Depending on the direct and indirect influences, decoding of these elements is either simple or complex. Construction practices are seen through the use of local materials, techniques and man power. The settlement patterns follow traditional practices depending on the local climatic conditions. Each settlements demonstrate smart and sustainable principles since they follow mixed land use, are compact, have easy access, and collective cohesiveness but are diverse in socio-cultural diversity (Dhingra & Chattopadhyay, 2016). Vernacular house are excellent sustainability models because they adopt low energy techniques (Khandekar et. al., 2017) (Khandekar, et.al.2017). There are various factors that influences the housing and settlement patterns for example migrations, natural calamities, environmental behavior, economic, social and environmental dimensions determinants (Ferdous, Kafy, Gafur, & Wakil, 2017). Other factors like increase in income and migration rate, variation in income source, and reduction of joint family are significant for the change in the settlement patterns (Ferdous et al., 2017). The settlement patterns depends on the internal plan and external layouts and both also depend on conditions like location, topography, vegetation and nature of soil (Ahmed, 1979). Social organizations, landscape configurations may be similar across the nations as well (Widiastuti & Vedamuthu, 2009). Traditional materials can be used effectively to make the buildings more sustainable (Architecture & Lanka, 2007). Topography in turn decides material usage, climate and soil decide the vegetation. Occupation is also an important factor that derives the settlement pattern. The patterns help to understand the community's life. Social hierarchy can be seen through the scale and richness. Landlords are an integral part of the villages and are administrators of the village. Landlord houses in Indian villages reflects unique features with rich carvings and have names that are particular to the region of India, for example: Haveli's in North India, Wada in Maharashtra, Rajbari in West Bengal, Deori in Hyderabad, Cathurmukham in Tamil Nadu, and Nalukettu in Kerala (Susilo, 2016). Many studies of settlements and documentation of traditional houses can be seen from various objectives for instance: to understand architectural elements, materials and construction techniques, passive principles, community participation, socio- economic significance, heritage values etc. The case studies of four Indian villages namely; Raghurajpur Orissa, Sawantawadi Maharashtra, Mattur, and Shirva from Karnataka. are discussed with traditional elements that derive the characters to the settlement

2 STUDY AREA:

2.1 RAGHURAJPUR, ORISSA

2.1.1 Introduction:

Raghurajpur is a village in Puri District in Orissa State and is known as a heritage craft village. The climate of the region is tropical, with high temperatures in the summer (35-40°C) and extremely cold in the winter (12-14°C). The village is known for its art and dance forms. The first, *Pattachitra* is an art form that dates back to the 5th BC on palm leaf engravings, also on sheets made of recycled old textile (sarees). Most of the paintings depict the stories of *Lord Jagannath* a lord of Universe is considered a form of Vishnu. The art forms are also depicted by using coconut shells and paper pulp. Waste coconut shells are reused and reshaped in the shell form and hand painted on it to use it as well as wall hangings. Similarly, the paper pulp and cow dung is used to make masks

and toys. In the year 2000, the village was developed as State's first heritage village by India National Trust for Art and Cultural Heritage (INTACH). The place is also known for its *Gotipua* dance form; an Odissi classical form performed by young boys who dress as a women.

2.1.2 Settlement Patterns:

The pattern of the village is display a linear and informal settlements. It is elongated on both side of the central corridor consists of series of temples. Other than the temples it has dance academy, few shops, gathering space and public amenities (Fig.1.0).

2.1.2.1 Houses:

Most of the houses are elongated with a small façade facing towards the main road in the village. The houses are of low rise with common wall on both sides, light and ventilation are through the front verandah and the backyard of the houses. The materials used for the construction are brick, laterite, timber, bamboo, cow dung, concrete floor with red oxide flooring and thatch roof. The scale of the houses varies based on the economic status (Fig.2.0). The verandahs acts like a gallery a location for display of their art work, with most of the works demonstrated on the verandah. The walls of the verandah are painted with stories of lord Jagannath. The indoor spaces are multi-functional, since the art work is carried out in all the spaces based on the other household activities (Fig.3.0).

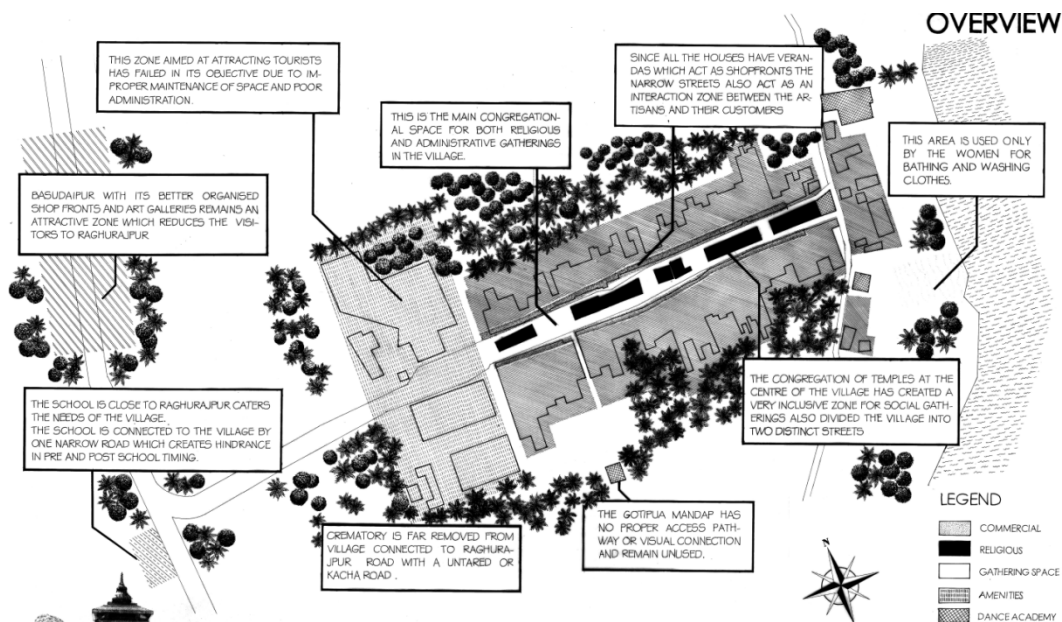


Figure.1.0: Settlement Pattern of Raghurajpur

Source: Documentation work by team of students of School of Planning and Architecture (SPA) Vijayawada, 2015.

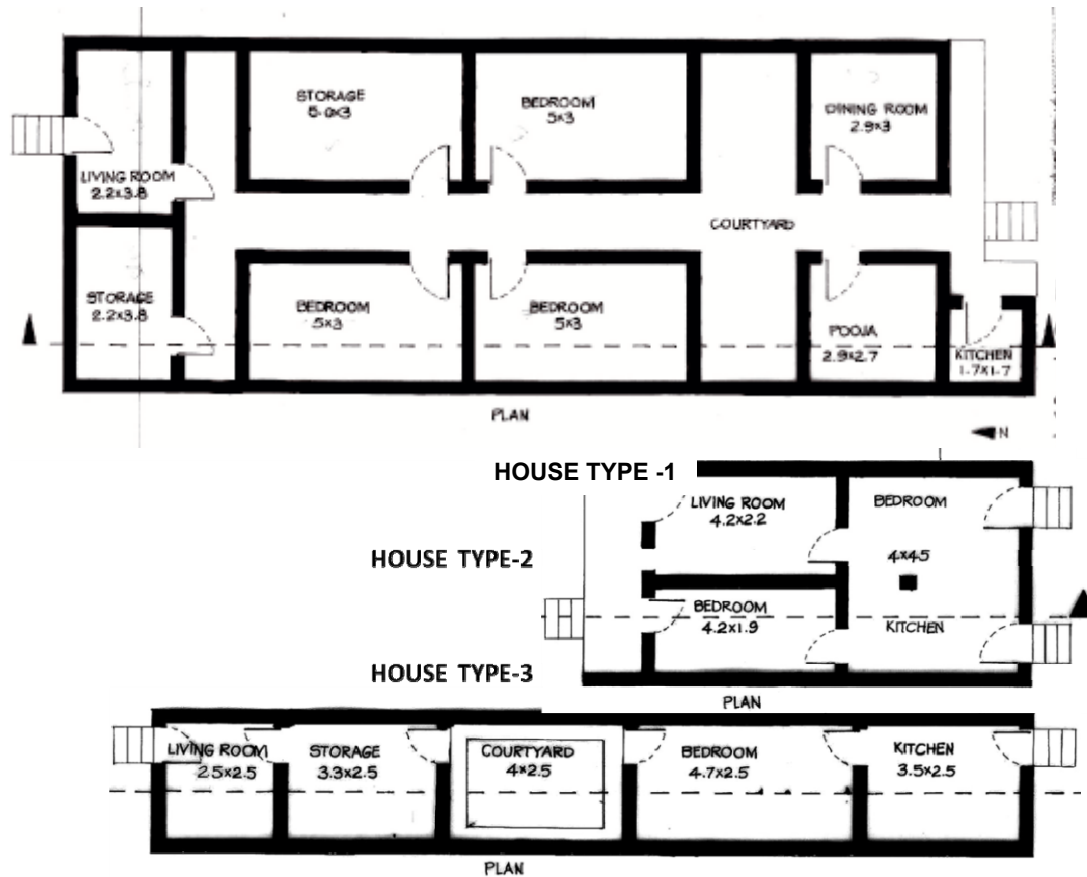


Fig.2.0. Different typology of the houses

Source: Documentation work by team of students of SPA Vijayawada, 2015.

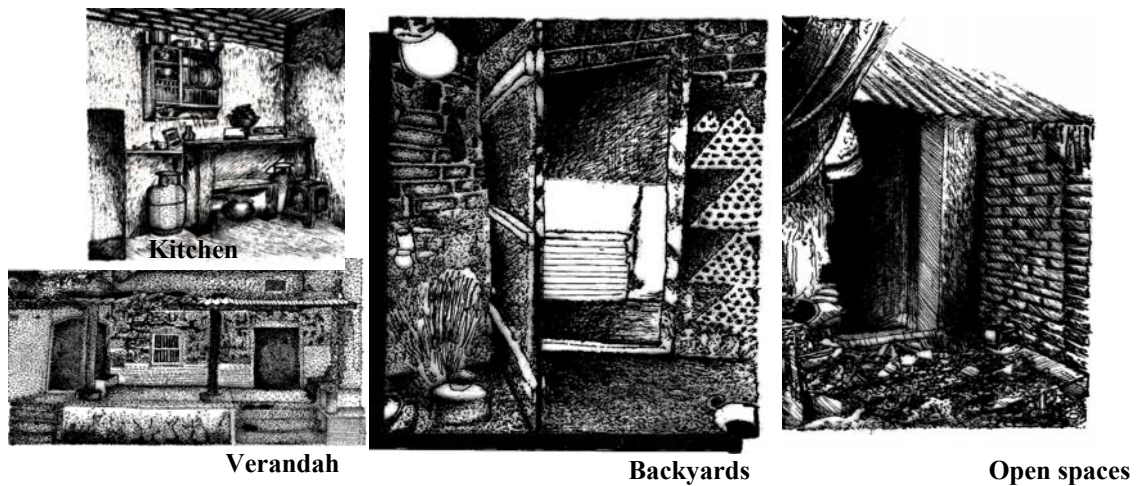


Figure.3.0. Sketches of indoor spaces

Source: Documentation work by team of students of SPA Vijayawada, 2015

2.1.3 Traditional elements:

The traditional beliefs and practices are reflected in their own way. The art forms are demonstrated on the facades of most of the houses. These attract tourists as well as add to the aesthetic of the buildings. The window grills are made from wood and used for hanging masks that are depictions of the heads of lord Jagannath.



Figure.4.0: Walls are demonstrating traditional art forms
Source: Courtesy of the Author

2.2. Sawantawadi, Maharashtra

2.2.1. Introduction:

Sawantwadi is a taluk, under Sindhudurga district in Maharashtra, and has a historical significance and was ruled by Marathas. The town is geographically located within the Sahyadri range towards the east and low lying coastal areas towards the west. Climate of the region is tropical with similar temperature conditions in winter and summer (Average temperature 26°C). Sawantwadi is known for wooden toys and *Ganjifa cards* (Fig.5.0) which are one of the tourist attractions. Artisans and craftsman belongs to *Chittar community*. In the recent times, there has been a rapid decline in the socio-cultural context within the city due to modernization and urbanization, but still the wooden toys and *Ganjifa cards* are made in the palace located in the heart of the city.



Figure.5.0 Ganjifa cards and wooden toys of Sawantwadi
Source: Courtesy of the Author

2.2.2. Settlement Patterns:

The history of settlement patterns show many sectors are dedicated to different communities for example: *Vishyawada* (of traders), *Bahir wada* (of Muslims), *Bhat Wada* (of Brahmins), *Kahskil Wada* (King personals), *Matewada* (place for burial) etc. (Fig.6.0). The spaces were divided based on the caste and occupation. However, currently it is difficult to find all the community but many still exists. The present settlement is concentric; lake at the center is a major attraction and is a major source of water for the local residents.

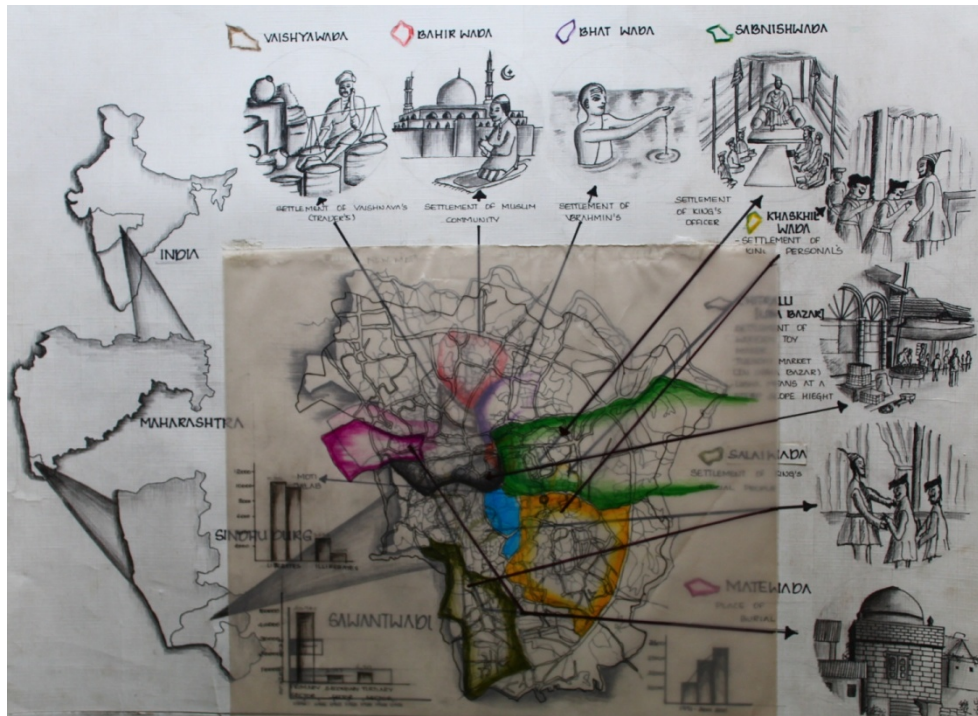


Figure.6.0 Community based settlement patterns

Source: Documentation work by team of students of Srinivas School of Architecture (SSA)
Mangalore, 2016

2.2.2.1. Houses

The houses are compact, elongated and with a common wall on both the sides with shops in the frontage. The backyard consists of all wet areas (bathrooms, toilets, kitchens). Most of the rooms are arranged on one side of the passage. The houses vary from single to double storeys. The materials used for the construction mud, stone, bricks, Mangalore tile roofs and wood. Light and ventilation are from front and backyard of the houses (Fig.7.0).

2.2.3. Traditional elements:

The Sawantwadi has a different community influence which is reflected in architectural elements. Islamic, Vernacular, Maratha and even Western Architectural styles are seen in the public and private buildings (Fig.8.0).

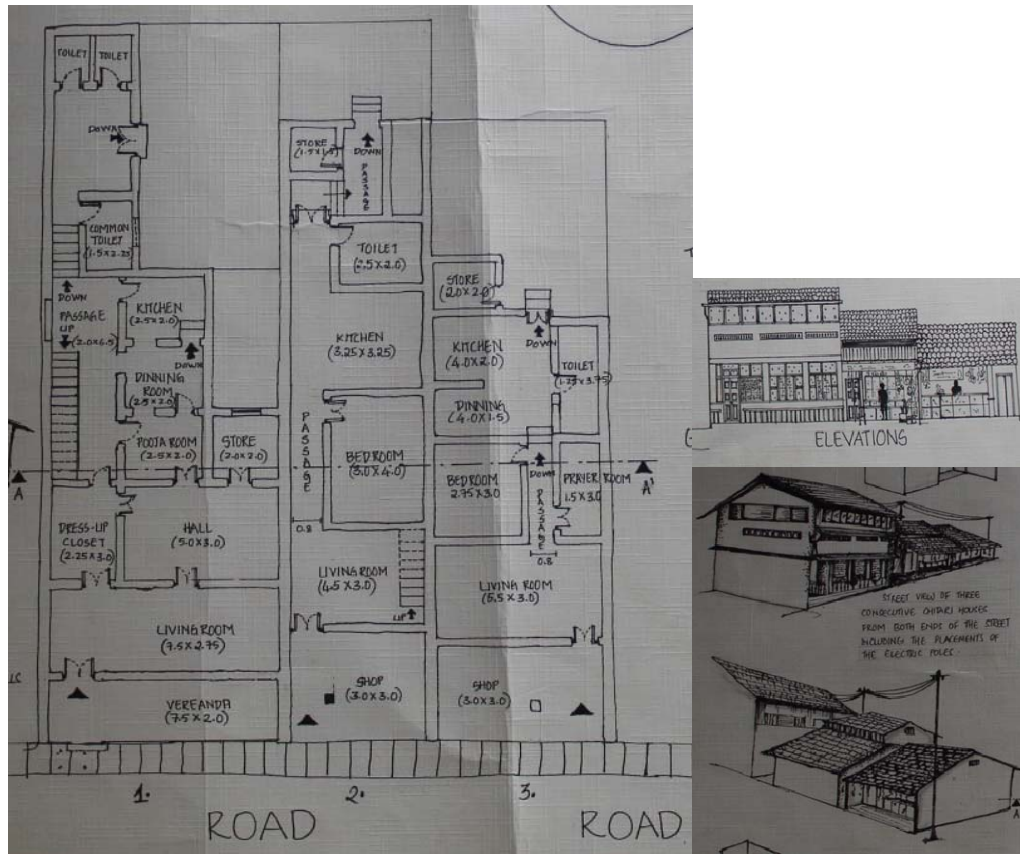


Figure: 7.0 Sample houses of Sawantwadi
Source: Documentation work by team of students of SSA Mangalore, 2016



Fig.8.0: Traditional elements of Sawantwadi
Source: Documentation work by team of students of SSA Mangalore, 2016

2.3. Mattur Village, Karnataka:

2.3.1. Introduction

Mattur is a tiny hamlet located on the bank of river Tunga near Shivmoga District, Karnataka. The village is known as “Sanskrit Village of India”. Most of the people

residing in the village are Brahmins; a community that migrated from Kerala and settled around 600 years ago. Sanskrit and Sankethiare the primary language; around 700 households use Sanskrit for their day to day communications. Social gatherings happen around the temples which are integral part of the neighborhood. It is also an agrarian village, primarily cultivates *areca* nuts and *paddy* (rice).

2.3.2. Settlement Patterns:

The settlement is compact, integrated with religious places of worship (Fig.10). Every house has a verandah in front which is used for social interactions.



Fig: 9: Compact settlement of Mattur Village

Source: Documentation work by team of students of SSA Mangalore, 2017

2.3.2.1. Houses:

The houses are compact and elongated with verandah in the front leading to the roads. The kitchen and *Pooja* rooms (place of worship) are more auspicious and other caste people are not allowed inside the house, hence the importance of the verandah as a place for social gathering and acting as a threshold. Most of the houses are either single double storeys. Material used for the constructions are laterite, brick and mud for walls, wood for openings, concrete flooring with red oxide finish and Mangalore tiles for roof (Fig.10.0).

2.3.3. Traditional elements:

The tradition is reflected through built and un-built spaces. The columns inside the living room are more ornate and reflect more of Hindu religious elements (Fig.11.0). The

outdoor spaces like river banks, banyan tree platforms on the village squares (Fig.12.0) and temple mandapa's (temple gathering area (Fig.13.0), are used for daily rituals, like the floating platform on the bank of the river to perform yagya.



Figure.10. Sample Houses Mattur Village

Source: Documentation work by team of students of SSA Mangalore, 2017



Figure.11.0: Column ornamentation in the interior spaces

Source: Documentation work by team of students of SSA Mangalore, 2017



Figure.12.0: Outdoor spaces for daily rituals

Source: Documentation work by team of students of SSA Mangalore, 2017



Fig.13.0: Indoor spaces for daily rituals

Source: Documentation work by team of students of SSA* Mangalore, 2017

2.4. NadiBettu, Shirva,

2.4.1. Introduction:

Shirva Village in Udupi District in Karnataka located, 46 Km from Mangalore city. The settlement is scattered with a population around 13,000. Agriculture is the main profession of the villagers with Tulu the spoken language. The traditional practices performed in Tulunadu (Tulu speaking region), some of which are well-known rituals include: Bhootakola (Demon worship), cock fight, Nagaradhane (Snake Worship), Kambala (Buffalo fight), Siri aradhane and, Pili vesh. Folk dances like Siddavesha and Aatikalenja; folk literature like 'pad-danas' (poetic stories); Yakshagana; traditional Tulu practices are the few to name.

2.4.2. Settlement Patterns:

Most of the rural settlement in coastal belt of Karnataka is scattered with the houses surrounded by paddy (rice), Arecanut trees, cashew nut and coconut.



Figure: 14.0: Scattered settlement of Shirva

Source: developed from Google map

2.4.2.1. Houses:

The Guttu's are the territorial units in the village/ Grama. They are not only the spatial or geographic locations but, were also economic production, distribution and surplus appropriation of units which functioned as semi-autonomous, politico-juridical zones in the past. At territorial level, the head of each guttu house was responsible for maintaining law and order and peace. The Chawadi (front verandah) of the houses were used to solve the disputes as well as to discuss the problem at territory level. Each village has sixteen sub-guttu families ranked from 'MundabettuGuttu' to 'PererGuttu' at

the bottom. NadiBettu at Shirva is one such important house as shown in the figure.15.0. Though the elevation is simple (Fig.16), the interior spaces have richly carved columns, ceilings and beams. All guttu houses are typical features of Chawadi, court yard surrounded by private rooms. Chawaadi is one of the important part of the Guttu houses, includes pooja room known as *BhutadKone*. Lower caste people are not allowed to enter the chawadi, unlike in the previous housing type where the verandah was the threshold and place for gather. Here the religious practice actually creates and reinforce the separation farther. Material used for the houses are laterite, mud, brick, jack wood, thatch or Mangalore tiled roofs.

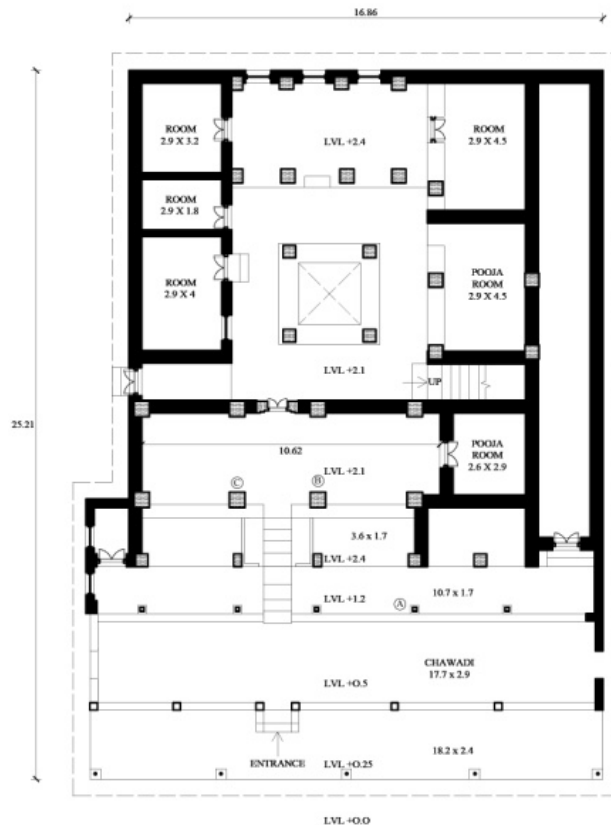


Figure.15.0: Plan of NadiBettu, Shirva



Figure.16.0: Elevation of NadiBettu, Shirva

2.4.3. Traditional elements:

Richness of the Tulu nadu can be seen in the Chawadi, which is auspicious. The exposed columns of Hebbelasu (Jack wood), varies from 450 mm to 550 mm in cross section, tapered towards the top. The columns, beams, ceilings and doors are richly embellished with a variety of motifs with gods and goddess. The motifs such as: a man riding a horse surrounded by floral decorations, geometrical patterns, *Gandberunda* (Two headed mythological bird), and *Nagamandala* (Serpent) motifs. Other carving details are parrots, *Garuda* (eagle), elephant, peacock, and floral patterns (Fig.17.0). Apart from the indoor spaces the culture is reflected in the form of *Kambhala* (place for buffalo fights) (Fig.18.0) and *Nagabana* (worship for snakes) (Fig.19.0).

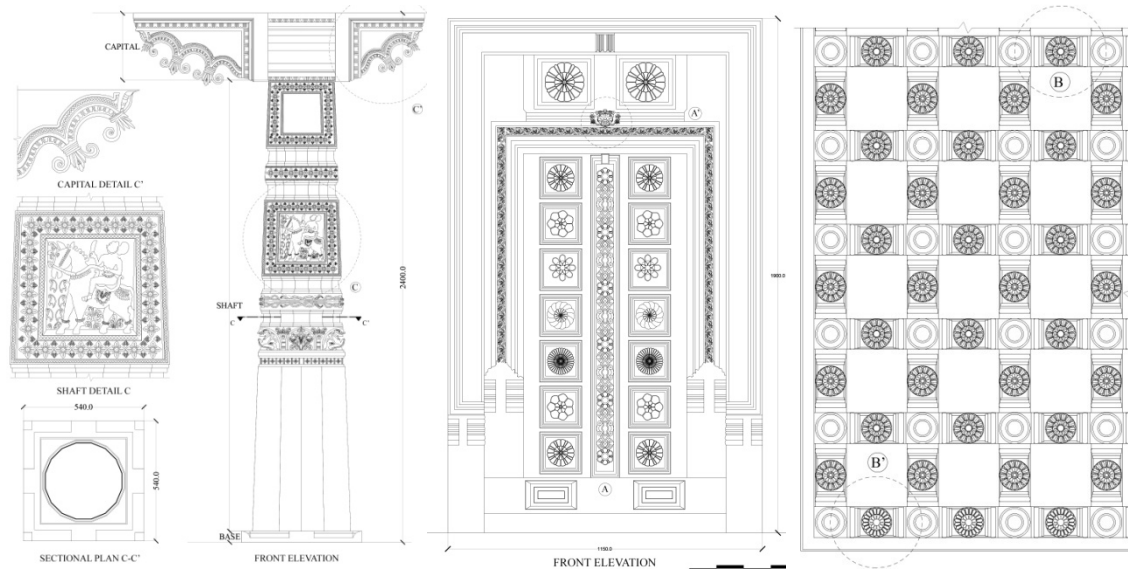


Figure.17.0: Details of Carvings at NadiBettu, Shirva



Fig.18.0: Kambhala at NadiBettu, Shirva



Fig.19.0: Nagabanaa place for worshipping snakes

3 Conclusions:

The socio-cultural and traditional practices are demonstrated in various forms in Indian villages. The patterns and traditional elements create an identity to each village in a unique way. Case studies of four Indian villages were analyzed through settlement patterns, typology of the houses, and their traditional practices. Each village added its own way to create an image. Raghurajpur is specially known as artisan's village, where linear settlement is observed due to its occupation. Houses are multi-functional, where art forms are practiced, displayed and demonstrated on the walls, columns and on the openings. Reused cloths, and waste beetle nuts and coconut shells are used for paintings. Sawantwadi is known for its wooden toys and for making Ganjifa (playing cards), verandah of the houses are converted into shops, and store next to it. Mattur is another such hamlet, known as Sanskrit Village of India, with a majority Brahmin community. The traditional practices of rituals are performed in both indoor and outdoor spaces. Shirva is a scattered settlement and landlord's house reflects their traditions through rich carvings depicting their traditions, similarly outdoor spaces for *kambala* and *Nagabana*. Thus, each community is unique in its way and is demonstrated either indoor spaces or outdoor spaces. These evolve based on individual practices

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A CONCEPTUAL MODEL FRAMEWORK OF SMART VILLAGE FOR SUSTAINABLE DEVELOPMENT

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Abstract

In the Indian context, villages are the heart of the nation. Almost 70% of India lives in villages where the social and economic conditions are sub-optimal. The country has often been touted as an emerging superpower even though most Indians remain super poor. There is a large scale migration of the people from rural areas to urban areas for their different needs such as education, employment etc. So the main aim to smarten the villages by offering basic facilities, education, employment generation activities, technology. Hence, for the overall development of the country the focus must be given to the grass root level, that means our villages. So there is an urgent need for designing and building the villages as smart villages across the country. Initially the concept of development of village is given by Mahatma Gandhi i.e. swaraj and suraj village a complete republic and independent of its neighbours for its vital daily needs. The vision of Smart Village is to catalyse sustainable energy services for development enabling the provision of good education, healthcare, clean water, sanitation, nutrition, the growth of productive enterprises to boost incomes, environmental sustainability, gender equality and democratic engagement which helps to support further improvement in access to energy.

This paper attempts to illustrate the conceptual framework of a village under Indian perspective in such a way that which is self-dependent in providing the services, employment and well connected to the rest of the world i.e. smart village. Taking education, skill for vocations etc. to villages can well channelize the energies of the youth as a powerful tool for the nation. The authors aim to propose an indigenous model of smart village by considering the efforts to mobilize the collective strengths of people from various streams and integrate it with information technology to provide benefits to the rural community. The proposed model of 'Smart Village' will encompass a sustainable and inclusive development of all sections of the village community, so as they enjoy a high standard of living.

Key words: Smart, vision, village, model, sustainable development

1. Introduction

Smart Villages are the need of the hour as development is needed for both rural and urban areas for improved livelihood. The idea of creating smart villages for sustainable growth and development in rural areas means focusing on productive enterprises as well as providing access to basic infrastructure like roads, water, power, information and communication technologies, and education and healthcare facilities. Agriculture through the energy-food-water nexus has the potential to create productive enterprises provided that energy can be produced to catalyse an ecosystem that connects farmers, small and medium enterprises, markets, local state and central governments, and industrial social and political organisations. Building productive enterprises that add value to agri-business and the food chain and engage women and girls in new enterprises. The assessment of smart and sustainable villages, however, is a major challenge. This makes the available monitoring and evaluation tools difficult to adopt and apply in different contexts to support planning and governance and foster evidence-based policymaking. In order to address this issue, the paper brings together knowledge-based development concept with smart and sustainable villages. The methodological approach of the paper includes the review of the literature on existing approaches on smart and sustainable villages' assessment, describing their main aspects, strengths and limitations, and discusses the potential contribution for the successful promotion of smart and sustainable villages, presented in a proposed conceptual framework.

2. Literature review

Since the mid-twentieth century, numerous environmental, social and economic crises on a global scale have significantly affected our societies (Yigitcanlar and Lee 2014). A sustainable village is a vision of the future, shared by its citizens. In order to provide better quality of life in the present while maintaining or expanding the possibilities of well-being and prosperity for future generations. Sustainable development is generally discussed in terms of environmental considerations, but from a rural community perspective, sustainable development must address how the people of the community generate the income to maintain their rural lifestyle (David Freshwater 2000). A sustainable village as the one that can generate the maximum socioeconomic benefits for its population without losing the environmental and equity parameters, measured by appropriate indicators (Mori and Yamashita 2015). A smart village, for instance, will

seek the goal of achieving its sustainability with the support of modern technologies; in fact, information and communication technologies (ICTs) can bring numerous benefits to cities, but its implementation. An integrated approach for the transition of villages and their regions into places of attraction, retention and development of intellectual and human capital that will ultimately create a knowledge dynamics applied to the urban context and foster innovation to promote an integral and sustainable development of the territory—not only for the economic terms, but also environmental and societal terms (Pancholi et al. 2015; Yigitcanlar et al. 2012, 2017). This paper highlights an understanding on these issues, and discusses a theoretical strategy for the promotion of smart and sustainable cities, presenting a conceptual framework .

3. Methodology

The primary research method for this study is literature review and conceptual modelling. Constraint identification and classification through a structured approach is being done. Various types of constraints and their characteristics is being reviewed. Based on this understanding, a classification method is developed to categorized constraint factors for the purpose of constrain identification and modelling. The existing constrain modelling method is identified based on a comprehensive review of current practices and academic researches. Finally, once the constraint classification and modelling techniques are identified a conceptual frame work is identified.

4. Conceptual Framework

The Smart Villages Initiative focuses on identifying the framework conditions necessary to support the creation of sustainable local energy solutions for rural communities which catalyse development. The Smart Village Conceptual Framework depends on the resource availability, people's occupation, co-operation between the villagers and social acceptance. It is indeed important to understand the dynamics of socio-economic aspects of the village with geographical features and quantifying available resources. Knowledge of current skills and practices with gaps in the agriculture, energy, water resource and livestock management will help in choosing apt technologies for sustainable development. Sustainability is a qualitative as well as quantitative parameter which is tagged with every process

Proposed Smart village framework is essentially management approach based on the nature's principles with sustainable technical interventions to achieve self-reliance in energy, education, job and other vital needs. The framework embraces local resources and skilled man power to ensure sustainable intervention of technology which are technically feasible, economically viable, user and environment friendly. Figure.1 gives the overall concept of a smart village framework for a self-reliant and self-sufficient village.

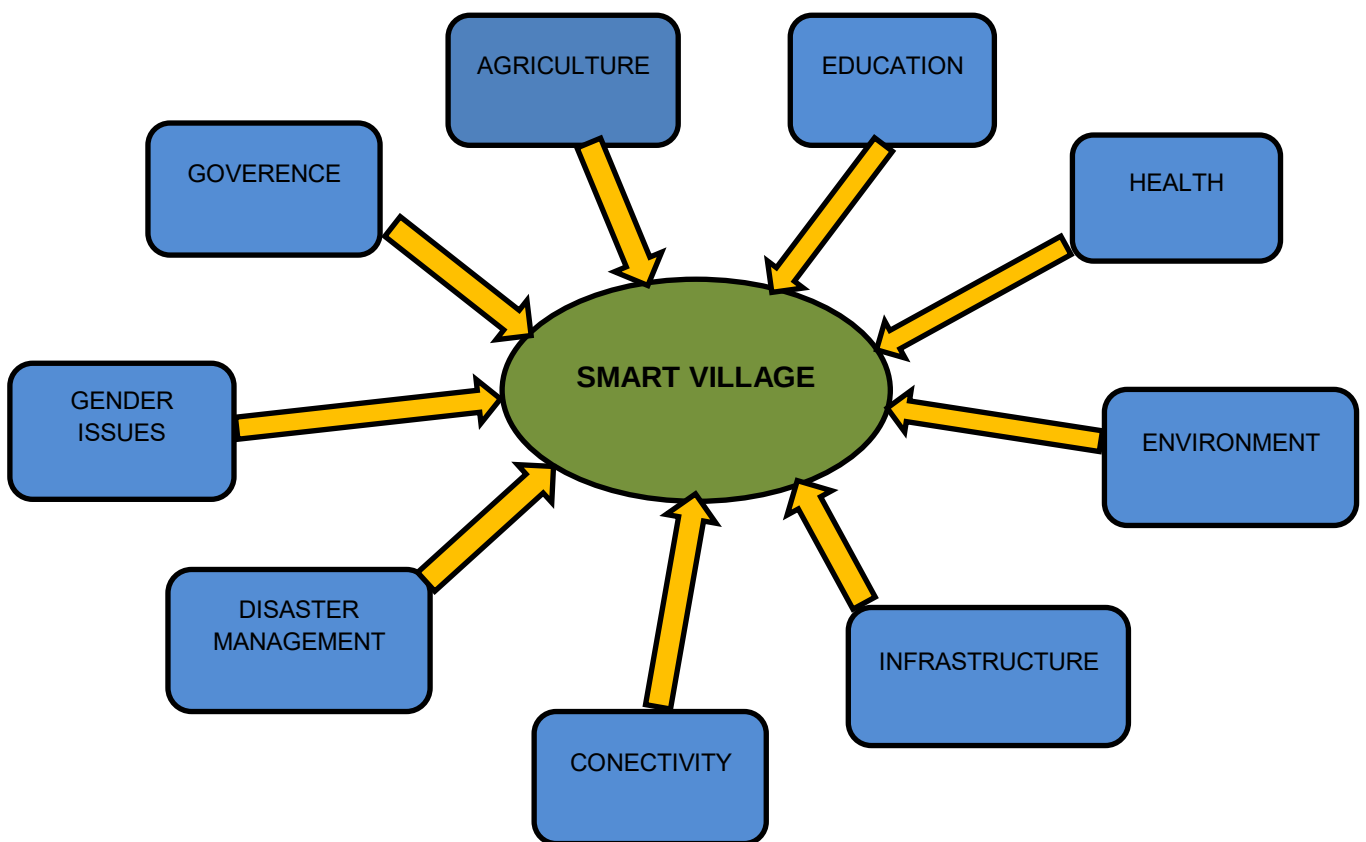


Fig. 1

4.1 Sustainable Agriculture

For any village, its agricultural eco-system is one of the most intrinsic identities that directly relate to its social, environmental and financial fabric. Efficiency and productivity in agriculture is directly related to the farming practices adopted by the communities. Fortunately, the intersection of technology and agriculture has opened up a lot of opportunities for the farmer, consumer and suppliers. This intersection is now called Precision Agriculture (PA). Now a day the major problem is of scarcity of water and it is same in our selected village. To avoid this problem, avoid the production of crops which require more quantity of water like sugarcane, banana etc. while taking crops first check the quality of soil and according to that take crops which are suitable. To reduce the wastage and overuse of water use latest modern techniques like drip irrigation, sprinkler irrigation and so on. Water and soil rejuvenation becomes more extensive and includes conservation, utilization, and rural rejuvenation to meet development requirements to drive local agricultural and economic development and prosperity.

Government launches so many schemes which help to reduce stress and pressure generated in farmers mind because of today's condition.

1. Soil health card scheme.
2. National agricultural development program to promote use of organic farming.
3. Fertilizer subsidy.
4. Bank loans, free electricity.
5. Gram Swaraj Abhiyan, Saksham Kisan, Samridh Bharat.
6. Pradhan Mantri Fasal Bima Yojna (PMFBY).
7. Crop intensification such as SRI
8. Micro-irrigation, Agro-service centre
9. Setting up seed banks

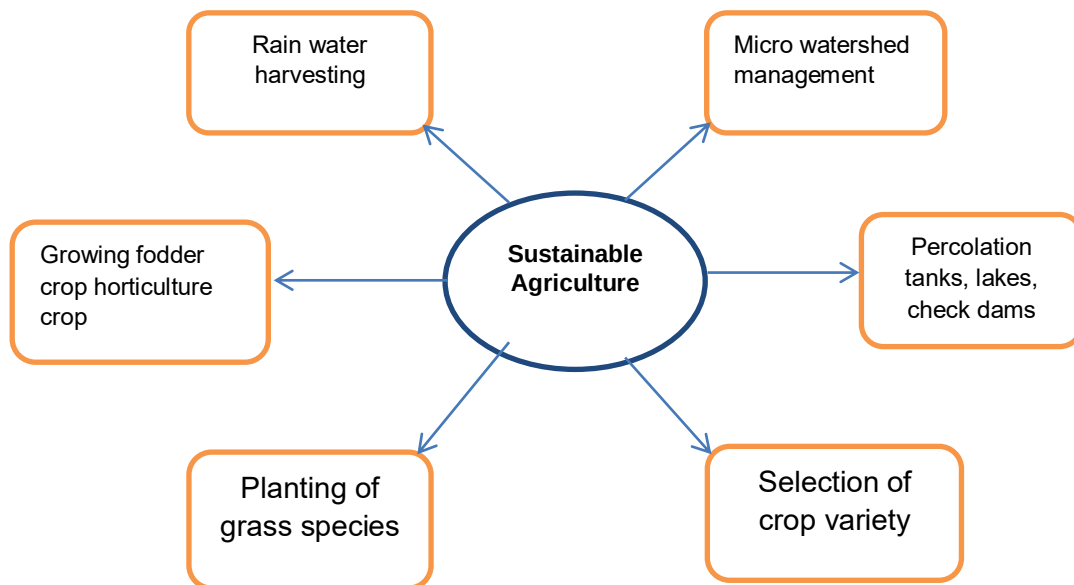


Fig. 2

4.2 Sustainable Education

ICT-equipped schools can provide a good deal of handholding in accessing internet and consequently the world's knowledge base, ending the information isolation experienced by many rural communities. In addition, ICT and internet access also have a "pull factor", providing incentives for school attendance and for attracting and retaining good teachers, addressing issues such as school dropouts and cognitive development. ICT-based teaching should not be used to replace teachers, rather to augment teaching resources and modes. Good quality software and programme materials should be developed which are locally relevant and presented in local languages. Education should develop the skills necessary for villagers to get jobs.

4.3 Sustainable Health

At the most basic level, households in smart villages will be able to consume potable water and a more nutritious diet due to the reduced cost of boiling water and cooking food, and enhanced agricultural productivity arising from associated development initiatives and reduced wastage. ICT-enabled m-health initiatives can enable mobile health diagnostic solutions, requiring relatively low levels of local medical skill and

providing access to specialist health-care services based in urban communities where necessary. Epidemiological data can be gathered, providing the opportunity for more effective interventions and early warning capability to address health related challenges such as malnourishment, underweight child birth, anaemic mother etc.

Facilities for telemedicine in villages should be embedded in a wider system that provides for early detection and action on outbreaks of diseases. Training should be provided to teachers and medical staff to make effective use of the new technologies. Smart villages aim to increase the time available for students to study and will address prevalent factors that negatively affect the ability of students to acquire the knowledge and skills necessary to achieve economic goals and improve labour productivity. Establishment of PHC Maintaining the ayurvedic hospital Vocation training on maintaining the cleanliness around household Mandatory toilet and bathroom for each home Constructing proper drainage system

4.4 Sustainable Environment

Smart villages can be stewards of the environment aided by technologies to monitor key environmental indicators such as forest health, water quality, soil conditions and changes to the landscape. They can also 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. Smart villages can host community-run recycling facilities ranging from those equipped to recycle wastewater and organic waste from agro-processing, to next-generation facilities for the recycling of e-waste, including energy-storage and generation technologies such as batteries and solar panels. Depending on geographical endowments, some smart villages will be able to operate as regional ecotourism hubs, an activity that can improve the welfare and connectivity of rural and urban communities.

4.5 Sustainable Infrastructure

In order to ease life of villagers in every possible way, a village has to be well supported with infrastructure to enhance efficiency of habitants and efficacy of inputs from the villagers. The infrastructure includes roads, institution buildings, weather

station equipment, hospital equipment, telephone towers etc. Most of these infrastructures can be established with well-intended village habitants and the guiding institutions through convergence of funds, functions and functionaries. Smart element needs to be included in every stage of infrastructure development.

4.6 Smart Connectivity

Smart connectivity has two distinct connotations for smart village concept. One is to provide reliable and high quality broadband and voice communications. And the second, probably more importantly, through a range of Information and Communication Technology (ICT) solutions, applications and services, be an integral part of smart technology solutions for all other domains like smart agriculture, smart water management, smart education, smart health-care and so on. Rural communities tend to be politically disenfranchised due to their relative remoteness. Consequently, they lack information on societal issues and have difficulty becoming actively involved in debates about how to address them. Smart villages, through ICT, can 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. The significant advances in ICT help to underpin the success of smart villages through communication, awareness raising, education, and capacity building. Innovative software applications can establish research-extension-market linkages that were previously poorly executed or non-existent. Such applications will continue to contribute to a growing range of educational activities which include weather forecasting, soil health, irrigation systems, precision agriculture, monitoring waste water systems, and threats from extreme weather events associated with climate change. In particular, they offer the prospect of replacing inefficient and expensive extension services with up-to-date and accessible knowledge sharing and information about best practices for smallholder farmers.

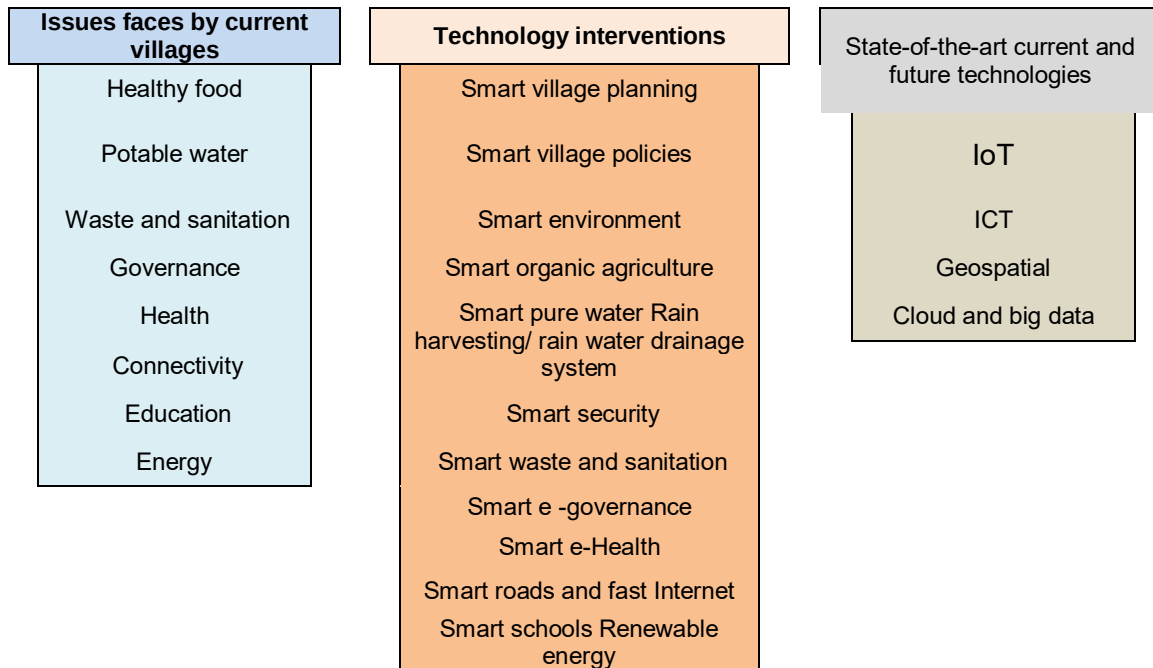


Fig.3

4.7 Disaster management

Villagers are easily affected by disasters due to lack of preparedness. The various players responsible for the key components of the infrastructure of villages— energy supply, communication links, health facilities, schools, etc.—should come together to take an integrated approach to establishing an appropriate level of resistance to natural disasters. Governments should map resources and vulnerabilities, sharing the information with local communities and municipalities. Systems should be in place to provide early warnings of impending shocks, and to support effective action during events and afterwards. Energy access and ICT should be used to develop their knowledge and skills in respect of mitigating risks. Support should be given to the sharing of knowledge and experiences between rural communities. DM cells may be set up at the panchayat level to address all the disaster related issues. DM cell will

connect to the National Disaster Management Authority (NDMA) through the central server for monitoring the future scenarios.

4.8 Gender issues

Issues of gender equality and the empowerment of women have been an important topic. There are many benefits to women arising from energy access through labour-saving devices, reduced burdens for collecting fuel wood and water, improved health and safety through clean cooking technologies and better access to healthcare, and improved educational opportunities. Responsibilities leave women with no time for other activities such as paid employment, engaging in the social and political life of the village, and education and training which could open up new opportunities. These impacts on their social standing in the village and their economic position and influence in the household. Women entrepreneurs have not yet been scaled up in number, yet women appear to conduct energy entrepreneurship better than men as a result of their social networks. There is a distinct track record of women functioning as effective entrepreneurs, with many visibly successful organisations and networks such as: Grameen Shakti, Self Employed Women's Association (SEWA).

4.9 Participation in governance processes

Smart villages, through ICT, will allow rural communities to become more aware of their social, economic and political rights, engage in governance processes at all levels and hold policy makers to account. Looking beyond the usual concerns to eliminate corruption in voting systems, realising the opportunities inherent in smart villages for rural communities to take a more active, informed, and influential role in governance processes requires governments to educate villagers in the workings of governance systems and how they can input to them. Governments should use the range of tools available through ICT, such as web-based referenda, consultations, and debates, to enhance transparency, accountability, and participation. Where possible, government services such as welfare benefits, birth and land registrations for individuals, and business registration and other regulatory processes for businesses should be made available on the internet.

5. Discussion and Conclusion

Smart Villages are the need of the hour as development is needed for both rural and urban areas for better livelihood and Information technology will offer effective solution. There are successful technologies available, which have been implemented in urban areas. There is tremendous pressure on urban landscapes due to migration of rural people for livelihood. Smart Villages will not only reduce this migration but also irrigate the population flow from urban to rural area. ICT/ IT and GIS are the unbreakable pillars to support the whole process of village development. Smart village concept will have potential to uplift the grass-root level of the country, hence adding feather in the overall development of India. Failure to utilize Information Technology tools for rural development is because of lack of strategy, unfocused planning and above all monitoring and execution of the activities. All these activities need to be addressed based on the varying rural situations. A specially designed suitable framework for rural areas on the grounds of Science, Technology, Engineering, Regulations and Management will play important role to build next generation smart villages. Each village is a unique example and having diverse set of problems and situations. It may be difficult to implement the same model of village development for all the villages. Benefits of the smart village efforts are foreseen to be tremendous. Smart village concept is having high replication potential in other countries of developing world. The concept of smart village may also be extended to small towns and also townships surrounding the big Cities.

Higher levels of economic activity in and around agriculture, and the activities needed to maintain and support the new service infrastructure in villages (energy, ICT, health, education, clean water and sanitation) bring new opportunities for local service industries (for example welding, carpentry, business support) which are most appropriately located in the villages. Other opportunities may arise from the distinctive location of the villages, enabled by the connectivity which provides the links to markets, for example tourism and craft products (unique, bespoke, etc.). New technologies for distributed manufacturing, 3-D printing, etc., will open up the potential for competitive manufacturing at scales possible in larger villages and clusters of villages. These new opportunities for village-level enterprises and income generation reflect the shifting of the balance of opportunities between rural and urban communities made possible by new technologies and business models. Once smartphone ownership and internet connectivity reach levels comparable to those in cities, those economies of scale and

agglomeration effects (that have driven urbanisation) arising from information flows can be reproduced in villages. So distance becomes largely irrelevant in respect, for example, of business services such as accountancy, consultancy, legal, licensing, etc. Internet-based recruitment can match people with the requisite skills to jobs wherever they may be located.

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ICT4D FOR SMART GOVERNANCE OF RURAL DEVELOPMENT

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Abstract: *Aligned with smart villages, smart governance can identify and address gaps between services provided to communities, the needs of communities, and support for self-reliant interaction within communities. This paper presents ongoing work on a survey-based information communication technology for development (ICT4D) model for smart governance and an associated proof-of-concept software tool, with an emphasis on an Assamese context.*

Keywords: *Smart Villages, ICT4D, GIS, Smart Governance, Assam.*

1 Introduction

Although the development situation in Assam, India, has in recent years been improving, there is still a considerable gap between the availability of data in useful form within levels of government and to the public, and the insight demanded of data by adopted development goals and rural needs. This gap affects areas, and creates needs within them, such as: communication to facilitate people working together; governance architecture that adapts to new technology; sub-state level governance to provide better data access to those who need it; integration and digitisation of disparate sources of data; and monitoring and evaluation to provide credible and adequate data for actionable insight.

In response to this gap, the Smart Villages Program (SVP) at the Melbourne School of Design, the University of Melbourne, is conducting as part of its research into use of “Smart Cities” approaches for rural development an internet-supported survey of rural household needs and conditions on the island of Majuli, Assam. This survey is supported by a work-in-progress framework for rural development through Smart Governance supported by Information and Communication Technologies for Development (ICT4D).

The objective of the ICT4D system is a small, scoped intervention to provide actionable insights, particularly at local level, as best can be provided as an outcome of the survey process. It is not intended to transform existing government structures, as this is beyond the scope of the project, but could assist internally-led transformation of government processes. Further, the approach is neither designed to, nor intended to, supplant any data-gathering or geographical information system by, or of, any department of the Government of Assam.

2 Context

The State of Assam, India, has in recent years improved in its economic outlook, yet still has significant disparity of conditions and opportunities between urban and rural citizens (Government of Assam 2018c). Rural citizens, who at 86% of the Assamese population number in excess of 25 million people, suffer disadvantage as measured by many metrics both with respect to the urban Assamese population and to India as a whole. In the 2011-12 period, 33.89% of rural Assamese citizens fell below the poverty line, compared to 25.50% for all rural Indians and 20.49 for urban Assamese. Assam ranks only 26th in literacy among the states of India; in urban areas literacy is at 88.47%, yet in rural areas it is at 69.34% and only 60.05% for rural females. The rural Infant Mortality Rate (IMR) in 2014 was, at 52 deaths of infants under one year old per 1,000 live births, well above the national rural level of 43, and greatly above the Assam urban level of 27. Rural provision of electricity is greatly below that in urban areas: although 84.10% of urban households use electricity for lighting, only 28% of rural households do so. There is a significant lack of communications access in rural areas of Assam with only 39.18 telephones per 100 people, compared to 132.26 per 100 in urban areas and a national average for rural areas of 48.04 per 100 (Government of Assam 2017).

Since 2005, The Government of Assam (GoA) has adopted fiscal reform measures that are stated to be “a key factor for attaining higher economic growth”. However, while the Gross State Domestic Product for the 2011-12 to 2015-16 period averaged 12.50% annual growth, the disparity between rural and urban welfare has not significantly narrowed (Government of Assam 2018c, 2017).

In 2016, the GoA adopted the *Assam 2030: Our Dream, Our Commitment* (Assam 2030) policy framework with provisions to improve the living standards of rural Assamese and reduce the rural-urban divide (Government of Assam 2016). The framework adopts and expands on the goals of the United Nations Development Programme's Sustainable Development Goals (United Nations Development Programme 2015).

The targets contained in Assam 2030 are ambitious. For example, under *No Poverty*, it aims to reduce Assam's poverty rate from 27.30% in 2015 to 0% in 2030, and under *Zero Hunger*, it aims to double the agricultural productivity and incomes of small-scale food producers (Government of Assam 2016). Beyond the difficulty of achieving any such target in isolation, complexity is introduced by rivalry between goals of the framework; for example, the goal to double agricultural productivity is made more difficult to achieve by the conflicting environmental aspirations of other goals.

The GoA also has supporting aid programs designed to address specific issues on the ground and improve development outcomes in the long term by leveraging funding allocation. One such program is the proposed expenditure by the State Agriculture Department of Rs. 2000 lakh (approximately \$4M AUD) to establish 800 mini oil mills with packaging units to support local oil markets and employment generation. A similar scheme for 2014-15 was the provision of spice and pulses grinding mills, power weeders, and paddy transplanters to rural women's self-help groups under the Chief Minister's Vision of Women & Children (Government of Assam 2017).

To achieve development goals such as those of Assam 2030, and to effectively implement supporting aid programs, is a substantial demand of existing governance frameworks. Indeed, the GoA acknowledges this in its Assam 2030 vision, and explicitly recognised as amongst the 'critical challenges' the issues listed hereunder (Government of Assam 2016):

- A. Communication: to bring together people to work harmoniously;
- B. Governance architecture: to reinvent governmental systems, and exploit rapidly changing technology, to better predict and shape the future;
- C. Sub-state level governance: to assist these levels in achieving development goals;
- D. Integration and digitisation: to capture and synthesise knowledge from disparate sources;
- E. Monitoring and evaluation: the 'dearth of credible and adequate data, and weak monitoring and evaluation systems, pose a serious challenge'.

3 Smart Governance and ICT4D

To address these challenges, there is need for informational support of the governance process to measure needs and conditions, formulate and implement policy, and assess outcomes. Government hence requires the ability to have information that is up-to-date, comprehensive, relevant to evolving issues, and accessible in part or whole to appropriate levels of government and sections of the community. Use of a smart government approach supported by ICT4D intervention can provide this.

Smart governance, as part of smart cities, provides an approach for improving the lives of citizens within smart communities through better outcomes and processes of governance. Meijer et al. (2015) identify four perspectives on smart governance which we used to inform our approach to ICT4D for smart governance of rural development in Assam:

1. 'Government of a smart city' through good policy and administration, and in which extant government structures and process require no change, and smart governance is narrowly considered to relate only to those activities of a smart city.
2. 'Smart decision-making', in which extant government structures and process require little or no change, and smart governance is emphasised to be the process of innovative decision making.
3. 'Smart government administration', in which greater change of extant government structures and process is necessary so that smart governance can synthesise for better community outcomes procedure, data, infrastructure, and institutions.
4. 'Smart urban collaboration' predicated on increased and more efficient interaction and communication between government and community, and in which any transformation within government complements the transformation of organisation outside of government.

Of these, 'government of a smart city' inhibits the scope and goals of any ICT4D intervention, and 'smart government administration' relies on formulation of government process and restructuring beyond the scope of an ICT4D intervention as considered within this paper. Conversely, 'smart decision-making' and 'smart urban collaboration' support leveraging of a survey-based ICT4D intervention to transform information flow between government and community for better outcomes for communities and processes of governance.

Further, Meijer et al (2015) distinguish between what smart cities *are* (including smart governance) and *aims* of smart cities (such as smart energy, smart building, smart mobility, smart infrastructure, smart technology, smart healthcare, smart environment, or smart economy). We extend this in our approach to smart villages to consider smart villages as not prescriptive with respect to goals: goals exist and are categorised in smart villages theory but the details are not immutable, and the theory instead indicates a framework, methodology, process, or approach for obtaining development goals. Such goals may come from local policy such as Assam 2030.

Although a definition of ICT is implicitly understood by most people, the meaning of ICT4D is more nebulous. Broadly speaking, it is to use ICT to achieve 'good' in the context of development, and may address areas such as: growth for eradicating extreme poverty and hunger; equality for universal education, literacy, gender equality and empowering women; health to reduce child mortality and improve maternal health, and to combat HIV/AIDS, malaria, and other diseases; or sustainability to support development without depopulating or degrading the environment. ICT4D programs may be informed by formalised development goals provided by NGOs and other bodies, such as the Sustainable Development Goals of the United Nations Development Programme, and those goals adopted in Assam 2030 (United Nations Development Programme 2015, Government of Assam 2016).

In Assam in progress at the state and national levels are ICT programs that fall within the ICT4D gamut, even if not explicitly recognised as doing so, in the domains of citizen services, intra-government services, and citizen connectivity.

In the domain of citizen services are:

- eDistrict. To provide state-wide government to citizen (G2C) ICT service delivery of such things as registrations and certificates (Government of Assam 2018a).

- Common Service Centre (CSC). Rollout of 4375 front-end delivery points providing to rural citizens government, private and social sector services via ICT with intent to promote rural entrepreneurship, build rural capacities and livelihoods, and enable community participation and collective action for social change (Assam Electronics Development Corporation 2017a).
- State Portal & State Service Delivery Gateway (SP&SSDG). Operates for citizens as a unified, central source of government information (Government of Assam 2018b).

In the domain of intra-government services are:

- State Data Centre (SDC). A physical centre currently under development for ICT infrastructure hosting including central data repositories, application backend servers, and citizen information/services and state intranet portals (Assam Electronics Development Corporation 2017b).
- Assam Wide Area Network (ASWAN). Commissioning of 304 Points of Presence (PoPs) with minimum of 2 Mbps links for multiple uses including the connection of all government offices in the state under the Horizontal Connectivity project. ASWAN will also support the National Registrar of Citizens (NRC) update program utilising 114 of its PoPs and the e-District project utilising 160 of its PoPs (Assam Electronics Development Corporation 2017b).

In the domain of citizen connectivity are:

- Internet access via Optical Fibre Cable & wireless Access Point technologies (The Hindu 2017):
 - Bharat Sanchar Nigam Limited (BSNL) plans to connect all gram panchayats in Assam with optical fibre internet access with a target for 2017 of 70% of all gram panchayats connected.
 - BSNL will supplement this optical fibre connectivity with 3,000 wireless access points.
- Household bank accounts: each Indian household is to be provided with a bank account (BBC 2014).
- Mobicash digital wallet by BSNL and SBI which is a digital wallet for use on even low-specification smartphones. It will be extended to 40,000 BSNL outlets throughout the northeast of India and can be used for paying bills and transferring funds between individuals (The Telegraph India 2017).
- Aadhaar system of identification, under which all Indian residents are issued a unique 12-digit number associated with their demographic and biometric data.

While these programs are extensive and worthy, they do not fully address the challenges of achieving goals such as those of Assam 2030 and effectively implementing targeted aid programs; in particular, they do not allow fully for assessing needs, condition, and impact, nor respond fully to the 'serious challenge' to provide monitoring and evaluation through 'credible and adequate data' (Government of Assam 2016).

4 Smart Governance for Rural Development ICT4D Model

To formulate a smart governance rural development ICT4D model, we examined government-community relationships in the context of development objectives and existing ICT program areas, with emphasis on response to the challenges identified in and selected from Assam 2030 and guided by application of 'e-governance relationships' discussed below.

Allied with smart governance is the concept of e-governance, which, through the use of ICT, can recast and improve interaction between citizens, government, and business (Davison et al 2005).

- Government to citizen (G2C): to provide citizens with access to a variety of government services, which they otherwise, traditionally, would need to access in person, if at all. A nuance here is the concept of two-way communication, in which citizens may respond to or message government on issues such as voting, or feedback.
- Government to business (G2B): providing to business information such as best-practice guidelines to services such as tendering platforms. Like G2C, there can be two-way communication in which the flow of information is from business to government.
- Government to government (G2G): to facilitate communication and processes within and between government departments and levels to improve efficiency and cut costs.
- Government to employees (G2E): improving communication between government and employees, and availability within government structure of information on each.

These relationships may also work conversely, for example the government-to-citizen relationship has the complement of citizen-to-government.

Of these e-governance relationships, we selected two as being most suited to the unique Assamese rural development conditions and extant government processes, to formulate a smart governance model for rural development ICT4D model. As well as government-to-government, and government-to-citizen and its converse citizen-to-government, we added an additional relationship that on cursory inspection is not part of 'traditional' e-governance: citizen-to-citizen communication.

This citizen-to-citizen (C2C) relationship facilitates communication between citizens; the involvement of government is to identify needs within communities with the aim of inducing greater self-reliance. These smart governance interventions should not supplant the mechanisms villagers have for self-sufficiency. To illustrate, in a survey of e-retailing in Chinese villages Leong et al (2016) identified a process of birth, expansion, and renewal leading from early adopters engendering community interest to government redefining its role in an increasingly autonomous community (Leong et al 2016). The citizen-to-citizen relationship offers to government smart governance support for 'bootstrapping' economies and social synergies within communities.

With the relationships between government and community assessed, we interpreted the challenges selected from Assam 2030 as requirements of an ICT4D model for rural development:

- A. communication: to engage citizens by supporting presentation of data to citizens, and allowing reporting of issues to government;
- B. governance architecture: assisting new governmental approaches;
- C. sub-state level governance: providing actionable data and insights to lower levels of government;
- D. integration and digitisation: assimilate the gamut of collected data to facilitate analysis and insight;
- E. monitoring and evaluation: provide a means to find conditions on the ground and report needs and opinions of citizens.

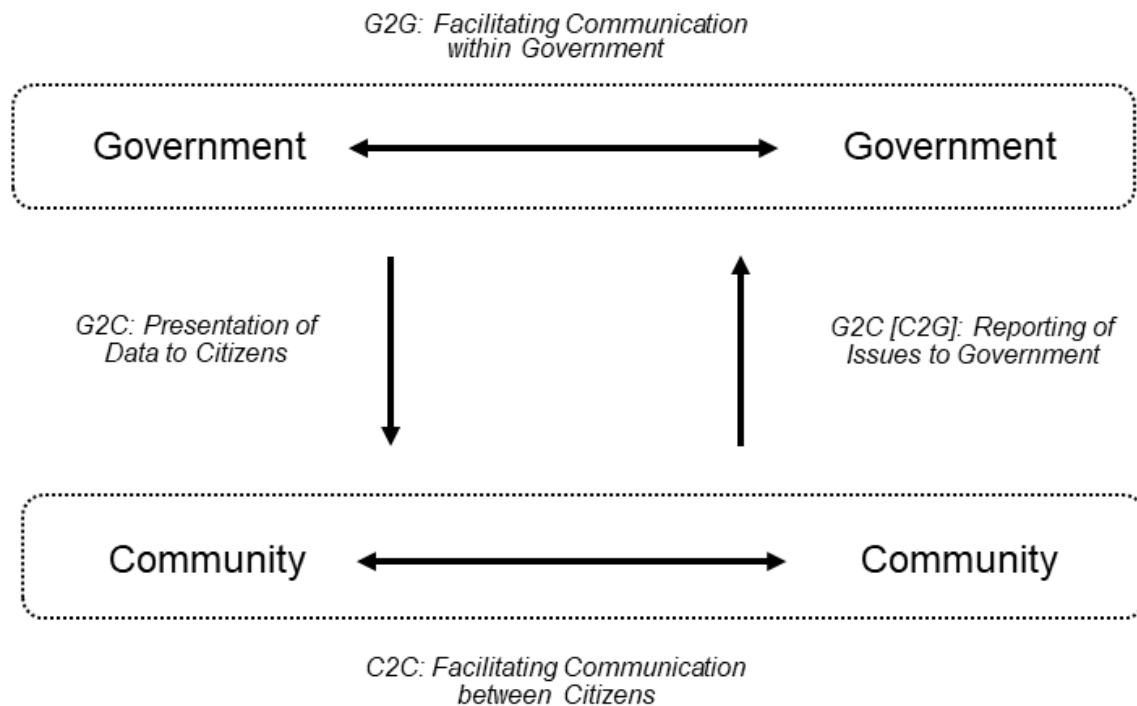


Figure 1 Diagrammatic representation of the Smart Villages Program's Smart Governance for Rural Development Model

The resulting model, shown in Figure 1, provides a minimal-intervention and gradual-introduction approach for introducing smart governance into rural communities through ICT4D supported with surveying, and offers a framework upon which can be hung multiple ICT4D interventions. The objective of the model is simple: identify the needs of the community, such as infrastructure or service, and facilitate the formulation and application of solutions.

5 Software Proof of Concept

A software tool was developed to demonstrate aspects of selected ICT4D communication flows and functionality within the Smart Governance for Rural Development ICT4D model (Figure 2).



Figure 2 Smart governance for rural development ICT4D model demonstrator

The essence of the proof-of-concept is the household as the atomic survey unit, which is incorporated as the lowest level of a geopolitical hierarchy including also village, district, and state.

Building atop this geopolitical hierarchy, the tool demonstrates four complementary 'layers' of communication flows. It is a hybrid of both proof-of-concept and prototype functionality across and within these layers. It contains proof-of-concept features to verify concepts are viable and can be implemented, to explore technologies, and to allow knowledge to be shared within the SVP team. It contains prototype features to convey possible user experience of the tool, and to streamline and guide further development.

Further, the tool in current form is a 'vertical slice' of proposed or tentative functionality – it contains a selection of features representing the essence of the SVP ICT4D model research and is not intended as a fully-featured package. The tool can be developed through this proof-of-concept and prototype vertical slice stage to a minimum viable product form for pilot project testing.

The layers of the tool are:

- a prototype core SVP survey layer including data, metrics, and analysis aspects;
- a proof-of-concept layer of departmental project data bound to geo-political regions of the survey layer;
- a proof-of-concept layer of smartphone integration exploring technology for feedback integration and community-based issue reporting; and
- a nascent proof-of-concept layer of automated surveying utilising machine learning technologies.

The prototype core survey layer provides metrics and analysis of the data of the SVP survey framework. The framework is designed within the flow of the SVP ICT4D model

to provide a rapid, flexible, and inexpensive means of accessing the conditions within and needs of rural communities.

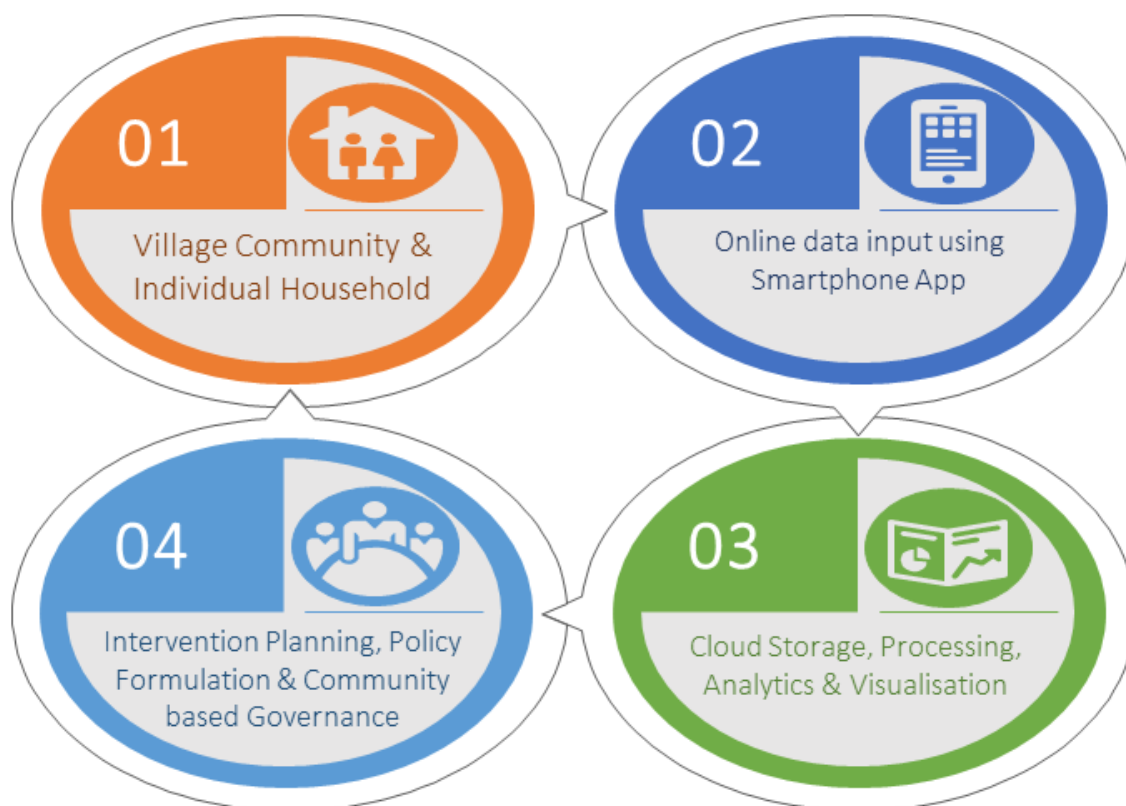


Figure 3 Smart Villages Program survey framework (Source SVP / R. Borah)

The Smart Villages Program survey framework offers a cyclical mechanism to assess community needs, act on those needs, and reassess in view of those interventions as illustrated in Figure 3:

1. In the initial step, village communities of interest are identified, and individual households within them are mapped.
2. Householders provide data via a smartphone app.
3. The data is uploaded to cloud storage, where it is processed, and then analytics and visualisation are provided to decision makers as shown in the demonstrator software tool.
4. Decision makers can undertake intervention planning, policy formulation and community-based governance. The effectiveness of changes can be tested in a new cycle.

While the survey in its early form must be administered by a field worker going house to house within a community, using predefined questions, the process is extensible to using smartphone apps that may be used by household members directly and updated remotely.

The proof-of-concept layer of departmental project data provides decision makers with an overview of projects planned for, or being undertaken in, a rural community so that it can be seen if needs are being planned to be met, or if projects in place to meet needs are in fact successful in doing so. Users can access project data in two ways, from a top-down departmental perspective – whereby a particular department and any, or all, of its

projects may be selected – or a bottom-up geographical perspective – whereby a geopolitical area may be selected to show the projects active within it. This layer, while focused on departmental projects, is a proof-of-concept of general integration with government departments.

The layer of smartphone integration provides a proof-of-concept for community engagement through bi-directional flow of information between community and government, and between community members themselves. The current framework allows geo-positioned community reports annotated with images and prose to be logged and viewed in the bespoke *SVP Engage* Android™ smartphone app, with these being updated in real-time in the software demonstrator. This framework is extensible to many uses, such as presentation of data to citizens, reporting of issues to government, or citizen infrastructure ownership.

Smartphone integration can be used to present policy and infrastructure proposals to citizens so that they can be informed about how funds are being allocated, which infrastructure works addressing local issues are underway or proposed, and they can offer feedback and comment on the information presented to them on the basis of which government may adjust proposals and moderate policy.

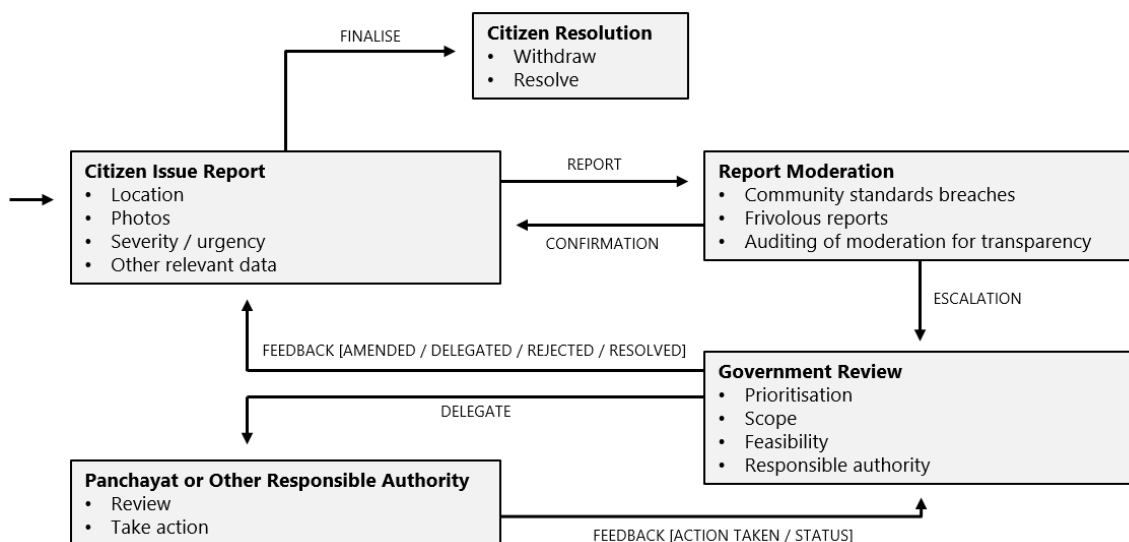


Figure 4 An ICT4D model for citizen reporting of issues

Reporting issues to government in smartphone integration acts as a converse of presenting policy and infrastructure proposal to citizens; reports are entered into the system directly by citizens, not by government. The processing of these reports must be embedded in a government process which considers issues such as maintenance of goodwill, respecting bottlenecks, exacerbation of negative sentiment, management of transparency and appropriate content, and user identification – an example model is given in Figure 4.

A speculative proposal for smartphone integration is to assist citizens to claim management of a resource in their locality. This ICT4D system could allow community groups to volunteer to mind and maintain some part of a resource associated with a significant environmental issue or section of infrastructure in which they have an interest. A fully-fledged system might include a smartphone app with intra-community messaging,

issue geotagging, and issue tracking functionality, however a prototype is likely possible using online mapping and forum services.

The layer for automated surveying provides a framework for a proof-of-concept utilising machine learning technology to make an ultra-rapid survey of a village. It exploits the outcome of the SVP survey process of a data set of a standardised house photo and questionnaire record of each house surveyed. By labelling the photos with selected corresponding survey data, a machine learning model may be trained to classify standardised house photos from as-yet-unsurveyed villages. Although it remains to be tested in-field what metrics can be well derived, it is anticipated that this approach might yield swift and low-cost initial analysis of a village that can guide further surveying or funding allocation.

6 Conclusion

The work-in-progress smart governance for rural development ICT4D model and proof-of-concept software tool presented in this paper provide a potential non-disruptive and incremental path for survey-based intervention in communities to assess needs, conditions, and policy impacts. While the current model as tested in fieldwork is limited to use of a relatively-static survey design, it is extensible to flexible survey designs that target specific issues or neighbourhoods and operate in real-time for live updating of data. Moreover, the approach could be applied to development contexts beyond rural situations. The approach complements existing ICT developments in Assam, and is not designed nor intended to supplant any data-gathering or geographical information system by or of any department of the Government of Assam; however the approach may aid transformation of government processes through 'smart decision-making', with smart government as the process of innovative decision making, and 'smart urban collaboration', with smart government predicated on increased and more efficient interaction and communication between government and community. The on-going survey-based fieldwork on the island of Majuli, Assam, will verify the applicability of this model and proof-of-concept tool, and guide in which direction it should be further developed to best meet the needs of both government and community.

Acknowledgements

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The new Assam smart village dwelling: meeting the challenge of absorbing new technologies

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Abstract: *This paper reports on the creation and testing of relatively accessible software that allows householders to reconfigure a replacement home built of safer and more technologically sophisticated materials (where required), with designs that conform to an identified set of culturally loaded conditions and expectations. For the State of Assam the 'Assam House', while a touch elusive in the vernacular architecture literature relative to other regions in India, nevertheless offers sufficient insight through which we were able to distil certain attributes that make the Assam house sufficiently identifiable for the purposes of developing a proof of concept, which is the subject of this paper.*

Keywords: *Computer-aided Design, Village housing, User-oriented, Community participation.*

1 Introduction

Village dwellings of Assam tend to have raised wooden platforms, sloped thatched roofs and woven bamboo walls which are sometimes plastered with mud. (Stack & Lyall, 1908) However, due to economic reasons and lack of one material and surplus of another has changed the way village dwellings are built. The changes in climate, topography, availability of local materials and the culture of the local community indicated the difference in vernacular architecture from place to place. (Das, et al., 2014) (Saikia, et al., 2016) (Singh, et al., 2009) The raised platforms are gradually being flushed with the ground removing the storage of dry goods and livestock. Brick, mortar and concrete are replacing the walls and floors reducing the natural air ventilation and increasing the heat retention of the house. While galvanised iron sheets are maintaining the sloped roof for the rain, it also retains heat in the house. Though the newer materials are a solution for permanent structure of housing, the characteristics of the materials have changed the construction style, modifying the architecture and space, resulting in the change of culture of the communities. These changes to the materials and construction style have ultimately led to changes in the living standards of the rural community.

In addition to differences in topography, there are more than 115 ethnic tribes are recognised in Assam. (Taher, 1993) As an initiative of the ministry of rural development under the Pradhan Mantri Gramin Awaas Yojna (PMGAY), the compendium of rural housing typologies- 'Pahal' has proposed six typologies for Assam that are based according to the prevalent construction trends in Assam and the division into five geographically characterised zones. (CBRI, UNDPIndia, 2016) People and society, geography, climate and natural hazards in Assam were among the criteria for developing the rural housing typologies. However, the oversight of the diversity of the ethnic cultures of Assam was indicated by the comparatively negligible number of proposals. Upon analysing the rural housing schemes such as Indira Awaas Yojna (IAY) and PMGAY, it indicated a rigidity in the delivering the housing requirement that could be availed through the schemes. (Katharpi & Doloi, 2017) This indicated a disconnect between the government schemes for rural housing development and the on-ground reality of rural housing support required by the rural community, resulting in compromises with the quality of life of the rural community.

In seeking to find a new model of dwelling for the Assam 'smart village', designers have to meet the challenge of identifying and absorbing appropriate and affordable new technologies while maintaining traditional community culture and values. When confronting the eternally vexed challenge of how to modernise traditional village housing improving amenity, security, longevity, and overall appeal – 'modernity' even, there is always great risk that the baby is dispatched with the bathwater. Getting rid of the used 'bathwater' refers to materials that lack durability, configurations that fail to absorb crucial aspects of modern lifestyles such as promoting better health outcomes (light and air movement, for example), and resilience to natural disasters. Meeting such challenges head-on, there is considerable danger that the 'baby' - traditional values and vital cultural identity, disappears with the bathwater.

Although this has been a familiar challenge in all countries and societies since the Industrial Revolution, today we have new digital tools and paradigms available to think about dwelling improvements without necessarily dispensing with the essential attributes that make a house a home, and not just a dwelling. By this we mean maintaining the villagers' ongoing participation in village life within familiar domestic contexts while

enjoying all the benefits that modern materials and construction techniques bring to an evolving housing stock; what can the designer do to offer greater confidence to the villagers to assure cultural continuity notwithstanding increased modernity?

2 Smart housing and community participation

Since we had already entered the post-digital era in the West, at least, by the end of the last century, computer-aided design (CAD) has since become a crucial and globally ubiquitous component for design practice. Many functions and new ways of working including BIM and Virtual simulation would not have been conceived as being possible in the architectural industry before the advent of digital practice, yet they are now regarded as indispensable within the professions. With those emerging new technologies, the way professionals can design for Assam village dwellings can be drastically changed, given that vital information can be acquired more efficiently and conveniently. But in today's post-digital era, even in remote communities, conventional architectural practice can be re-thought by both building designers and the house owners. In this paper we consider the opportunities for delivering householders an 'app' that allows the owners to develop options for building a new house adhering to traditional Assam village dwelling principals while all the time getting real-time feedback in terms of size, program (the house plan and configuration of room layouts), and very importantly, budget. We are dubbing this as 'smart design' for 'smart homes' for 'smart villages'.

2.1 Smart Design

Designing a house is a relatively complicated process as the final decision is very much a compromise between many aspects, such as the aesthetics of appearance, cultural considerations, and economic constraints. The emergence of the Smart Housing concept (Buys, et al., 2005) has offered entirely new opportunities for designers such that the link between different construction components and their description via numerical information (BIM) can be achieved and reconfigured from the very initial stage of the computer-aided design (CAD) process. The proposed checklist for an intelligent system to facilitate the house design options includes but is not limited to: site and landscape, dwelling access, plan layout, outdoor living area design, building materials, and finishes. (DPW Queensland, 2008) This idea can be further coupled with CAD techniques and therefore suggests various applicable design outcomes much less time-consuming when compared with the traditional design iterations.

In 1993, Professor Robert Woodsbury and Jeff Heisserman had proposed the first automatic dwelling model generation method which is called 'Boundary solid model' based on grammatical paradigm. (Heisserman & Woodbury, 1993) It suggests a logical reasoning mechanism that follows certain construction rules to express complex geometrical conditions for various space combinations. This case-specific approach has shed a light on the early automatic dwelling design approach, while 25 years later, the greater computational power and emerging new algorithms could now afford much higher freedom for architects and developers.

In a more recent study by Merrel, an equation-based self-generated plan concept was proposed. (Merrell et al., 2010) The author initialised the system with the 'bubble map', which is commonly used by architects in the concept design stage, by understanding the correlations between different functionalities. A Bayesian network model was applied and

the data derived from real design schemes were feed into it. This process was repeated in iterations and, therefore, automatically generated a series of floor plans for each storey and a 3D models of each proposal. The model implements tools that use data and algorithmic drivers to constantly create architectural layouts with relatively complete morphological and functional coherence. (Fig. 1)



Fig 1. Floorplans and 3D models of multi-story buildings can be automatically generated based on algorithms.

Space Plan Generator™ is an automatic plane generation software based on Dynamo™, a Revit™ visual parametric design plug-in. (Das et al., 2016) It can automatically generate a single-layer building plane according to the designer's functional requirements by using a genetic algorithm where typical design considerations like the available commercial area and office-service proportion can be optimised. (Fig. 2)

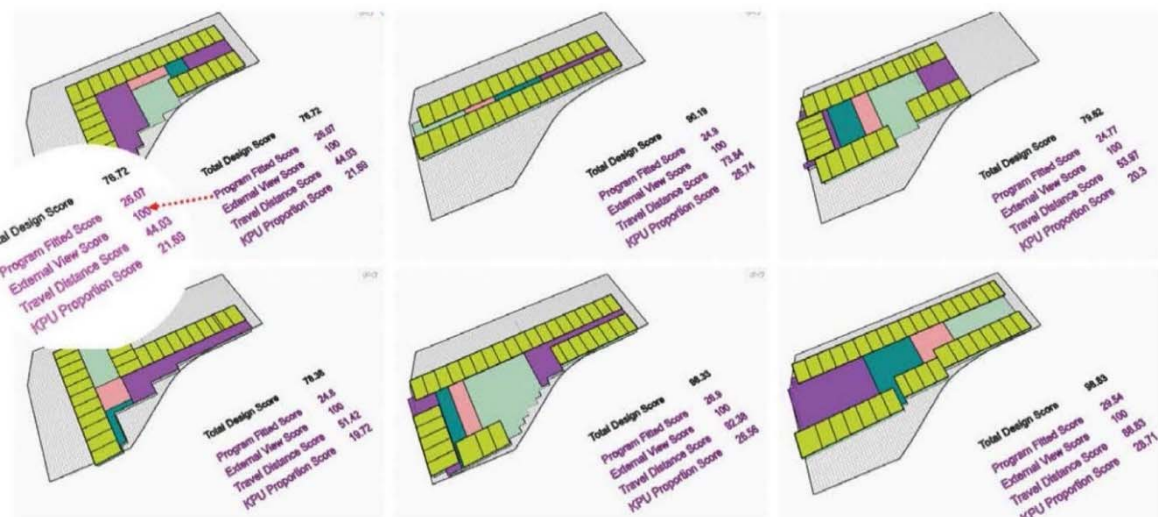


Fig 2. 2D floor plan generated based on the given numerical criteria.

2.2 Community Participation

Encouraging community participation becomes increasingly viable and is an important opportunity today: houses and villages designed with the occupiers rather than for them. It is a trajectory that is emerging from a growing recognition that inappropriate design and mismanagement of the physical environment is a major factor contributing to global social and economic ills. “Advocates for this viewpoint come from the professions of architecture,

landscape architecture, and planning”, according to Professor Henry Sanoff from the North Carolina State University. (Sanoff, 2000) We are investigating this concept, not only because of the growing complexity in design expectation in contemporary society, but also in reaction to the increasing awareness of ‘vernacular culture’: what often comes across as arbitrary design direction applied ‘top-down’ by an architect solely can be challenged through the creation of new digital design tools.

A prominent exemplar that supports this idea is a series of Chilean social housing projects designed by the Pritzker winner Alejandro Aravena and his firm Elemental commencing in 2003. (Pacheco, 2016) In the Quinta Monroy project, he was commissioned to find a solution for a new community to accommodate more than 100 families with a limited budget and a restricted land supply. This was indeed challenging; Aravena decided to split the ‘design task’ into two parts where the community was invited to be part of the design team from the start. The whole design process was filled with meetings, compromises between different stakeholders, and the negotiated reconfiguration of the plan layouts. As the result, a half-house was complemented by another householder-provided other half. (Fig. 3)



Fig 3. Quinta Monroy project in Iquique, Chile by Elemental. (Zilliagus, 2016)

This method seems to be very applicable when confronting many challenges that village development have --- investment shortage, vernacular sensitivity, among other challenges. 15 years on, through the involvement of digital design we can now imagine pushing public participation up a step further in the design process, and propose the decentralization of decision-making power. Solution-based enumeration of the financial implications of any design decision along with visual representation of each version could make it possible for end-users/householders to pick their own preferred options from the potential smart design system, conforming to their given budget. The synchronisation mechanism between different platforms would ease the cost of communication between various stakeholders, providing a more direct connection, particularly between architect

and house-owners. With the assistance of new digital technologies, designers will also be able to transform their position from a single design solution exporter to a design system organizer for accommodating the desires of diverse customer groups.

2.3 Digital Prototype

The software that we outline below, developed to a 'proof of concept' (PoC) level, is intended to be deployable as a smartphone app, and would not be contingent on access to a PC necessarily.

To test our approach operationally, we first aimed to develop a more accessible prototype using the widely available 3D modelling software Rhinoceros™ combined with its graphical algorithm editor, Grasshopper™, which offers a suitable operating environment without the steep learning curve.

The prototype is initialised with an anchor-point based system, a framework whereby all subsequent geometries are defined from those points and the lines connecting them. This structure gives enough freedom for future adjustment, enabling users to change even the most fundamental parts of the building model. The coordinate origin is subject to change according to different design needs with each geometry relatively easy to reconfigure by just dragging the sliders, with vector direction and distance altered accordingly. (Fig. 4)

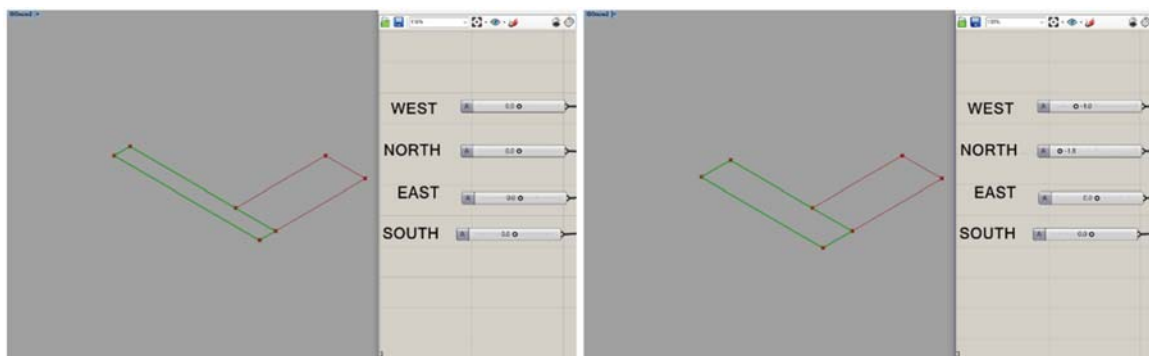


Fig 4. Users drag sliders to experiment with different geometrical layouts using the anchor-point based system.

Every unique floor plan layout is formed by defining the links between different anchor points. In a more complicated scenario, we can add annotations to identify each object more clearly. For instance, in this floor, anchor points are annotated from A to T. Points MLJK defined a rectangular room where point M and K are constrained by being attached to line ET. Similarly, room TMLROS is defined by six points and it is associated with room MLJK such that were points M and L positions change, TMLROS will change accordingly. (Fig. 5) This means all geometries within the system are connected and organised correspondingly, and by giving a height vector and thickness values, the wall can be modelled in a matter of seconds. (Fig. 6) The prototype has been further developed and tested with a richer complexity in the following case study in Assam, India.

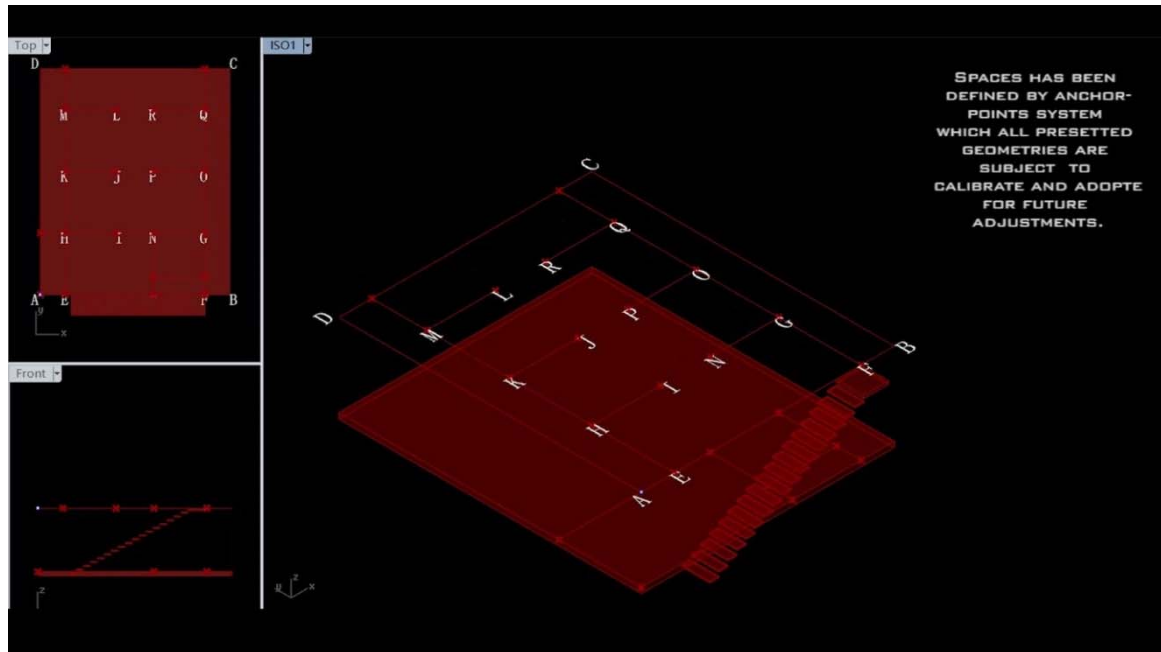


Fig 5. Simple plan layout defined by anchor points system where all pre-set geometries are able to be changed and calibrated for future adjustment.

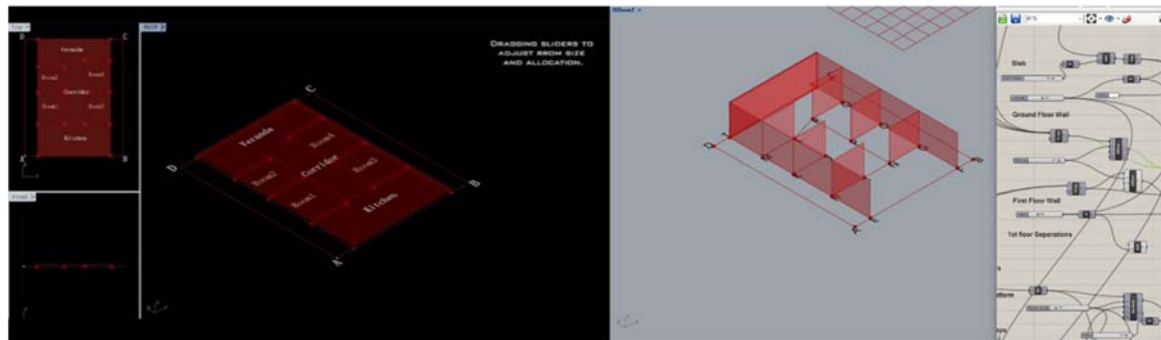


Fig 6. Left: Dragging sliders to adjust room size and column allocation. Right: Visualising wall structure with given height and thickness.

3 Case Study in Assam

3.1 Background

The Smart Village Assam is a collaboration project involving the University of Melbourne and the State Government of Assam, aiming to grow local capabilities for the creation of smart village development methodologies, in our team's case, through computer simulation toolboxes aimed towards yet to be identified emerging local prefabrication technologies. The project includes investigating the adoption of local construction methods and processes, with an eye on the economics of the required consumables necessary to accommodate the growing smart village housing needs in rural Assam. Community participation and flexible modelling applications are positioned here as the key requirement of the overall project, aiming to utilise CAD technique to improve design efficiency while increasing the participation level of local householders.

3.2 House Arrangement

The State of Assam is located in the north-eastern part of India and the great majority of Assamese live in rural areas. The State of Assam has unique weather conditions referred to as tropical monsoon rainforest climate, which includes heavy rainfall and high humidity throughout the year. The hilly areas may experience temperature fluctuation while the plain areas are in a sultry climate all year round. (Das et al., 2014) Confronting with these climate conditions, vernacular architectures based on bioclimatism have evolved and been used by Assam people over centuries. Specific house arrangements were adapted to respond to and accommodate different requirements varying between the warm-humid areas (plains) and the cool-humid areas (hills) (Singh et al., 2009) (Fig. 7)

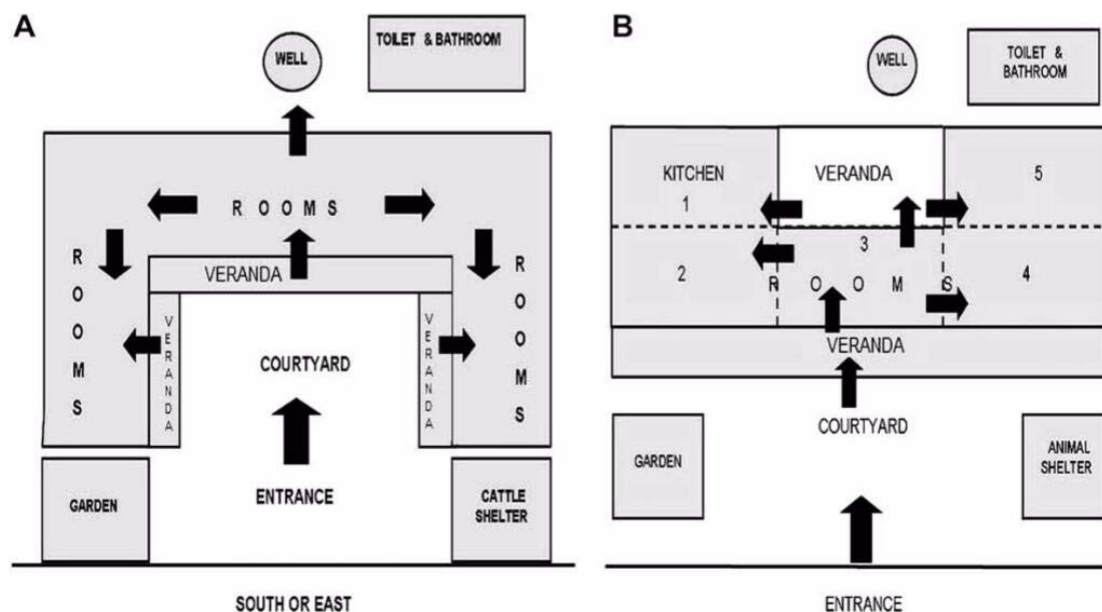


Fig 7. Common building plans for the warm and humid climate.

In our study we have firstly analysed the vernacular housing principles from different aspects, including number of rooms and their relative position, functionalities, and circulation. Key attributes were then abstracted and applied in our digital workbench, suggesting a series of new housing arrangements and visualisation as 3D models. (Fig. 8) This digital workbench was developed to describe both interior and exterior spaces with sufficient details and specifications, allowing end-users to change all the relevant settings receiving instant feedback as they proceed. (Fig. 9)

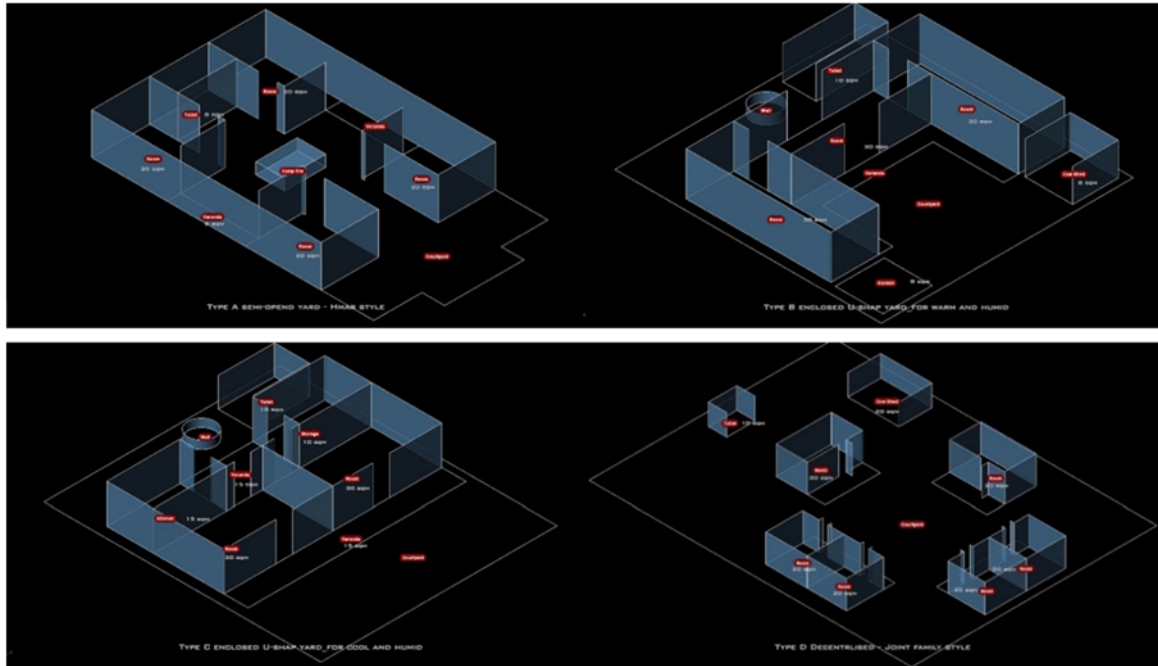


Fig 8. Four housing arrangements for different climate conditions.

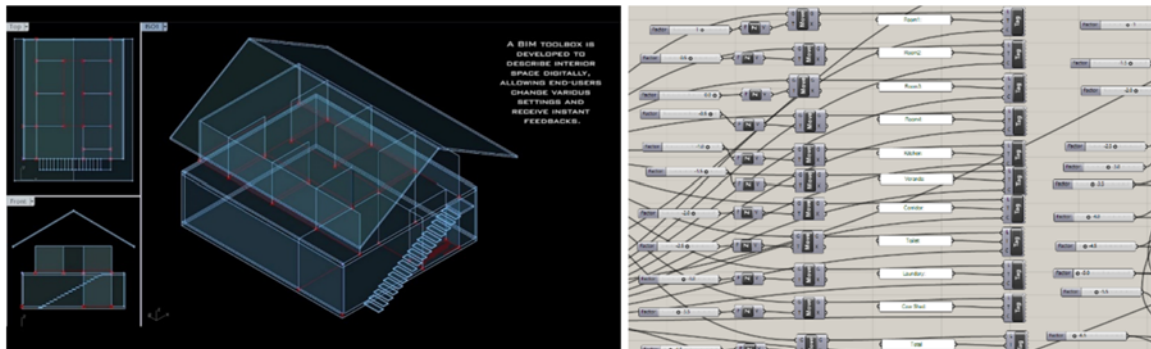


Fig 9. Left: X-ray rendered view for visualisation. Right: Control panel with sliders and annotations

3.3 Massing and Plan configuration

For this functional module, we proposed a typical 'shed' unit configuration by absorbing many vernacular characteristics with respect to the local culture and tradition. The ground floor is designed as an animal shelter and storage room while it is the upper level that is configured for living. In the case of our prototype digital workbench, roof slope is critical because of the monsoon rains, and the building base is constructed with a stilt or pole structure both to avoid potential inundation on the plains, or accommodate the challenges of hilly terrain. The top sides of the façade are deliberately kept open for cross ventilation in this invariably humid region.

In proceeding to generate design iterations, it is crucial to keep both the designer and householder in the loop and we aimed to push this collaboration to a relatively higher level. By this we mean all users (designers and householders) can reconfigure the basic 3D model together, including roof angle, wall thickness or even profile and the diameter of the structural supports via a control panel. This does not require professional training as the user interface has dials and sliders that people simply need to twist or drag. (Fig. 10)

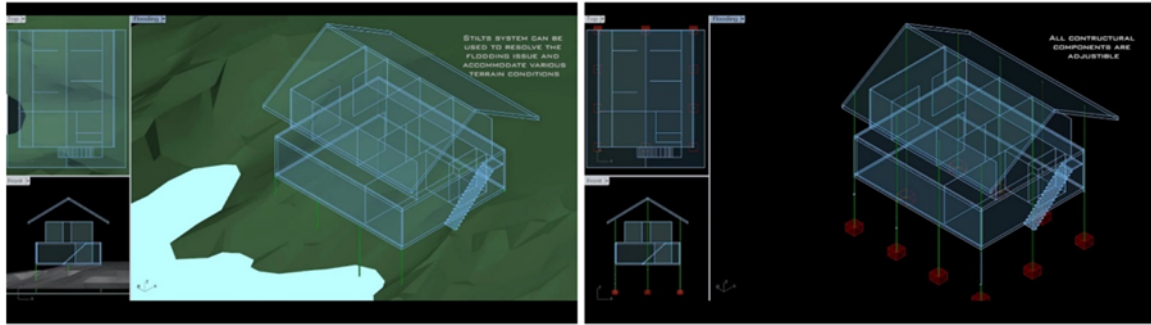


Fig 10. Left: The structural support system (poles) can be used equally to hoist the residence above flood levels and adapt to hilly terrain; Right: Adjusting anchor and stilt columns.

The digital workbench can be equipped with a function and cost calculator. This helps people to understand where and how their money is going to be spent and also assists architects to balance the design to remain within a defined and typically limited budget. Village lifestyle, traditional materials, and fabrication techniques are also recognised and respected as is the room size and proportions, construction components, and ceiling height, all of which are subject to change conforming with the houseowner's own desire and therefore affords customised layouts based on unique family needs. (Fig. 11)

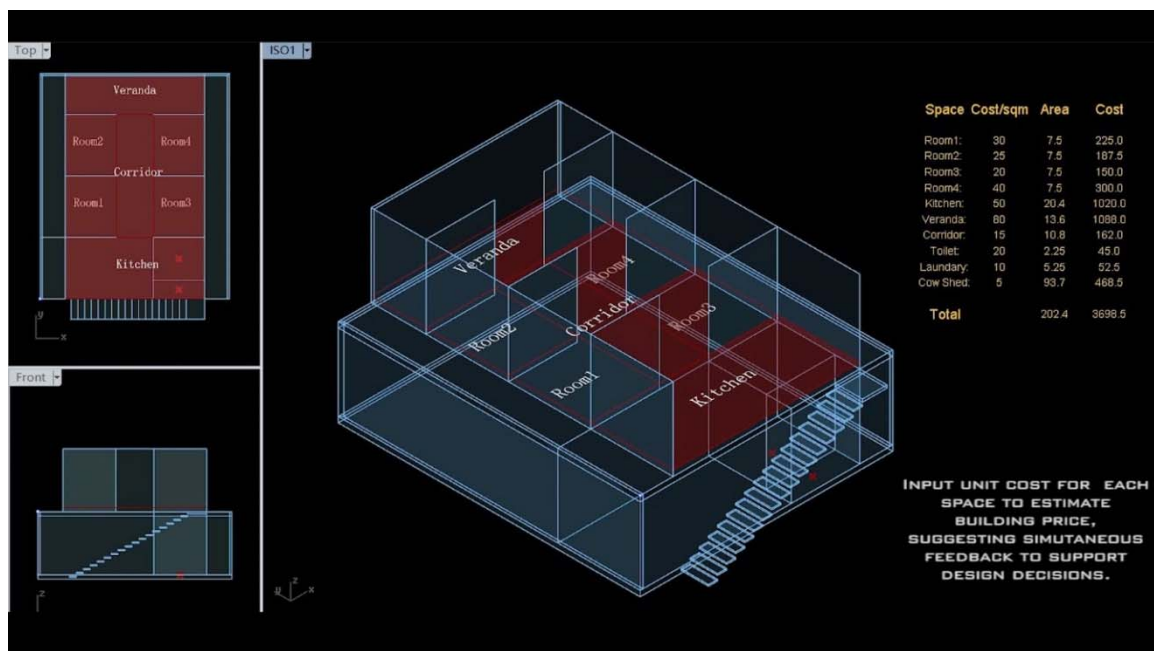


Fig 11. Dynamically linking unit cost to changing spatial configuration to estimate building price for each part of the house, providing simultaneous feedback to support design decision-making.

This function can be further evolved into an automated plan generator by coupling with the generative algorithm. For example, each householder can set the number of rooms, room orientation, and cost per square metre, etc. as data in a spreadsheet, for example. This data would be the input into the spatial modelling system generating a series of both viable and optimal two-dimensional plans and the 3D model options for the householder to choose from. This process is handled through Galapagos™, an open-source generative design plug-in in Grasshopper™. Using this procedure, technicians may be required to assist with the manipulation of the application so that architects can concentrate more on more fundamental design matters per se, in order to discuss potential options with homeowners. The final design information can be presented to the householder in a simple

and visual way, making it more intuitively understood. Meanwhile, the communication gap between the designer and the householder(s) can be greatly reduced, which makes the whole iterative design process more efficient and productive than any traditional architect-client dialogue allows.

3.4 Frame Structure System

In order to collaborate with engineers with greater efficiency, we have further developed a frame structure simulator that can be considered as a simple BIM (building information modelling) system. The flooring and its frame are automatically allocated to suit the required massing layout while the sizes, section modules, and column spacing can be easily modulated to meet the anticipated bearing load. (Fig. 12) A timber sub-frame is an available option for interior enclosure and configurable steel truss frames are provided if additional support is needed. For more detailed selections, opportunities for different cladding, types are offered where not only steel cladding but also local fabrication methods such as bamboo, or wattle and chicken wire with cement render are required. Window sizes, positions, section ratio can also be varied to satisfy different climate conditions. (Fig. 13)

For the roof structure, users are free to choose different options from the drop-down menu in the control panel. By setting different inputs for the variables, we can readily change the number and the components' section profiles to customise the roof frame. Similarly, roof purlins can be adaptively regulated. In this case, their dimensions, element number, and the unique names of each constituent part can be displayed, providing a simultaneous visual feedback when an adjustment is applied, as well as facilitating construction using clearly identified components. (Fig. 14)

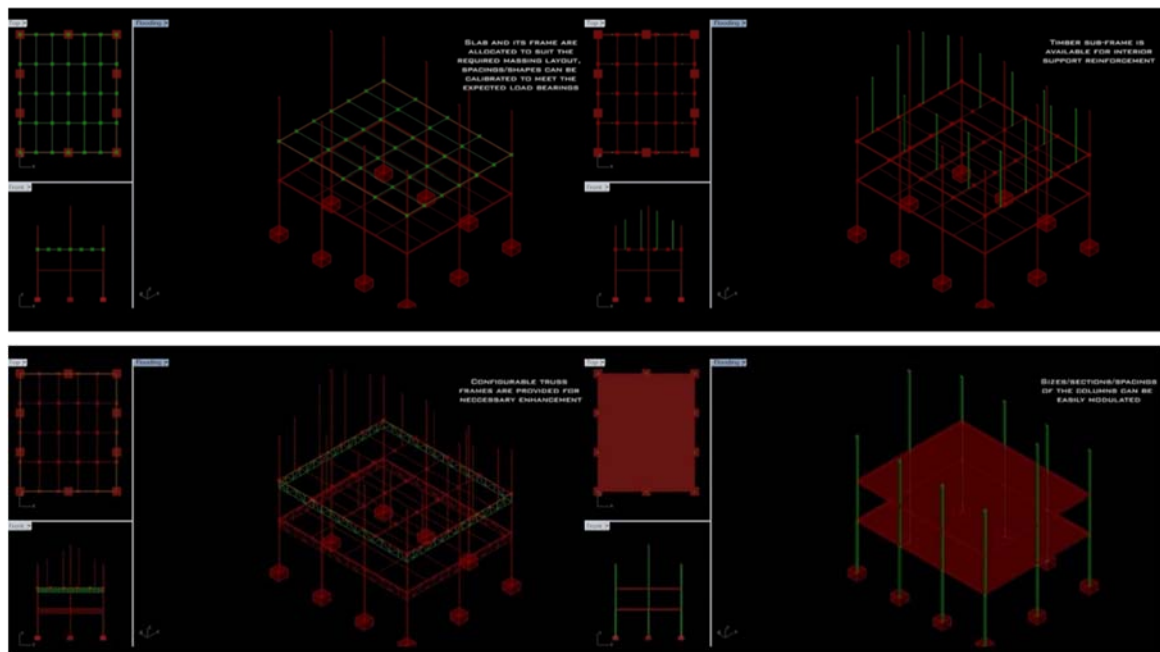


Fig 12. Shaded view for the column and beam structure customisation and optimisation.

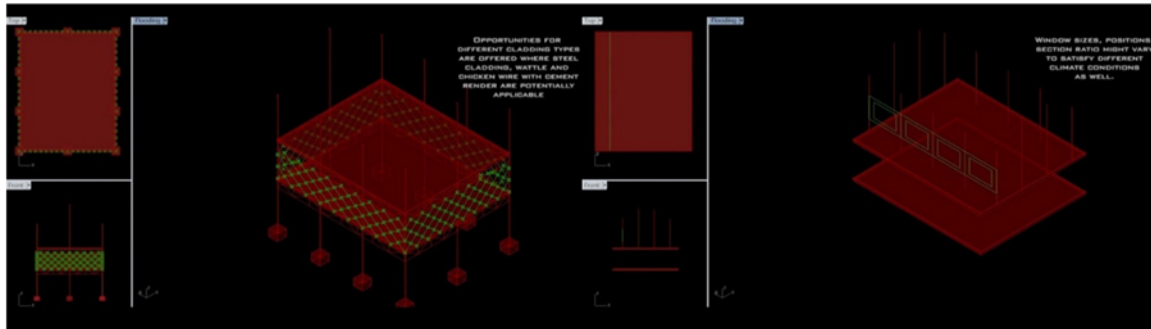


Fig 13. Changing the cladding options and window specifications.

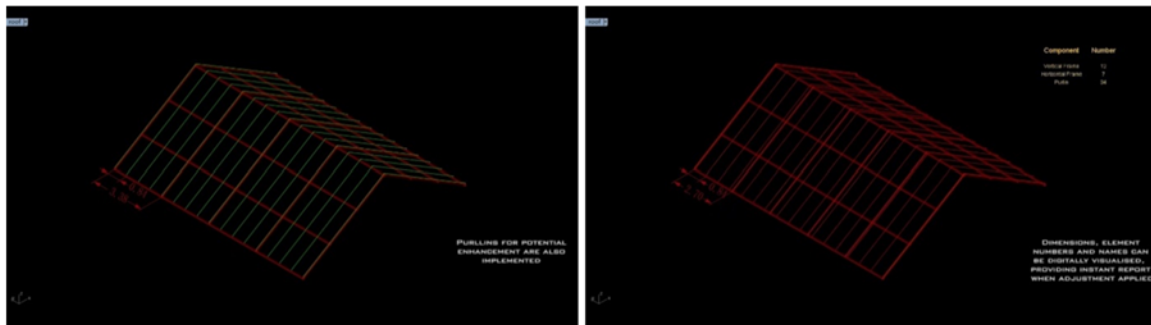


Fig 14. Rooftop structure with annotations and number counting.

4 Summary and concluding notes

This case has emphasised that the use of digital workbenches is not constrained to being the sole privilege of professionals but rather, reveals an opportunity for encouraging participation of the community of householders through a viable direct application. After streamlining the manipulation procedure through modular scripting, a feasible user interface is provided in which, as a result, non-professionals can obtain timely feedback on the design alternatives in a relatively efficient manner. This makes the layout comparison more accessible and allows householders to refine their options within their available financial resources.

Designers can potentially take a back seat, and gradually transform their role into the system designer and workbench maintainer instead of a 'plan dictator'. The design description and communication costs can be considerably reduced through digital visualisation and associated synchronisation techniques. Working alongside architects and related consultants, the local community can be enfranchised to embrace the modern dwelling design but working within an awareness and accommodation of vernacular sensitivities. Imposition of affordable housing based on international generic models has been a controversial topic during past decades, starting with post Second World War reconstruction efforts, with the standardisation espoused by the Modern Movement encouraging a numbing uniformity of response worldwide.

Working in the way that our proof of concept sets out to demonstrate in this paper offers an affordable way out of the cultural imposition of standardisation: smart village householders will be able to access a more appropriate use of contemporary materials and building techniques while co-designing within a formal vernacular architectural language. The outcome of our experimentation to this point suggests that there is a potential accessibility to self-help design solutions today that will be far more democratic.

Future work will take us into the territory of leaving the proprietary software used for our proof of concept towards developing standalone apps that will perform all the tasks outlined in this paper, but using no more than a smartphone.

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TOWARDS THE ENVIRONMENTALLY SUSTAINABLE SMART VILLAGE

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Abstract: *Environmental sustainability is a critical global challenge. Housing and infrastructure demand huge quantities of resources and result in significant environmental effects. The creation of 'smart villages' offers a unique opportunity to redefine how housing and infrastructure systems interact with the natural environment and explore solutions for improving their environmental sustainability. The concept of the Smart Village has a heavy focus on using technological solutions to enhance the existing networks and services available within a village community. This inevitably leads to an increase in resource use (both for construction and operation) which can be counter-productive to improving the environmental sustainability of villages. With environmental concerns becoming increasingly integral to decision-making, the design and implementation of Smart Villages must consider the potential environmental implications and performance of Smart Village solutions if they are to be considered truly 'smart'. This paper introduces a four-step process for identifying, analysing and implementing solutions for achieving an environmentally sustainable Smart Village. This involves an integrated design process where the current environmental performance of a village is assessed (step 1), the local context is analysed to determine what resources, skills and expertise are locally available (step 2), potential Smart Village solutions are identified and analysed (step 3), and the Smart Village is designed and implemented, with the assistance of trained professionals and village communities (step 4). A village community located in Assam, India is used as a case study to demonstrate the application of step 1. By using this process in the design and implementation of Smart Villages, greater confidence is able to be placed in ensuring that potential solutions, both technological and non-technological are not creating greater environmental issues than already exist within villages. It can also be used to provide a better understanding of current village performance and that of potential Smart Village solutions so that opportunities for further environmental improvements are able to be identified and prioritised.*

Keywords: *Smart villages, Environmental sustainability, Housing, Assam.*

1 Introduction

While there is a global trend towards urbanisation, over-population of cities, especially without appropriate supporting infrastructure, has been shown to have serious consequences on resource availability (for example, the 2018 water crisis in Cape Town, South Africa (Maxmen, 2018)) and the health and wellbeing of their inhabitants (for example, due to the high levels of air pollution in Delhi, India (Rizwan *et al.*, 2013)). As population increases so does the demand for housing and infrastructure, further increasing the demand for resources and the waste and pollution produced as part of construction and other associated activities. For example, it is predicted that at least 200 million new houses will be required in India alone by 2030 (Planning Commission (Government of India), 2008). This is driving exponential growth in global resource demands. For example, the demand for minerals, ores, fossil fuels and biomass is predicted to be 2.5 times greater in 2050 than it was in 2010 (UNEP, 2016). Demand for energy is on a similar trajectory, also expected to be 2.5 times greater in 2040 compared to 2013 (IEA, 2015). Demand for fossil fuels has seen a rapid increase in global carbon dioxide levels, contributing significantly to climate change (IPCC, 2014), and reduced air quality (with half of the world's population living in countries with unsafe air quality (Yale University, 2018)). Evidence shows that the built environment (buildings, in particular) is responsible for a significant proportion of human induced resource demands and environmental effects. This includes 36% of global energy use and 39% of carbon dioxide emissions (UN Environment and International Energy Agency, 2017). Increasing demand for housing, lifestyle changes and rising expectations, especially in developing countries, will only further exacerbate the demand for materials, changes to land-use and increases in greenhouse gas emissions and pollutants emitted into the environment. The most critical issue with this is that not only are the Earth's resources finite and being rapidly depleted, but the ability for it and humans to cope with the damage that is already being done is also limited.

Much has, and is being done to address the broad challenges being faced by the world's cities, including work on developing 'Smart Cities' and improving their environmental performance. However, a significant proportion of the world's population still live in regional and remote communities (often referred to as towns or villages). Living standards, access to infrastructure, housing, healthcare and education, and environmental sustainability are equally important to the people living in these typically less urbanised areas. The decentralisation of human populations is also seen as an important element in dealing with future population growth. This can help balance out and better manage the resource, pollution and other challenges facing many of the world's expanding cities, but can also provide a better quality and more equal living standard to those living in villages, unable or unwilling to move from village communities. It can also encourage village communities to build upon their existing strengths and develop new opportunities, facilitated by smart solutions.

Figure 1 shows the relatively primitive nature of some villages.



Figure 1: North-East Indian Village
(Source: Wild Frontiers Travel, 2018)

1.1 Smart Villages

The idea of Smart Villages is a relatively new phenomenon, taking learnings from the Smart Cities movement and contextualising them in relation to the challenges and characteristics unique to typically smaller, more remote, less populated and less developed communities. The European Commission (2016) defines a Smart Village as a village who's 'traditional and new networks and services are enhanced by means of digital, telecommunication technologies, innovations and the better use of knowledge, for the benefit of inhabitants and businesses'. This definition of 'smart' tends to imply a technological solution to aspects such as healthcare, education, housing etc..

Access to critical services, such as healthcare and education are often much more difficult in villages due to their remoteness and lack of infrastructure and investment. Important elements of what makes a village 'smart' may include: education and training in e-literacy skills, e-health and other basic services, circular economy approaches to agricultural waste, using technology to promote local products, and specialisation for agri-food projects, tourism and cultural activities (European Commission, 2016).

This definition of Smart Villages lacks a consideration of the sustainability dimension, particularly from an environmental perspective. While digital and telecommunication technologies can play an integral part in improving amenity, access to services and quality of life for people living in village communities, the environmental sustainability of these communities should be considered equally important.

1.2 Villages and the Environment

In some ways, villages are no different than cities. They require natural resources to support the livelihoods of their inhabitants and produce waste that must be managed. One of the main differences is the scale of these and the ability to manage them. There are

three main natural resource inputs required for the various aspects of a village to function (from the initial construction of its buildings, roads, bridges and essential services infrastructure, to its operation, and ongoing repair and maintenance). These include energy, water and raw materials (Figure 2). The use of these resources results in the production of waste, that must be managed, and the release of pollutants into the environment. These resource demands and outputs of waste and pollutants are having a detrimental effect on the environment and human health.



Figure 2: Inputs and outputs associated with a village

As is the case with Smart Cities, the development of Smart Villages must not be treated in isolation of their longer-term environmental consequences. Smart Village solutions must consider the context of resource availability, waste and pollution management and human health and wellbeing to ensure long-term sustainability. For example, there is little point in a technological solution for better communication, education and healthcare services if the natural resources used for the provision of these technologies (e.g. energy and minerals) are easily depleted or cause indirect environmental or human health concerns, resulting from the release of greenhouse gas emissions or pollutants, for example. What is needed is a model for Smart Villages that not only enhances the services and networks within villages but that also ensures that these villages are environmentally (as well as financially and socially) sustainable. Surely a village cannot be considered 'smart' if it ignores or pays mere lip-service to the ever-increasing global environmental concerns.

The aim of this paper is to present a framework for achieving environmentally sustainable Smart Villages and to demonstrate its application using a case study village in Assam, India.

2 A Pathway Towards the Environmentally Sustainable Smart Village

Environmental sustainability is often considered using a retrospective approach (Figure 3). The problem with this is that decisions (material choices, and solution design and selection, for example) are often locked in and difficult to change. This often means that a compromise is necessary and decisions are modified or solutions 'retrofitted' to address environmental sustainability goals for particular housing or infrastructure projects. This leads to sub-optimal solutions that can potentially be even more wasteful and inefficient than business-as-usual options. The more preferred approach for designing Smart Village solutions that address environmental sustainability concerns is an integrated approach (Figure 3), where environmental criteria are a key driver in the development of Smart Village solutions from the outset. This approach enables maximum potential environmental benefits from the optimisation of resource use and minimisation of waste and other environmental effects. It can also provide opportunities for better cost

optimisation as a reduction in resource demands and waste production often leads to reduced costs.



Figure 3: Different approaches to integrating environmental sustainability into Smart Village solutions

In order to facilitate this integrated approach to the development of Smart Village solutions, a four-step process is proposed. This includes Step 1: Understand current performance, Step 2: Understand local context, Step 3: Identify and analyse potential Smart Village solutions, and Step 4: Design and implement 'sustainable' Smart Villages.

Step 1: Understand current performance

It is important to understand how a particular region, country or village currently performs from an environmental perspective in order to identify opportunities for improvement and to provide a benchmark for the performance of potential Smart Village solutions. Depending on the scale of the information required, various sources of this information exist. For example, the Environmental Performance Index (Yale University, 2018) provides environmental performance data at the country scale across a total of 24 environmental performance indicators.

Other tools and frameworks can also be used to provide an understanding of a region's current environmental performance, such as the UN Sustainable Development Goals (UN, 2018). A survey of community members and observation of specific village communities can also provide the empirical evidence needed to better understand the current performance and issues being faced within a village. Bottom-up data like this is typically preferred, due to its greater specificity and reliability.

Step 2: Understand local context

A critical element of improving the environmental performance of a village is to understand its current characteristics and context. This step involves exploring the local resources available, such as materials, energy and water, and determining the ability for these local resources to be more widely used in the construction and operation of a village. An understanding of locally available skills and expertise is also essential, especially as maximising the use of these to meet specific village community needs is a key component of creating a sustainable Smart Village.

By closely aligning the selection of construction methods and materials with community needs, expertise and skills it is also possible to meet social sustainability goals. While the

ultimate goals may be to improve the environmental performance of a village, current community expertise may not be conducive to maximising this environmental performance. If new construction techniques or better performing construction materials are shown to perform better from an environmental perspective than current practice, then further training and education of villagers may be necessary. This can then be supported by other Smart Village solutions, such as e-learning.

Step 3: Identify and analyse potential Smart Village solutions

This step involves identifying potential Smart Village solutions considering the contextual information gathered in Step 2. Appropriate solutions for one village may not be the best solution for the next village. It is important that each potential Smart Village solution for improving environmental performance is assessed in the context of each village. In addition to considering the contextual aspects of potential alternative construction methods, materials or systems and their appropriateness (Step 2), each potential solution for improving the environmental performance of a village must be analysed from a life cycle perspective. This involves quantifying the total input flows (energy, water and resources) and output flows (waste, emissions and pollutants) over time, to determine whether net environmental benefits are able to be realised and ultimately whether or not a potential solution is environmentally sustainable. This should also be used as an opportunity to identify areas for further improvement in the way things are currently done and in the proposed alternative solutions, in the interests of striving towards achieving an environmentally sustainable Smart Village.

A number of approaches exist for analysing the environmental performance of Smart Village solutions, such as Bioregional's One Planet Living (Bioregional, 2018) (Figure 4) and The Living Future Institute's Living Building Challenge (Living Future, 2017). More in-depth analysis is also possible using sophisticated life cycle assessment data and techniques, as outlined by Crawford (2011).



Figure 4: Bioregional's One Planet Living assessment criteria
(Source: Bioregional, 2018)

As part of identifying and analysing potential solutions for achieving an environmentally sustainable Smart Village it is important to identify the associated training and education

needs for their implementation. This capacity building could take the form of higher education or on-the-job training for villagers.

Step 4: Design and implement ‘sustainable’ Smart Villages

The final step in the proposed process for identifying and implementing sustainable Smart Village solutions is to design and implement the selected solutions. This should involve the village community as well as trained professionals (designers, engineers, contractors etc.). This will not only help ensure that certain construction standards are met, but will also help to maximise the opportunity for villagers to be trained in any aspects of this process that may be appropriate, and develop skills and capabilities that will enable them to modify and maintain buildings and infrastructure systems into the future. This will provide an element of ownership and promote a greater feeling of engagement in the Smart Village upgrade process.

3 Case Study - Step 1: Understand Current Performance

This section describes one approach to step 1 of the proposed framework - understanding the current environmental performance of a village. As mentioned previously, a range of tools can be used to assess the current environmental performance of a village, including Yale’s Environmental Performance Index and the UN Sustainable Development Goals. While these tools are able to provide a very broad and high level overview of the performance of a country or region, which may help to prioritise areas for improvement, they don’t provide the level of detail necessary for community or village specific decision-making. For this, a bottom-up approach is needed. This involves collecting data from a specific village, or group of villages. The environmental performance of a village is based on a broad range of criteria, as shown in Table 1.

Table 1: Environmental performance criteria

Global warming (greenhouse gas emissions)	Water use	Acidification
Resource depletion (non-renewable materials and fossil fuels)	Eutrophication	Land use
Ozone depletion	Eco toxicity	Human toxicity

3.1 Approach

A holistic understanding of the environmental performance of a village would ideally consider all of the criteria in Table 1. However, capturing data on each of these criteria in a remote location is challenging, not only for logistical reasons (distance, time, cost), but also as much of this data is not routinely captured by homeowners or authorities.

3.1.1 Location

The state of Assam in India is used as a case study to demonstrate step 1 of the proposed framework. Assam has a very high proportion of its population living in villages, many of which are characterised by poor quality housing and insufficient infrastructure. A significant opportunity and need exists for improving village living standards, with the challenge being to achieve this while also improving environmental performance. A total of 2,153 houses across 37 local villages on the island of Majuli were surveyed in 2017-8 as part of a larger project with the Government of Assam. This survey covered population demographics and housing characteristics, from which some environmental-related data can be extracted (see Table 2).

Table 2: Environmental-related data collected

Data	Environmental relevance
Transport infrastructure	Resource demands for construction, operation and maintenance
Public transport access	Propensity for using more energy efficient transport modes
Travel distances	Propensity for walking or cycling, ideal transport modes
Travel modes	Type and quantity of energy use per person
Transport ownership	Resource demands for vehicle manufacture, operation and maintenance
House construction	Resource demands for house construction, operation and maintenance
Electricity availability	Grid-sourced electricity used and associated greenhouse gas emissions
Electrical appliances owned	Energy use and greenhouse gas emissions for operation of appliances
Cooking fuel	Energy use and greenhouse gas emissions for cooking
Crop types and quantity	Land use, sequestered greenhouse gas emissions

3.2 Findings

The data collected highlights the relatively primitive nature of village housing and lifestyles compared to that which is more prevalent in cities or more developed countries. For example, air conditioners, heaters, hot water systems, televisions, computers, washing machines and refrigerators are not universally owned. This section presents a sample of village characteristics and the associated environmental sustainability considerations.

3.2.1 Housing construction

In relation to housing construction, a variety of materials are used, ranging from more primitive earth and timber elements to brick and plastic (Figure 5). There are two key considerations in determining the environmental sustainability of the use of each of these materials: 1) is the material renewable? and 2) is it being used sustainably? Both questions are important to answer as a material may be renewable (e.g. timber), but it may be used at a rate faster than which it is able to be renewed (i.e. not sustainable). Various factors need to be considered, such as harvesting/extraction rates and processing practices, and rates of replenishment. Figure 5 indicates that the majority of existing houses use quite primitive, often renewable materials. The risk associated with improving housing in these villages is that materials that are non-renewable (e.g. concrete and plastic) may become more desired and prevalent, diminishing, rather than enhancing the sustainability of villages, in relation to housing construction at least.

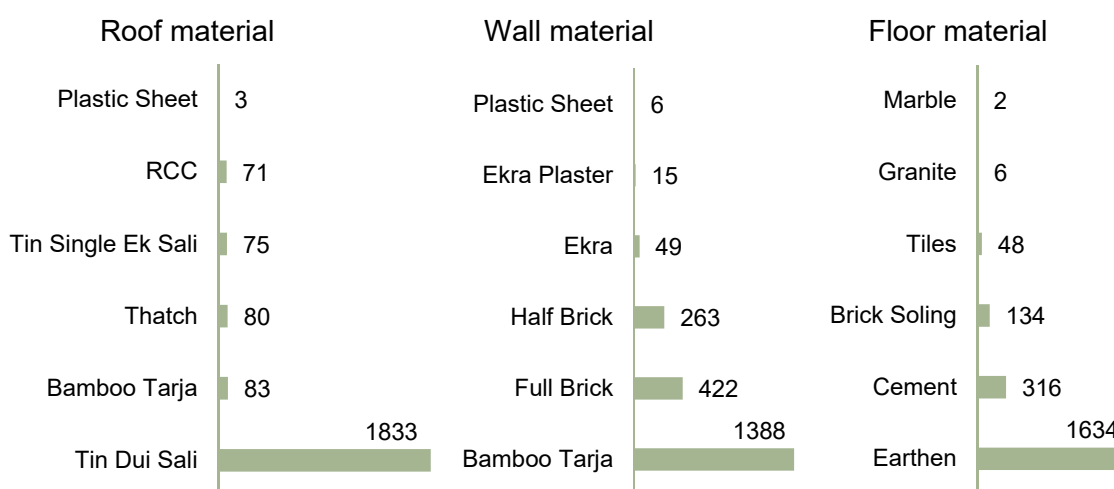


Figure 5: Housing materials of surveyed Majuli villages (no. of houses)

3.2.2 Cooking

Data collected on cooking fuels (Figure 6) shows that households use a mix of renewable and non-renewable fuels. However, in this case, renewable fuels (e.g. firewood) can lead to negative health consequences due to reduced air quality. This shows the importance of a more holistic approach than a sole focus on environmental sustainability (for which burning timber may be a reasonable solution). As with housing materials, improving the environmental sustainability of cooking will involve shifting to more renewable fuel sources but will also need to consider the context of changing expectations and lifestyles, where existing cooking technologies and methods may be progressively replaced with more advanced technologies.

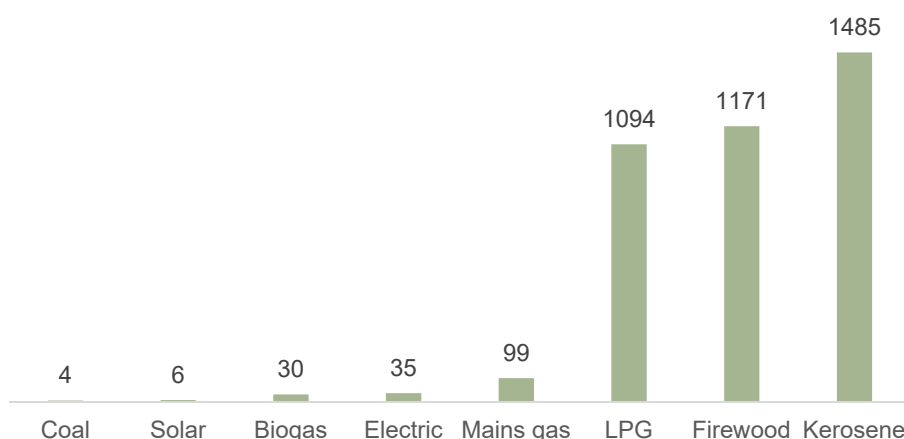


Figure 6: Cooking fuels used in surveyed Majuli village houses (no. of houses)

3.2.3 Technology

Technological solutions for Smart Villages will inevitably increase the demand for connected devices, such as smart phones and computers. According to the survey data, 77% of households do not currently have access to either of these devices. The uptake of devices needed to take advantage of Smart Village solutions (such as e-health and e-learning) will not only demand resources in their manufacture, but also electricity for powering them. This will create an increase in energy use within villages, potentially negatively affecting the ability for a village to perform sustainably, unless renewable energy sources form part of the Smart Village solution.

This case study uses only a sample of the data that is required to understand the environmental performance of a village, but it does give some insight into the process involved and the type of data that is required. It is important to note that the survey was not designed with the primary purpose of understanding the environmental performance of the villages surveyed. A more targeted survey would thus be more useful in understanding the resource inputs and waste and pollutant outputs associated with a village. This would include developing an understanding of the environmental flows occurring both within and outside of the village. The data collected should give an indication of the types of resources, wastes and pollutants associated with a village as well as their scale. The collection of this data provides a benchmark for Smart Village performance so that potential Smart Village solutions can be assessed against the existing performance of a village to ensure environmental sustainability improvements and targets are able to be achieved (step 3). It also provides an indication of the extent of intervention that is needed to deal with the scale of the issues for a specific village.

4 Conclusions

Smart Villages must go beyond a purely technological solution to enhancing the existing networks and services of village communities. At a time when environmental issues are of utmost concern, promoting the utilisation of more of the very resources that have been responsible for these current issues is unsustainable and outright negligent.

This paper proposes a four step process for identifying and implementing sustainable Smart Village solutions. This involves a holistic and integrated approach to identifying appropriate solutions for improving the environmental performance of villages. It goes beyond a purely technological approach and relies on community engagement and an understanding of the local context, particularly in relation to available skills and resources, and local issues. The importance of a bottom-up approach to understanding the current environmental performance of villages was highlighted. The ability to understand and address specific village issues and characteristics using this approach was demonstrated through a preliminary study of data collected from a number of villages in Assam, India.

While environmental concerns are of utmost importance, the other aspects of sustainability – social and economic – should not be forgotten. These should also be considered when assessing any potential solutions for Smart Villages that might be proposed. Solutions that enhance all three aspects of sustainability should be prioritised, as these are likely to not only improve the environmental performance of a village but also provide health, education, employment and equity benefits.

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COMPUTER AIDED DESIGN OF A MULTIPURPOSE WHEELCHAIR FOR RURAL AREAS OF ASSAM

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Abstract – In rural areas of Assam, individuals face many barriers to accessing services of healthcare facilities which create problems in their normal life. To overcome transportation barrier a design of multipurpose wheelchair is being proposed. The basic problem of manual wheelchair is architectural barriers on its way. To increase the flexibility of the wheelchair many research have been done. In this study, a wheelchair concept has been developed which can overcome the architectural barriers of a wheelchair as well as transportation barrier of rural individuals to a considerable extent. The proposed conceptual design of multipurpose wheelchair will act as a stretcher whenever any uneven surface comes on the way, which will help the patient and gives comfort. In the proposed design, ergonomics is also considered as one parameter to make the wheel chair more flexible. The design is developed in Solid works 2015 in a HP computer with specification such as windows7 ultimate, service pack1, RAM 4GB, Processor- Intel i3 4th generation, 64-bits. The proposed design of the wheelchair is for multipurpose use and hence it is assumed that it can overcome almost all the barriers. It will also easy to carry and it will definitely help rural individuals.

Keywords: Rural barrier, Architectural barrier, flexibility, Stair climbing

1 Introduction

From literature it is found that one-fifth of the population, i.e. between 110 million to 190 million people suffer significant disabilities. There are various types of disabilities e.g., eye, ear, hand, leg etc. The first records of wheeled seats found in China; the Chinese used early wheelbarrows to move people as well as heavy objects.

Generally people who use wheelchair are as follows:

- a. Patients at the hospitals
- b. Aged people.
- c. Lower limb disabled people

In this paper, a manual multipurpose wheelchair design is proposed which overcome not only architectural barriers but also transportation barriers. It is basically designed for rural people of Assam which help them to access services of healthcare facilities. The multipurpose wheelchair is also used as a stretcher which serves rural individuals to carry a patient easily from one place to another.

Many types of wheelchairs are seen in the market some of them are manual and some are powered wheelchair. Commonly noticed wheelchairs are as follows:

- a. Manual self-propelled wheelchair
- b. Manual attendant-propelled wheelchairs
- c. Powered wheelchairs
- d. Mobility scooters
- e. Single-arm drive wheelchairs
- f. Reclining wheelchairs
- g. Sports wheelchairs
- h. All-terrain wheelchairs

Australia is one of the most urbanized populations in the world, about 70% of people living in capital cities or major metropolitan areas. Of the remaining 30%, about 45% live in regional cities or large country or coastal towns and surrounding agricultural areas. A further 45% live in small country or coastal towns and their surrounding agricultural areas, and about 10% live in remote areas. (Australian Institute of Health and Welfare, 2002).

The development of the Rural, Remote and Metropolitan (RRMA) classification, in 1994, interprets the distinction between rural and remote areas using 'distance and personal distance factors'. This is related to the geographic distance from an urban centre of a population of 10,000 and the 'remoteness' of the average distance of residents from one another. (Australian Institute of Health and Welfare, 2004).

Zenith was a manual wheelchair having stair-climbing capabilities. Josefinia Chaves-Posse et al. in collaboration with the University of Alberta design this manual stair-climbing wheelchair (Chaves-Posse *et al.*, 2010). Zenith moves on two tracks on flat terrain and climbing stairs. It is found that there are clusters of three legs with small wheels at the ends that help during climbing mode.

Health needs of rural communities is limited and inconclusive, however there is sufficient data to indicate that health status and healthcare issues differ due to geographic locations and the diverse nature of the rural environment and the type of rural health service available. (Humphreys J, 1998)

From literature it is observed that, in 1962, Ernesto Blanco designed a self-propelled stair-climbing wheelchair (Melis, 2006) but the model was never built. Nevertheless, a small replica of Blanco's design was built to display how his wheelchair works. Unfortunately, no peer reviewed literature was published on Blanco's wheelchair.

In another observation, The Manuscale is found. The Manuscale was a manual wheelchair. In this case also, little information has been given. It moves on the drive and turning wheels as a typical manual wheelchair (United-Spinal-Tech-guide, 2013).

Vardaan is a third manual stair-climbing wheelchair found through an internet. It is competent of climbing a wing of stairs. The power arms are connected to ratchets and braking systems making a safe and stable climb and descend (Sharma, 2012).

The Stairbike is a working prototype of a manual stair-climbing wheelchair designed to help active individuals with good condition who suffer from paraplegia (S. S. f. E. B, 2008).

Since little information was derived from the limited literature on manual stair-climbing wheelchairs that is why in this study a manual multipurpose wheelchair design is proposed to overcome the barriers for rural individuals. Since multipurpose wheelchair is designed for rural individuals, it can be operated manually. A stretcher is embedded in the wheelchair which helps the people to carry, pull and push the patient and it can be use in sitting condition also.

2. PRINCIPLE COMPONENTS

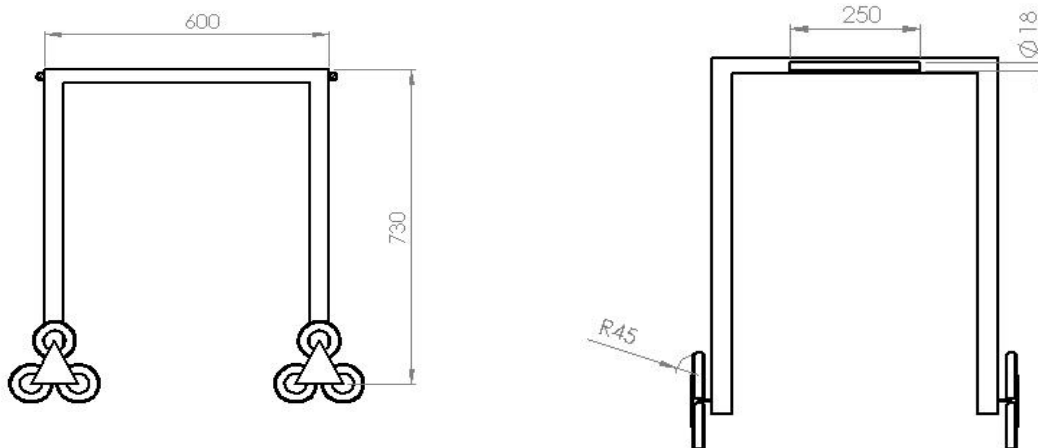
The wheel chair consists of following principle components:

- A frame is a structural system that supports other components of a physical construction or steel frame that limits the construction's extent. Wheels are designed to move the wheelchair as well as the stretcher.
- The flexible chair is one of the main parts of the wheelchair. The chair is fitted on to the frame of the wheelchair in such a way that it can be use as a stretcher by unfolding the arrangement.
- The flexible stretcher is also an important part of the multipurpose wheelchair. It is used to overcome transportation barrier and architectural barriers on its way.

3. COMPUTER AIDED DESIGN OF MULTIPURPOSE WHEELCHAIR

The detail proposed design is given below:

Detail dimensions (in mm) of the proposed design



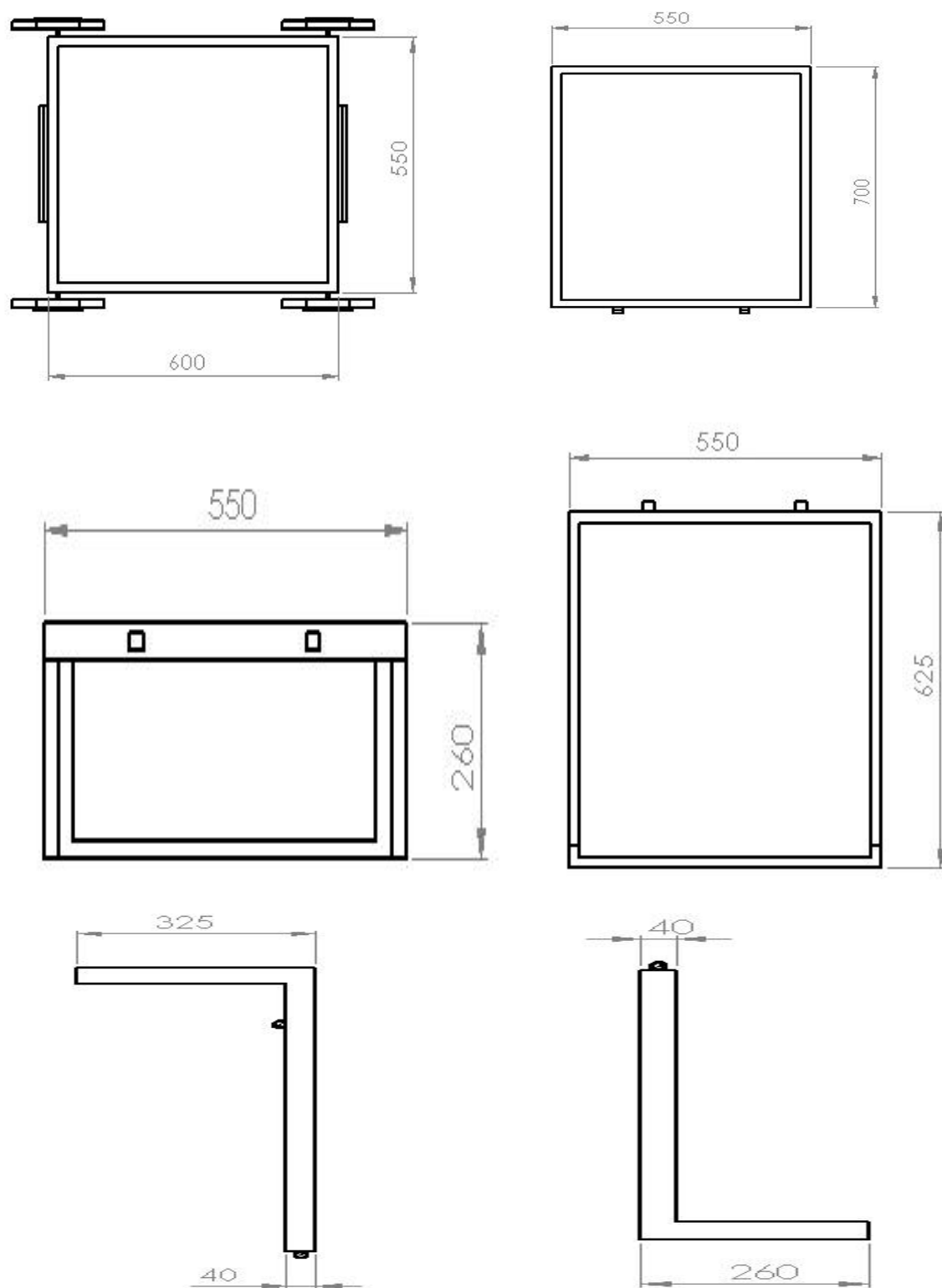


Fig.1. Dimensions of various parts of the multipurpose wheelchair.

Detail computer aided proposed design

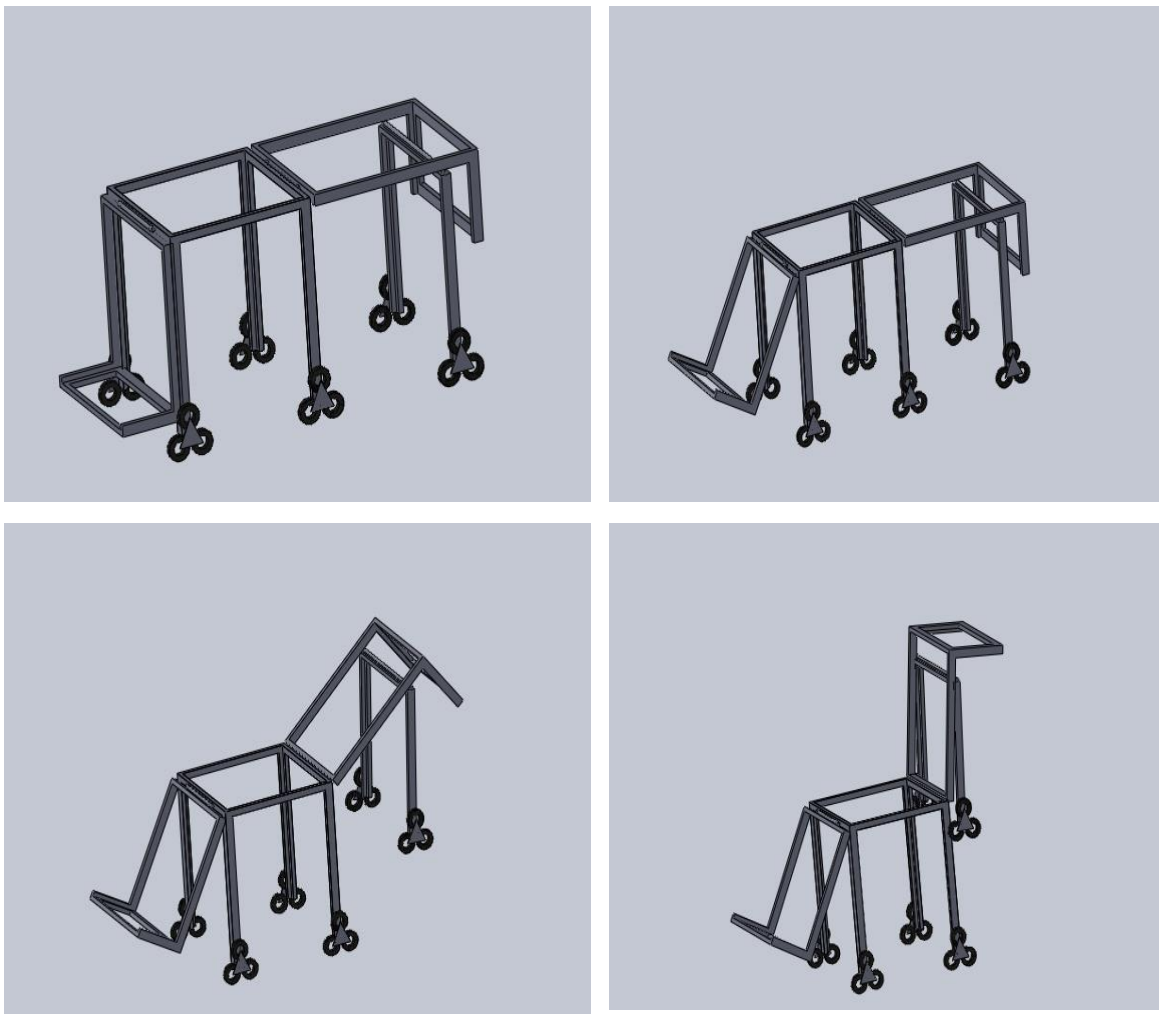


Fig.2. Frame flexibility

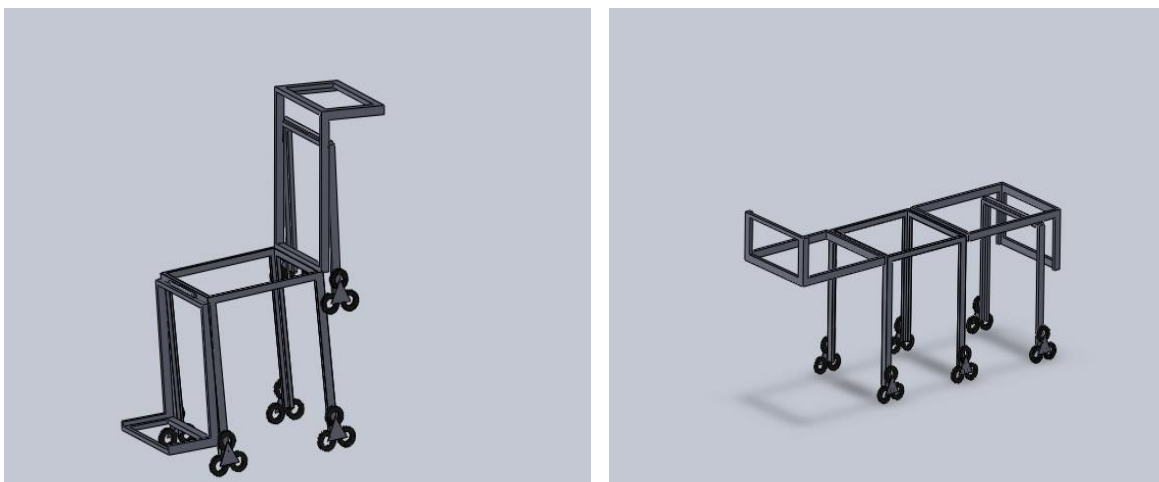


Fig.3. Wheelchair frame

Fig.4. Stretcher frame

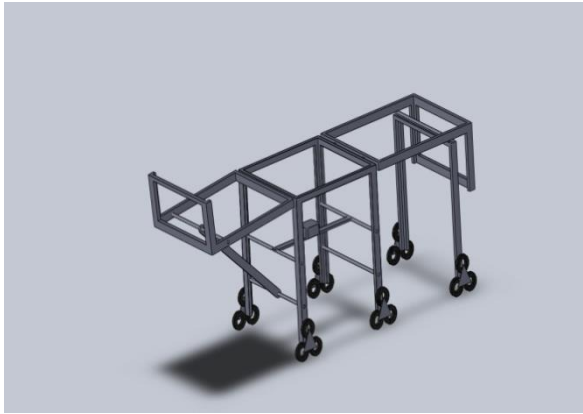


Fig.5. Complete frame assembly



Fig.6. Complete assembly

4. ADVANTAGES

- The wheelchair can be used to climb up or climb down the inclined planes.
- The wheelchair can be converted to stretcher when needed to overcome barriers.
- The multipurpose wheelchair can be used in bad condition roads.
- The operation of the multipurpose wheelchair is easy. It can be push, pull and carry as well.
- It is manually operated design so if it is fabricated it causes no harm to the environment.
- It can be used in hospitals, public places, home, etc.

5. CONCLUSIONS

The conceptual design of the multipurpose wheelchair is compact and flexible one; hence, it can be used in rural conditions. It is greatly useful in rural areas of Assam; where individuals face many barriers to accessing services of healthcare facilities which create problems in their normal life. In this study, a solution to overcome transportation and architectural barrier of rural people of Assam is given. For that a conceptual design of multipurpose wheelchair is being proposed. If the proposed design is fabricated, it will definitely helps rural individuals of Assam to a considerable extent.

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COLLABORATIVE GOVERNANCE STRUCTURE FOR MAINTENANCE OF RURAL ROADS

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Abstract: *The purpose of this paper is to establish a conceptual collaborative governance framework for the maintenance of rural roads. Rural road covers almost 70% of the total road network in India and over 70% of Indian population lives in rural areas, even then maintenance of rural roads has not received its diligent attention. Given India has an agriculture-based economy, there being roads kept in serviceable condition is crucial for the rural-agricultural growth and it is also affording means of access to millions of rural people to social facilities viz. medical, education as also to market. Lack of maintenance affects the poor people badly as the time for access to markets and other social infrastructure increases. Therefore, connectivity that has already been created would require much more attention in terms of its long-term maintenance i.e. in addition to routine maintenance, there is a need to upkeep roads built through periodic maintenance. In India, the responsibility for maintenance broadly rests with State Governments. However, in many States, there is still a lack of clarity over the ownership of the roads, long-term arrangements for the management of the network, sustainable and reliable finance for maintenance, and the organization set up for effective execution of maintenance activities. As there are many loopholes in the current administration and governing structure, it is a high time to explore for an alternative in which a collaborative governance structure may work wonders. From the literature, we identify critical variables that influence whether or not this mode of governance would produce successful collaboration. Based on these variables we attempt to develop a three-tier collaborative governing framework where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to manage rural roads.*

Keywords: Collaborative Governance, Rural Road Maintenance, Public Participation

1 Introduction

The first attempt to prepare a coordinated road development programme in a planned manner happened in the year 1943, popularly known as the Nagpur Plan. So, the necessity of a proper road network for the development of the country was understood quite early in India. The Road system is classified into a functional hierarchy comprised of National Highways (NH), State Highways (SH), Rural Roads (RR), Urban Roads (UR), Project Roads (PR). The length of Rural Roads was 3,935,337 kms out of 5,603,293 kms as on March 31st 2016 which converts into 70.23% of total road network in India as shown in Table 1.1 and the trend of growth in road length for the period 1950-51 to 2015-16 is also depicted in Figure 1.1 (MORTH & GOI, 2017). Vision 2025, the latest rural road development plan has accentuated a planned rural road network development with the aim of providing all-weather roads by the year 2021-22, connecting all the settlements with populations over 250 persons.

Table 1.1 Length of Road Network in India

Category of Road	Authority responsible	As on 31st March 2016	
		Length of Road (km)	Share in total road length(%)
National Highways	Ministry of Road Transport and Highways	101,011	1.80
State Highways	Public Works Department of State/Union Territory	738,106	13.17
Rural Roads	Panchayats, JRY and PMGSY	3,935,337	70.23
Urban Roads	Local governments and municipalities	509,730	9.10
Project Roads	Various State/Union territory government departments, and SAIL, NMDC and BRO	319,109	5.70
Total		5,603,293	100

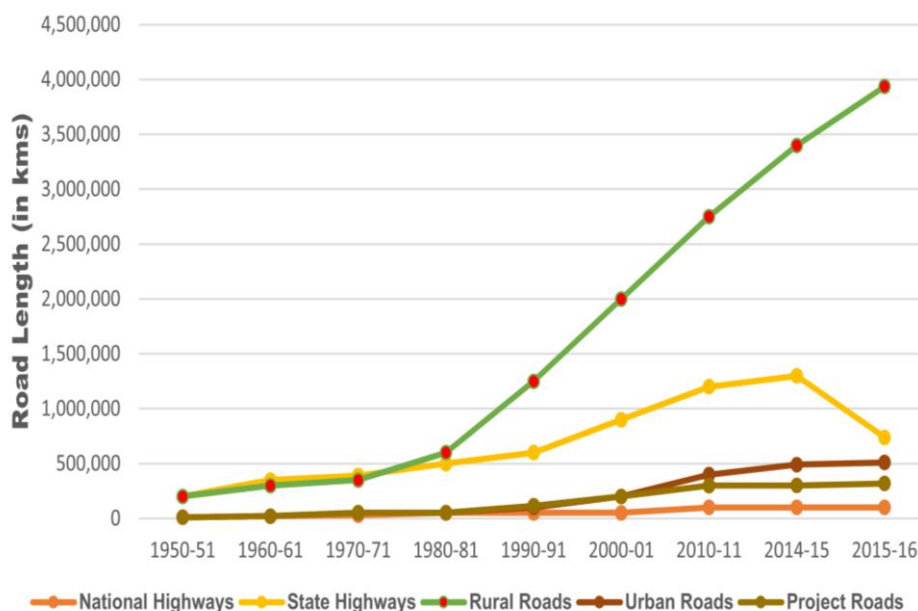


Figure 1.1 Trend of Growth in Road Length by Categories: 1950-51 to 2015-16

As per Indian Constitution, development of rural roads is a subject of the state government and thus previously the central government was not directly involved in the funding of rural road projects. However, after the 5th five-year plan, the central government started indirectly funding to the rural road projects through various schemes and programmes such as the Minimum Needs Programme (MNP), the National Rural Employment Programme (NREP), the Rural Landless Employment Guarantee Programme (RLEGP) and Jawahar Rozgar Yojana (JRY), etc. (Sarkar, 2011). Also recognizing the fact that the provision of rural roads is a crucial factor in reducing poverty in rural areas (MORD, 2007), the Government of India (GOI) initiated a National Rural Roads programme in the year 2000, known as the Prime Minister Gram Sadak Yojana Programme (PMGSY). PMGSY's objective is of connecting all villages having populations over 500 persons (250 persons and above in case of Hill States, Desert and Tribal Areas) by the end of 2007. Bharat Nirman, a similar program to PMGSY is a time-bound plan which was started to provide rural infrastructure during 2005-2009, in which rural roads was made one of the deliverables and was integrated with the PMGSY programme. Along with providing connectivity to unconnected villages, it has also targeted to upgrade existing rural roads for overall road network development. Though lots of progress has been made in bringing up new rural roads but the maintenance of part of it still remains a key issue. The vital challenge before the nation is both the expansion of the road network to connect all deprived villages and to upgrade and maintain the existing rural road network. According to the policy document made by government "Rural Road Development Plan: Vision 2025" (MORD, 2007), challenges encountered are summarized as follows:

- Multiple agencies handling the rural roads work. Barring PWDs and some rural engineering department, no funds for rural road maintenance are allocated practically. There is no clear ownership of rural roads being built and maintained except under the PMGSY where five-year routine maintenance is assured through state governments allocating funds for the purpose.
- Absence of an institutionalized system virtually for condition survey and inventory and planning and management system for rural roads. It can help to identify and prioritize maintenance interventions.
- Panchayat Raj Institutions (PRIs) not raising any funds for maintenance, although they are expected to be finally made responsible for maintenance. They are not being provided with funds for maintenance by the state. Moreover, they do not have any technical support to undertake such activities.
- About 80 percent of rural roads are in poor condition due to a combined effort of several factors, lack of funds and poor quality of construction. The culture of better quality construction of rural roads is now increasing with the PMGSY setting up three tier-control in this direction.

In this paper, to address these challenges and to propose an alternative solution, we conduct a literature review on collaborative governance and based on some critical variables that would influence the effectiveness of this mode of governance we proposed a conceptual framework to provide a more effective governance for India's rural roads. The tendered framework resolves a number of issues with respect to how future maintenance (routine, periodic, special, and emergency maintenance) could be done under one umbrella by different stakeholders (agencies) involved, in a synchronized and structured way.

2 Why Maintenance is Needed?

It is true that roughly around 80% of the total traffic, flows over 20% of the road network and hence, more priorities should be given to the roads with higher demand. An analogy of Indian roads can be made to that of a river system. As the main river would dry out without proper channelization of its tributaries, the same way the roads with higher importance in terms of demand, will not sustain without its feeder roads. The rural roads contribute highest in these feeder roads, therefore, it should be given equal importance as any other roads, especially when it comes to the subject of maintenance.

Rural roads are not merely for mobility and transportation; it is way beyond that, it provides access to all socio-economic facilities and helps in sustainable eradication of poverty. It is generally found that noticeable advantages start appearing when an area receives first time road access, as goods, services and facilities become more and more accessible. This can bring huge economic and social benefits, opening up the area to markets, health care facilities, schools, government services, etc. But merely creating these assets is not enough as it has to be preserved carefully and a road, which is not maintained well, deteriorates fast. The society has to pay heavily for an inefficient and ill-preserved road network. Figure 2.1 shows the relationship between investments in road development and socio-economic benefits (ILO and NRRDA, 2014).

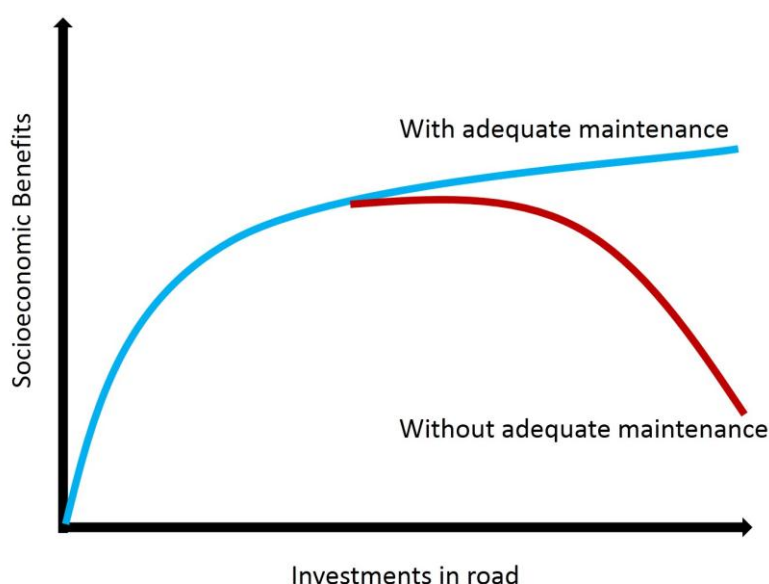


Figure 2.1 Relationship between investments in road development and socio-economic benefits

Delay in road maintenance results in huge direct and indirect costs. If early defects are taken care of promptly, the cost is usually modest. If defects are neglected, it may lead to reconstruction, which is three times or more the cost, on average, of maintenance costs. Many studies suggest that one lakh INR invested in routine maintenance save two lakh INR necessary for periodic surface renewal and one lakh INR invested in surface renewal save two lakh INR necessary for reconstruction (ILO and NRRDA, 2015). Delayed maintenance results in indirect costs as well, unattended roads gradually become unserviceable and it results in increased vehicle operating costs i.e. frequent repairs, more use of fuel and increases unwillingness among transport operators to use those roads. As a result, the local economy gets impacted as the passenger movement and freight services get distressed, there is a consequent loss of economic and social development opportunities to that community.

Maintenance work can be classified according to its timing or frequency as well as the scale or complexity of activities according to which work can be divided among different stakeholders according to their capacities. Maintenance based on frequency is classified as routine, periodic, special, and emergency maintenance (ILO and NRRDA, 2014). *Routine maintenance* activities are generally small-scale, widely distributed and often requires using manual labour. These are to be performed on a regular basis throughout the year. It consists of both off-carriageway and on-carriageway activities. Most common activities are removing debris from the roadway and drains, clearing drains, clearing culverts and other water crossings, repairing shoulders and side slopes, patching potholes, sealing cracks and repair edges of pavement, cutting grass and bushes, maintaining road signage and pavement markings. *Periodic maintenance* generally covers renewal of the road surface. Normally on rural roads, it may be required at 5 to 10 year intervals depending upon the initial construction standards and quality, traffic and weathering effect. (ILO, 2015). *Special maintenance* is required when culverts and bridges have suffered serious distress and damage requiring major repairs or even replacement. Protective works in such as retaining walls, etc. which are considered as major repairs may also be treated as special repairs. *Emergency maintenance* required when unforeseen events occur such as landslides, floods, earthquakes, etc. The immediate task is to re-open the safe passage on the road and subsequently plan for and provide for restoring the road to its former or better condition. The work involved in periodic, special, and emergency maintenance is normally larger and require more equipment and specialist skills. As a result, this work is costlier than routine works.

3 Defining Collaborative Governance and its Possibilities in Maintenance of Rural Roads

Problems in societies such as maintenance of rural roads are often complex, characterized by blurred causalities, multiple stakeholders, ambiguous boundaries, and complicated feedback. To deal with these problems often requires effective collaborative efforts bridging the gap between the public, private and social sectors. In collaborative governance, policy matters to everyone and everyone matters in policy. It includes the government, community and private sectors interacting with each other and working together to achieve more than any one sector could achieve on its own. Ansel and Gash 2007 explained collaborative form of governance as a governing structure where multiple public agencies directly engage non-state stakeholders in a collective decision-making procedure that is formal, consensus-oriented, and deliberative and that seeks to make or implement public policy or manage public programs or assets. While Emerson et al. 2012 defined collaborative governance as the processes and structures of public policy decision making and management that involve people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished. If collaborative governance is effectively implemented, then it has many advantages such as it allows a shared and better understanding of intricate problems where multiple stakeholders are involved and allow these stakeholders to solve it out together and achieve a solution. It could also help policymakers identify and target problems and deliver action more effectively. Stakeholders those are involved in fabricating a solution are more inclined to accept directions given or decisions made collaboratively. It can, therefore, serve as a way to find policy solutions that have greater purchase in the community. Furthermore, it can help in new idea generation on issues and policy solutions and thus offer new ways to implement strategies for development. It also helps public officials working as administrators and managers, it can bring in a wider range of ideas and suggestions for the policy process (Emerson et al., 2012).

Literature (Ansell and Gash, 2008; Emerson et al., 2012) suggests some critical essence for setting up Collaborative Governance which are as follows:

- the forum is to be initiated by public agencies or institutions,
- participants in the forum would include players from all sectors related directly or indirectly with rural development, allotted with define roles and responsibilities
- participants engage directly in decision making process and are not merely consulted by public agencies,
- the forum is formally organized and meets collectively, and timely,
- the forum aims to make decisions by consensus, manage and supervise implementation,
- provision for the mechanism of dispute resolution in case of consensus not achieved
- the focus of the collaboration should be strictly on making policy and management of rural roads.

Self-start of such forum happens in the extreme situation when administration completely marginalizes the society from better infrastructure. Citing as an example, residents of Notun Leikul village in Assam (India) decided to make the road themselves when administration repeatedly neglected their request for a new road. So, to avoid such a scenario and to maintain uniformity throughout the country forum needs to be initiated by public agencies. They may initiate collaborative forums either to ease out their own responsibilities or to comply with a mandate, including court orders, legislation, or rules governing the allocation of central or global funds. By using the term “public agency,” our intention is to include public institutions such as bureaucracies, courts, legislatures, and other governmental bodies at the local, state, or central level.

The collaborative governance for rural road maintenance would be a consortium of state and non-state parties working collectively. It is believed that diligent maintenance of rural roads is impossible without involving local communities as they understand the need for well-maintained roads which would help in prioritizing roads. As discussed earlier, involving communities would also be helpful in developmental spin-offs. The collaborative effort would address the issue of multiplicity of agencies handling the work of rural roads. The forum can fill the gap of an institutionalized system of inventory and condition survey and planning and management system for rural roads, which can identify and prioritize maintenance interventions for the core network. The problem of funding can be solved using the two-way mechanism i.e. both top-down and bottom-up funding, in which power can be assigned to the forums for raising funds and collecting tax for maintenance and would also be provided with timely funds from the state as per the budget for the same. Technical support can be incorporated through various agencies through collaboration. Finally, the forum is expected to be made responsible and ultimately held accountable for the maintenance of rural roads.

4 Proposed Collaborative Governance Framework

The drafted conceptual framework is based on secondary data. The primary data are drawn through a questionnaire, personal interview, telephonic interview, and the secondary data are derived from Journals, books, internet and from some of the Government of India official websites. The literature (Ansell and Gash, 2008; Emerson et al., 2012; Ojiako et al., 2015) suggests a number of factors that impact upon implementation of collaborative governance and determines the success of collaborative governance structure. Summarizing the factors for framing our collaborative process would include, among others are (i) institutional design; (ii) inclusiveness; (iii) leadership; (iv) institutional functioning structure with clear ground rules; (v) forums; (vi) institutional resources; (vii) incentives to participate; and (viii) process transparency.

4.1 Institutional design

Institutional design suggests here to the basic protocols and structure for collaboration, which are necessary for the procedural validity of the collaborative process. The most essential institutional design feature of governance structures is considered as formalization (Fung and Wright 2001; Imperial 2005). In a vast country such as India, collaboration for maintenance at the national level would be very difficult and the process may be quite inefficient. Therefore, decentralization is very much essential for implementing maintenance of rural roads in a collaborative manner. According to a suggestion note on maintenance policy for rural roads, Ministry of Rural Development (MORD) has prescribed that the policy actions to be adopted by the state governments should be giving away the authority of rural roads maintenance to the local governing bodies in villages i.e. Panchayati Raj Institutions (PRIs). According to the 73rd Amendment Act, 1992, the state should enact their own Panchayati Raj Act in conformance with the provisions of the Constitution and is also expected to transfer 29 functions listed in the 11th Schedule. The state is also required to devolve concomitant powers and authority to PRIs to carry out the responsibilities conferred on them (Shah, 2006). Panchayat is the generic term for the governing body at the local level. It exists as three tier systems – at the lower, intermediate and upper levels (Figure 4.1).

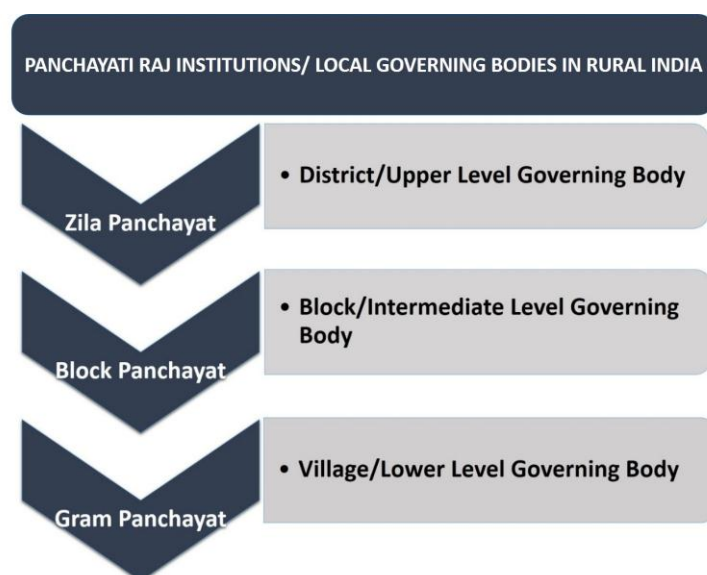


Figure 4.1 Panchayati Raj system in India

Adhering to the suggestion note from MORD, ownership of rural roads should be entrusted to Zila (District) Panchayat in every district by the state governments as the first step of designing the institutional structure for collaboration. No matter which department/government develop the road network but Zila Panchayat should be responsible for maintenance (ILO, 2015). To match up with the current local governing structure, we divide the collaborative governance structure into three-tier viz. Zila(District) level, Block(Intermediate) level, and Gram(Village) level maintenance forums. Each of these form would act as a subcommittee under each tier of PRIs i.e. Zila, Block, and Gram Panchayat respectively. The Zila level maintenance forum (ZMF) in collaboration with Block level maintenance forum(BMF) and Gram level maintenance forum(GMF), work for the maintenance of the rural road in a particular district. Individual-level would also have the collaboration of different stakeholders from different sectors. GMF's general body would include Sarpanch of the village, a Maintenance secretary (MS), and road representatives (RR) from every 500m stretch of road in the village, with technical assistance from Junior Engineer (JE). The term of maintenance secretary would be of one year and to be selected out of previous road representatives on the basis of performance. BMF's general body would include Member of Legislative Assembly (MLA), Block divisional officer (BDO), and a representative from each GMF under that Block, with the technical assistance of Assistant Engineer (AE) and JEs. Similarly, ZMF's general body would consist of Member of Parliament (MP), District Magistrate (DM), and a representative from each BMF in that District, with the technical assistance of Executive Engineer (EE), AEs and JEs. The ZMF would coordinate with the State Rural Roads Development Agency (SRRDA) in the state for timely progress review and arrange meetings when necessary. Similarly, SRRDA would coordinate with National Rural Roads Development Agency (NRRDA) for overall progress in the state. SRRDA and NRRDA are the autonomous organisation under Department of Rural Development in State and Central government respectively. Each forum in its own level would be responsible for maintenance management functions which consist of planning, organizing, implementing and controlling of maintenance activities (Haroun and Duffuaa 2009). As suggested by scholars, one of the important institutional design criteria is deadlines because collaborative meetings can be endless (Glasbergen and Driessen 2005). Therefore, it is suggested that GMF would be holding meetings quarterly every year, BMF would be having meetings semi-annually, and ZMF would held meeting annually. After each meeting, minutes of meeting needs to be submitted to upper forum giving details about complete work, future proposals for the anticipated issues, details about used funds and available funds. An overview of the working structure of forums for a district is shown in figure 4.2.

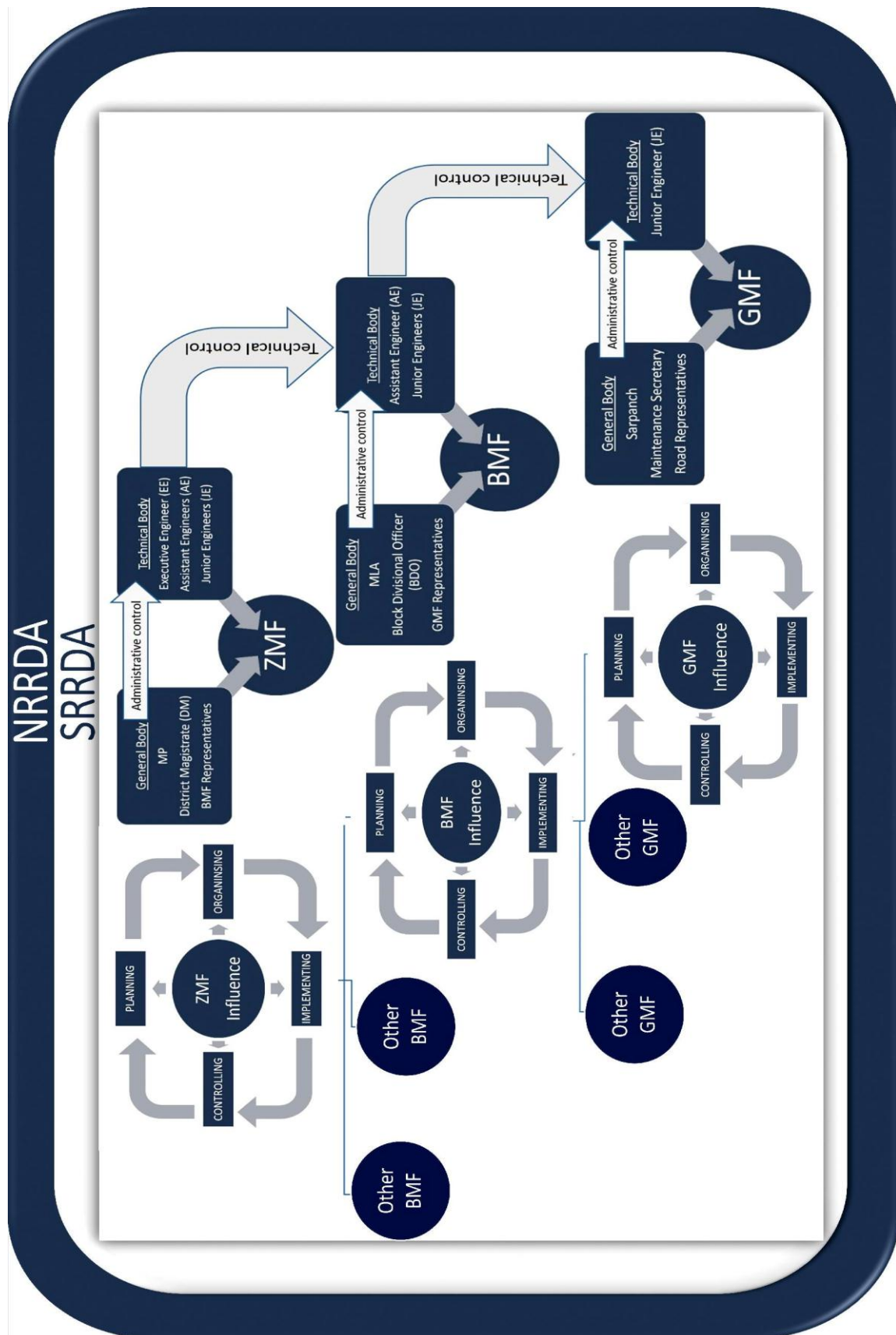


Figure 4.2 Overview of working structure of forums

4.2 Inclusiveness

The need for collaborative forms of governance originates from promises emanating from within theories of democracy. The focus of collaborative governance, as earlier referred to, is to facilitate consensus in decision making. Collaborative governance also seeks to address the concerns of civil society relating to the need for greater and more direct accountability of the public sector. That being the case, a number of studies (Huxham et al., 2000; Newman et al., 2004; Ojiako et al., 2015) have identified some challenges with collaborative governance. One such limitation has to do with the inclusiveness of public participation which may negatively impact the projects that require specialist skills. But with help of educational institutions such as selected Technical Universities or Institutions viz. National Institute of Rural Development and Panchayati Raj (NIRD), skills could be developed through training of representatives, representing in the different level of forums. Training modules and booklets prepared by the NRRDA with the support of International Labour Organization (ILO), containing the course material for field engineers and contractors and communities associated with rural road maintenance works may foster inclusiveness of such players. Arrangements for capacity building and training of the forum functionaries and Junior Engineers and Technical Assistants may also be done. The labourers being created and skilled under the MGNREGA may also be provided training in routine maintenance of rural roads so as to supplement the existing cadre of site supervisors. The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), is an Indian labour law and social security measure that aims to guarantee the right to work whoever demands for it.

It is generally accepted that inclusivity remains core to democratic principles and may positively impact effective policymaking and implementation, inclusiveness must reflect the social contract between the state and its citizens. The danger, therefore, is that without proper consultation and management, collaborative governance has the potential to disenfranchise or at least create the impression that citizens are being disenfranchised. Therefore, to have a meaningful collaborative governance, strategy of empowerment and representation of weaker or disadvantaged stakeholders or the public is adopted by directly involving them in the consensus decision-making process and implementing first aid maintenance work under GMFs and indirectly involving them in BMF and ZMF through stewardship. There is a sturdy case, therefore, for policy advocacy by both the Central and State Government to empower the PRIs as units of local government administration to endow the maintenance of rural roads to the PRIs. It would be able to more effectively promote community involvement and also, the communities can then more forcefully demand their involvement in this effort.

4.3 Leadership

Leadership is believed as an essential ingredient in bringing different stakeholders to the table, guiding them through the initial days and for steering them through the rough patches of the collaborative process. Researchers argue that to move collaboration forward, leaders must often intervene in a more directive way to shape the agenda (Vangen and Huxham, 2003). Leadership is essential for setting and maintaining clear ground rules, building trust among all, facilitating dialogue, and exploring mutual gains. Legislatures would play the vital role as leaders by devolving necessary powers to the forums which would allow them to work and sustain independently. NRRDA at the national level and SRRDA at the state level would help the forums by providing adequate technical support and capacity building during initial days of collaboration. This kind of leadership is important for embracing, empowering, and involving stakeholders and then mobilizing them to move collaboration forward. Scholars assert that collaborative governance requires specific types of leadership. Ryan (2001), for example, identifies three components of effective collaborative leadership: (i) adequate management of the

collaborative process which would be done by general body of the forum, (ii) maintaining technical credibility which would be taken care of by EE, AEs and JEs, and (iii) ensuring that the collaborative is empowered to make credible decisions which would be ensured by state legislature and bodies such as NRRDA and SRRDA. Researchers also have described the leaders as a steward in the collaborative process which would be played by different representatives in the upper forums. Leadership is also important for empowering and representing weaker stakeholders which are ensured by placing road representatives (RR) in the general body of the lower forum. Collaborations may also have multiple leaders, formally and informally, rather than relying on one leader (Bradford 1998; Lasker and Weiss 2003). This framework has also multiple leaders at various stages and levels steering the whole process of collaboration.

4.4 Institutional functioning structure with clear ground rules

The literature suggests that clear ground rules and process transparency are important design features (Ansell and Gash, 2008; Emerson et al., 2012). Clear definition of roles and responsibilities can also be important (Alexander, Comfort, and Weiner 1998). Proper functioning structure of needs to laid out so as to avoid confusion among forums. Out of three-tier of collaboration, ZMF would hold the downright responsibility for the maintenance of the rural roads in the district and BMFs, and GMFs would be working as sub-units. BMF would have authority over periodic and specials maintenance and GMF would have charge of routine maintenance of roads. During the initial period, the ZMF in collaboration with GMF and BMF, prepare a layout of the roads from the existing revenue map of the District Panchayat and plot District Rural Roads Plan (DRRP) which would act as an inventory of roads. These maps shall be digitized and hosted on a GIS platform. Each section of rural road in every district should be given a Unique ID number similar to Aadhaar Card which is a unique identity number for every citizen in India. It would help in keeping total stock of rural roads available at one place i.e. in the ZMF and each road with their ID should be tagged with BMF and GMF according to their jurisdiction. Further, the ZMF, through the GIS platform can monitor and track the progress of maintenance. The ZMF would strengthen the capacity of GMF and BMF by placing JEs, AEs and Revenue officials to prepare the maps. The SRRDA would support training of Engineers and Revenue officials. Provisions are also need to be made to enable these forums to engage junior level technicians and engineers from the market on a contract basis for efficient execution of works. To enhance efficiency and increase accountability, MGNREGA is already supporting the PRIs in computerization of various activities and instituting Management Information System (MIS). Similarly, computerization would certainly help ZMF to handle the increase in the volume of work and function in a smarter way. This needs to be mainstreamed to include the proposed management of maintenance of rural roads. In order to handle and computerization of data of various activities, a technician may be hired or computer teacher of local primary school may be taken into the picture for such jobs.

Each GMF may have one Junior Engineer and each BMF may have one Assistant Engineer and two Junior Engineers to provide technical support in the execution of civil works in the maintenance. It is proposed that these technical personnel may be under the administrative control of the GMF or BMF while technical control may rest with the Executive Engineer at the ZMF level. Each ZMF may have one Executive Engineer supported by two Assistant Engineers and four Junior Engineers. One of the AE should be the superintendent of record keeping of all maintenance activities on the rural road network in the district and upload the information on the Zila Parishad website to make the whole process transparent. The state governments may consider lending the engineering personnel at EE, AE, and JE levels from their regular road agencies such as Works Department(PWD)/ Rural Engineering Works Departments (REWD) to the

different forums on deputation basis for upscaling good technical practices in planning and execution of road maintenance works or dedicated EEs, AEs, and JEs may be assigned in each forum.

As discussed earlier, each forum would be responsible for maintenance management function which consists of planning, organizing, implementing and controlling of maintenance activities.

Setting performance objectives and developing decisions on how to achieve them is done under the *planning process*. The stretches and roads under the responsibility of the ZMF, brief inventory details (length, width of road, carriageway, cross-drainage works) and condition (based on visual inspection) would be carried out every year immediately after rains and compiled. The General bodies of BMF and GMF level would be deciding priorities for required maintenance of roads and prepare detail cost estimate for each work order. It is developed duly considering the results of inventory and condition surveys at their own level with expert assistance from private sectors or technical institutions. Final report is being prepared at ZMF compiling reports of other two forums and this should form the basis of preparing Annual Maintenance Plans at district levels and submitted for approval of the SRRDA. Since routine maintenance is a basic community service, the state governments may allocate full funding as per the district level plans approved to ZMF. For periodic and special maintenance of roads, funds to be allotted depending upon availability of budget and final state priorities of roads based on the severity of damage, prepared by SRRDA. The Annual Maintenance Plan and allotted budget under various type of maintenance work need to be uploaded and updated monthly on a GIS platform in the Zila Parishad website.

Creating structure, distributing the work, arranging resources, and coordinating task to perform maintenance tasks are done under the *organizing process*. For routine maintenance, GMF would be mainly responsible for maintenance and management of roads under that particular village. For periodic and special maintenance of all the roads under the block level would be carried out by BMF. Emergency maintenance would be handled only with the direct intervention of state government taking the help of ZMF. As maintenance works of roads are geographically spread, the management of this type of activities can be more effectively organized at the local level, BMF and GMF may deploy local community through community contracting, local petty contractors or self-help groups may be piloted for such works. Maintenance work could also be mooted in the Public Private Partnership (PPP) mode, where the contract could be granted by the concerned forum on a concession basis to a private party/concessionaire. The contracting would be based on the principles of EPC, where the payment of annuity/semi annuity would be performance-based, i.e. linked to the maintenance standards, usability and availability of the road for the users. Information about all the types of contractor with their past works and performance needs to be recorded for future references. Locally available materials required for maintenance should be given first preference, it could be either donated by the community to the forum or it needs to be procured. Database of natural materials with geotagging to be developed at Zila level so that resource sharing can easily take place within GMFs or BMFs. Provision for tax collection by the forum and receiving donation for maintenance work should also need to be formalized and the whole process should be brought online so as to increase transparency and accountability.

Executing the plans to meet the set performance objectives is done under the *implementing process*. For the execution of maintenance of rural roads, there are a few options that can be considered, engaging local petty contractors, engaging local communities, engaging self-help groups or labour cooperatives. In order to involve them in maintenance work, the NRRDA is developing simple contract forms for community contracting with the technical assistance from the ILO for the World Bank funded PMGSY projects. Similar contracts may be undertaken as pilots for such community

contracting. Performance-based maintenance contracts may also be developed for such activities. The concerning forum would need to collaborate with the line departments handling the work of rural roads to put in place an effective mechanism for execution of maintenance works. The formats should include simple conditions of the contract, work plan, bill of quantities and payment arrangements. The tendering process should be fast and works award need to synchronize with working season. Works under routine maintenance can be easily performed by local communities and self-help groups living close to the rural roads. The JEs and AEs posted with the GFM and BFM can provide good technical support in the inspection of such works and oversight on the performance of the local communities so engaged. Learning from the execution of MGNREGA, the community contracts and contracts for jobs to be performed by contractors should incorporate all the decent work elements of the ILO for the workers engaged for maintenance activity. The GMF and BMF would also need to develop contract management capacity in association with the AEs and JEs who would inspect and supervise works and requests the ZMF to release payments to the contractors or the workers as the case may be.

Measuring the performance of the maintained road and taking preventive and corrective actions to restore the designed specifications comes under the *controlling process*. Apart from yearly planning for maintenance, regular local level controlling needs to be done. Every year on quarterly basis, general body of GMF, members of gram sabha, local petty contractors, labourers under MGNREGA, and self-help groups or labour cooperatives etc. would assemble together to discuss issues related to roads and after hearing all the projected concerns and complaints, on a consensus basis the General body of GMF decides the priorities for required maintenance of roads with technical assistance from JE and prepare work order to carry out routine maintenance. Maintenance Secretary would be in charge of timely conducting the assembly and would be looking after the process to be transparent and smooth. The road representative from each 500m stretch of road would ensure concern of every individual is addressed in the forum and he/she will also act as a supervisor to check the quality of work done in the road under his/her jurisdiction. Tracking of ongoing work and update about completed activities is submitted to ZMF regularly. The BMF and ZMF would be monitoring this process and they may directly or indirectly involve in such procedure.

4.5 Forums

Forum is essential feature of collaborative governance, as it brings public and private stakeholders together with public agencies. Research (Robertson and Choi, 2012; O'Leary and Vij, 2012) suggest to the expansion of collaborative forums as the public sector increasingly seeks to give both the public and civil society an increased role in policy development and implementation. However, although forums are highlighted as desired examples of democracy, sceptics (Nabatchi et al. 2011; Shine and Bartley 2011) argue that there is a darker interest among the public sector which is more about the tokenism that exists within the democratic agenda and less about managerial efficiency (Ojiako et al., 2015). In traditional participatory processes, people participation is more indirect however in our collaborative governance maintenance forums, participation is direct in lower forum i.e. GMF and participation in the other two forums are through stewardship. Exclusiveness is also an essential ingredient for the success of collaboration which is attained by consigning all the necessary powers to the forums to carry out the maintenance work (Ansell and Gash, 2008).

4.6 Institutional resources

Three basic resources for road maintenance are Man, Material, and Money. As referred earlier, the forum gets human resource such as supervisors, technicians or monitors, and labourers through MGNREGA labours, self-help groups or labour cooperatives. Which can cut maintenance costs and increase community responsibility and participation. Natural resources, e.g. timber, soil, gravel and rock deposits which are locally available should be used first for maintenance or else may be procured. Most important resource of them is Money for which there are quite a few sources of funds out of which funds could be allotted to concern forum required for maintenance of rural roads. These sources include state government budget under the non-plan Revenue Expenditure, Rural Development Cess, Market Committee Fee, State Finance Commission, or getting certain percentage of funds from Central Road Fund. Since routine maintenance of rural roads is a labour intensive job with low material and equipment requirement, maintenance of those roads could be accomplished with funds under the MGNREGA. The current merged guidelines of MGNREGA & PMGSY allow for post 5-year routine maintenance of PMGSY roads from MGNREGA funds.

One more way to generate fund is by creating dedicated maintenance funds for rural road network at Zila level. Gram panchayats may collect money in form of land revenue of village, house tax, vehicle tax or creating a special tax for road maintenance which can be directly deposited in the fund created and it would ring-fence the same for assured maintenance on the ground. The forums would collect, monitor and manage such funds. GMF, BMF, and ZMF would have 70:20:10 stake from the fund collected by individual gram panchayat. The rationale behind GMF getting higher stake is as GMF would be doing most of the routine maintenance work and fund directly under their control would allow them to independently solve the local problem locally and availability of funds directly under their control may also act as an initiative for collaboration.

Learning from the Government of Finland, road co-operatives may be adopted at GMF level depending upon the financial situation and acceptance level of the villagers. A road-co-operative is a rural road maintenance organization whereby people residing along a road take up responsibility for its maintenance. It would have a legal framework which stipulates the right-of-way, co-operative ownership, and the formula for distribution of maintenance costs amongst the road users and property holders along the road. Participation in the road co-operative is to be made compulsory for property owners who use the road. The cost of road maintenance would be shared amongst the members of the co-operative depending on the benefits to each member in the form of the size of the holding and the created traffic. Each co-operative would hold an annual general meeting to decide the fees, to accept new members and to audit the previous year's accounts (Isotalo,1992).

4.7 Incentives to participate

Given participation is vastly voluntary in nature, it is critical to study the incentives that participants have to enlist in collaborative forums and the factors that decide those incentives (Ansell and Gash, 2008). This encompasses analysis of the inducement for public agencies to sponsor collaborative governance. Gray (1989) asserts that power disparities among players influence their willingness to participate in the forum. Part of incentives to participate also bank upon stakeholder expectations that whether the collaborative processes would yield fruitful results, particularly against the balance of time and energy that collaboration requires (Bradford 1998; Geoghegan & Renard 2002). Incentives increases as stakeholders find a direct connection between their participation and concrete, tangible, and outcomes from effective policy (Brown 2002). But they dwindle soon if stakeholders perceive their own input to be just advisory or largely ceremonial (Futrell 2003). Although collaborative processes may be mandated by

legislatures or courts, stakeholder participation is generally voluntary and the incentive for stakeholders to participate is likely to increase when the collaborative process is the exclusive forum for decision making. Types of participation of a community to take part or share in an activity are given in table 4.1. and participation type against road classification is shown in figure 4.3 (Wattam, 1998).

Table 4.1 Types of participation

Participation Type	Characteristic
Passive participation	People participate by living in the area of the project. They may be told what is going to happen or has already happened but will have no other input.
Participation for material incentive	People participate by being paid for labor in food or cash, for a pre-determined project. This may be as a 'community' or as groups.
Participation by resource contribution	People participate by contributing a resource such as labor or money, to a pre-determined project.
Participation by consultation	People participate by being consulted (perhaps with options) on projects where the majority of the decisions have been made. Their view may/may not be considered.
Interactive participation.	People participate by joining with external professionals in analysis of their situation, developing action plans and determining common projects.
Spontaneous mobilization	People participate by taking their own initiative independent of external professionals to change their situation. This may lead to self-help projects or requests to other institutions for assistance

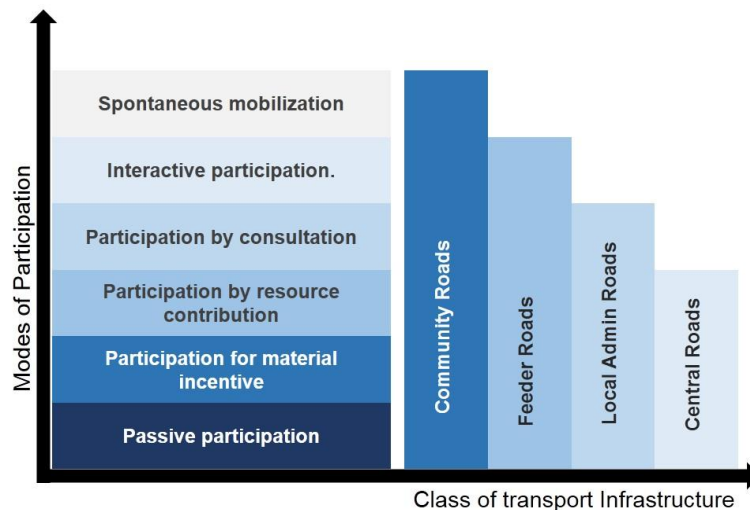


Figure 4.3 Participation type against road classification

From the above figure, it is evident that for maintenance of rural roads (Community roads & Feeder roads), almost all the modes of participation are valid, which suggests that there is high scope and incentive for participation in the collaborative process.

When collaborative forums focus on “small wins” that deepen trust, commitment, and shared understanding, a virtuous cycle of collaboration tends to develop which further foster the participation. Also adopting methods such as road co-operatives, generates a great sense of ownership and the very idea of ownership is a huge incentive to participate in the forum.

4.8 Process transparency

Finally, on process transparency, scholars (Emerson et al., 2012; Kim and Lee, 2012) suggest that transparency implies that an element of openness can be construed as an instrument of collaborative forms of governance. According to Hood (2006), transparency, therefore, implies the idea of government openness in terms of information

relayed to the public. Transparency promotes the 'right to know' about public affairs. Therefore, all actions must be in the public domain. Proactive disclosure of basic information relating to list of roads in Zila level being taken up for maintenance together with cost details, funds received, expenditure, etc. displayed at notice boards at the office of GMF and BMF and also available online on Zila Parishad website. There is a need to establish a system of performance evaluation at the ZMF to enhance the accountability. Some of the indicators that can be considered for this purpose are uploading of photographs of road stretches before and after maintenance, amount of routine maintenance spent annually per km of road length, percentage of the rural roads within the jurisdiction of the BMF and GMF which is in poor condition and regular technical audits would be undertaken with the support of the PIUs and observations arising from that should be factored in to improve performance. Involving the community and small contractors in maintenance work at the local level as they are the direct beneficiary of the roads, it is expected that their involvement and commitment would be of the highest order. In addition, the local community would be free to express their dissatisfaction if any of them freely and the contractors would be under pressure to perform at a desirable level. Regular financial audits should be done through the Comptroller and Auditor General and observations should be compiled. This would also serve towards implementation of reforms and efficiency in future maintenance activities by the forums. Similarly, to MGNREGA that has a system of concurrent social audits which could be extended to the maintenance activities taken up by the forums.

5 Conclusion

Over the years, maintenance of rural roads has been highly neglected in India and on an emergency basis, it needs to be taken seriously. Otherwise, the country would lose a significant amount of money in form of a huge amount of depreciation in the value of the asset and other indirect losses such as from agriculture sector which could adversely affect the overall development of the nation. However, with the implementation of collaborative governance incorporation with various schemes, maintenance work could be quite effective. This mode of governance seems to assert that if we govern collaboratively, we may avoid the confusion of responsibilities towards maintenance work among multiple agencies involved and help to expand democratic participation. Sustainable maintenance of rural roads would also be strenuous without improving the relationship between the various stakeholders, public partnership, finance management, integration of sectors and incentives for them to collaborate. This paper extensively discussed eight important criteria: institutional design; inclusiveness; leadership; institutional functioning structure with clear ground rules; forums; institutional resources; incentives to participate; and process transparency, which determines the success of collaborative governance and its implementation for maintenance of rural roads. Keeping note of these criteria, the framework for collaborative governance was structured in a three-tier system viz. ZMF, BMF, and GMF which are maintenance forums at each level of rural governing bodies in India. Each of these forums would be performing their own responsibilities concerned to their jurisdiction. The very essence of this framework is creating possibilities of solving issues of maintenance locally, which promotes community involvement effectively and also, the communities could then more forcefully demand their involvement in this effort for better infrastructure. All the strategies proposed in this paper for strengthening the capacity and performance of the forums to undertake maintenance may be considered and discussed among key senior-level policy administrators both in the central level (Ministry of Rural Development and in Ministry of Panchayati Raj) and the state level (Rural Development Departments and SRRDAs, other rural road agencies). This would help in refining these strategies and chalking out a roadmap for the steadily devolving function of maintenance of rural roads to the forums.

Simultaneously with capacity building of the elected representatives and official functionaries including the engineering personnel and providing funding support together with enhanced accountability and transparency would certainly foster its implementation on the ground and make country's rural road network more efficient in order to maximize economic and social benefits.

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IMPLEMENTATION OF POWER MODULATOR CIRCUITS IN SMART VILLAGE BUS ARCHITECTURES

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Abstract: Rural isolated areas are gradually transforming into smart villages. In this regard, the power is considered to be one of the fundamental necessity and researchers found it best to implement solar photovoltaic panels in producing electrical energy with renewable sources. Authors surveyed practical cases of power loss and deterioration in the quality of power delivery. Paper proposed two bus architectures i.e., square-ring and mid-point bus and finds the one with least copper loss. In addition, authors designed solar inverter and a four-arm bridge circuit that can effectively modulate the power using the principle of autotransformer and combined self and mutual inductive effect. A change in magnitude of resistance-inductance in bridge circuit changes the mutual inductance and varying the power profiles of the circuit. Accurate control of the resistance-inductance-capacitance (RLC) can produce a variety of waveforms especially triangular, sinusoidal, steep-shifted powers. The inverter circuit is designed to convert a DC voltage to an alternating current (AC) by simultaneous switching and auto-transformation. A number of fixed RLC elements are recommended to be replaced as variables for proper tuning of the output waveforms.

Keywords: Universal Power Conversion Circuit, Power Inversion, Auto Transformation, DC-AC Converter.

1 Introduction

Rural areas are transforming to smart villages by imparting equal importance in a number of domains including food, medical, transportation, energy, civil architectures, electronics, telecommunication, and electrical power (Anderson 2017:6-16). In energy context, a number of material and energy researchers are studying new materials that can provide power with certain advantages including cost-effectiveness, non-toxic, economic, easily available, low operating and manufacturing cost, and environment-friendly (Madduri 2016:1195-205). The recent problem defines that the power supply is significantly irregular in rural isolated areas and can be overcome by installing solar energy systems. A number of villages are provided power by wind and solar hybrid models for equivalent energy production in sunny and windy conditions and reduces dependency on the conventional power grid (Adly 2018:436-446).

Authors considered specific power conversion techniques *i.e.*, *power inversion and universal power conversion*. Inductive effect of autotransformers and parallel coupled inductors change the texture of signals from continuous to discrete, triangular, positive-negative shifting and increases flexibility of the power profile (Kwasinski 2011:835-51). The efficiency of auto-transformer is considerably higher as total energy is transferred from primary to secondary windings by flux linkage and electrical connections. A spontaneous switching of DC input voltage produces a purely sinusoidal wave on allowing the current to flow through the passive filters.

Paper is structurally divided into four main sections: section one defines a preliminary overview of the renewable solar system and the inductive effect of two power circuits; section two defines the solar modules and its specifications; section three defines square-ring and mid-point bus architectures; section four defines the power inversion and RL bridge converter operation and section five discuss the simulated results of the two power converters using standard software.

2 Solar Module Specifications

Paper implements PV array in the DC grid that consists of 40 strings of PV modules connected in parallel. The string consists of ten modules connected in series and considered to a reference model for the analysis (Fig. 1(a)) (Adly 2018:436-46).

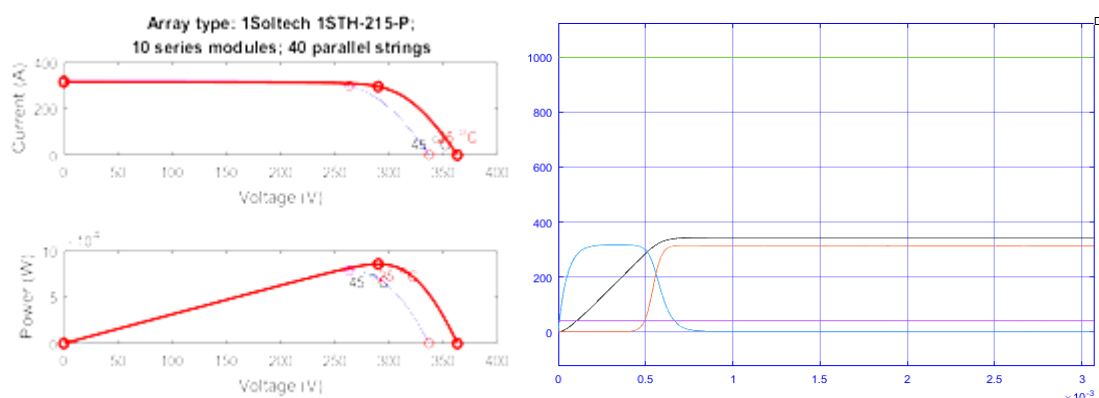


Figure 1: Solar array data curves
(a) current, power and voltage (b) panel characteristics

Module Specifications: (Fig. 1(b))

Module: 1 Soltech 1STH-215-P

Maximum Power = 213.15W

Cells per module (N cell) = 60
Open circuit voltage = 36.3V
Short-circuit current = 7.84A
Voltage at maximum power point = 29V
Current at maximum power point = 7.35A
Temperature coefficient of Open circuit (% per °C) = -0.36099
Temperature coefficient of short-circuit current = 0.102

Model Parameters: (Fig. 1(b))

Light-generated current = 7.8649A
Diode saturation current = 2.9259e-10A
Diode ideal factor = 0.98117
Shunt resistance = 313.3991Ω
Series resistance = 0.39383Ω

3 Square-Ring and Mid-Point Bus Architecture

Bus arrangement is a fundamental rural power grid structure that enhances power distribution and transmission. Generally, efficient and reliable hybrid models of renewable energy systems are built by cascading hydro, solar, wind and biogas plants to power the villages all through the year. Consider, microgrid consisting of four houses that are being isolated from the main grid and is powered by solar modules (Fig. 2). Practically, the resistance of conductors is responsible for DC conduction losses and inductance effect is negligible and omitted for calculative studies (Salomonsson 2009:1045-53).

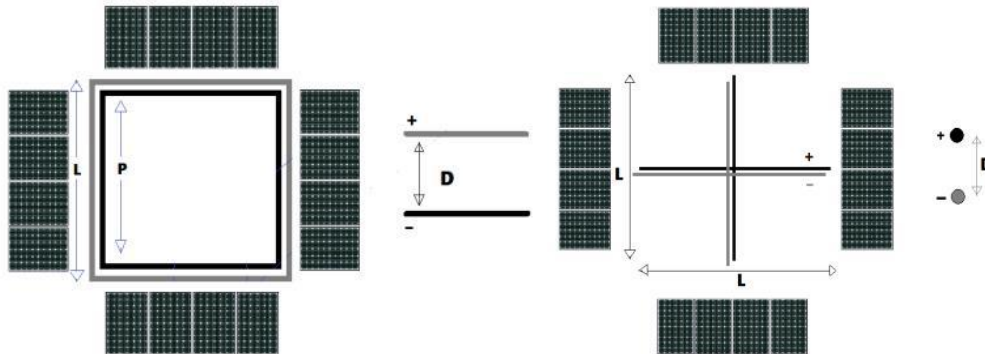


Figure 2: Solar array and bus arrangement
(a) square-ring (b) mid-point

Authors have considered two simple bus structures; square-ring and mid-point to detect the model with the lowest active power loss. Buses are installed in the square-ring along the perimeter of the inward square build by the solar panels in its four sides (Fig. 2(a)). On the other hand, the mid-point bus arrangement is built by connecting midpoints of the opposite solar arrays by a single pair of the bus. The bus of the opposite side pair intersects with each in the midpoint of the square (Fig. 2(b)). For the analysis of power loss, square configurations are considered as reference polygon as each of the sides and angles are equal. Finally, the resistance of the mid-point bus arrangement is comparatively less than the square-ring bus (Equation 1, 2) (Karamanakos 2013:337-46).

A significant power loss along the length of the conductor results in voltage drop towards the end of load power distribution enhancing the power and voltage instability in bus networks and can be overcome partially by reducing its resistive voltage drop.

Implementation of cable length reducing technique in both bus systems proves to be an effective way of diagnosing the loss (Starke 2008:1-7).

$$R_{Squarering} = 4r(L + P) \quad (1)$$

$$R_{Midpoint} = 4rL \quad (2)$$

4 Power Inversion and RL Bridge Circuits

Paper proposed an inverter circuit to invert DC voltage by switching it periodically using a highly efficient auto-transformer. Power semiconductor switches such as SCR, power IGBT and MOSFET, and thyristor are responsible to shape a sinusoidal wave. An accurate adjustment of the capacitance across the secondary winding improves the voltage profile of the circuit (Fig. 3(a)). The autotransformer consists of two windings of the inductance of 1mH and 8mH and resistance 1Ω and 5Ω respectively. Switching frequency is standardized at 50kHz for resonating the inductive and capacitive reactance (Forouzesh 2017:9143-78).

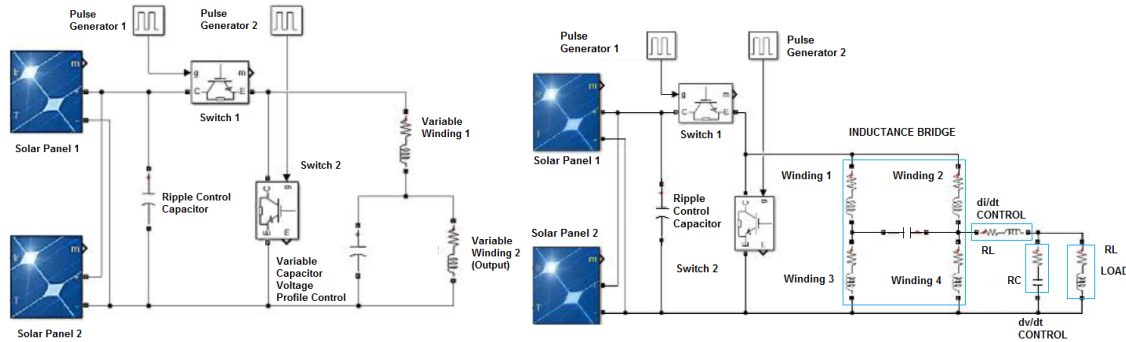


Figure 3: Power modulation circuits
(a) inverter (b) RL bridge circuit

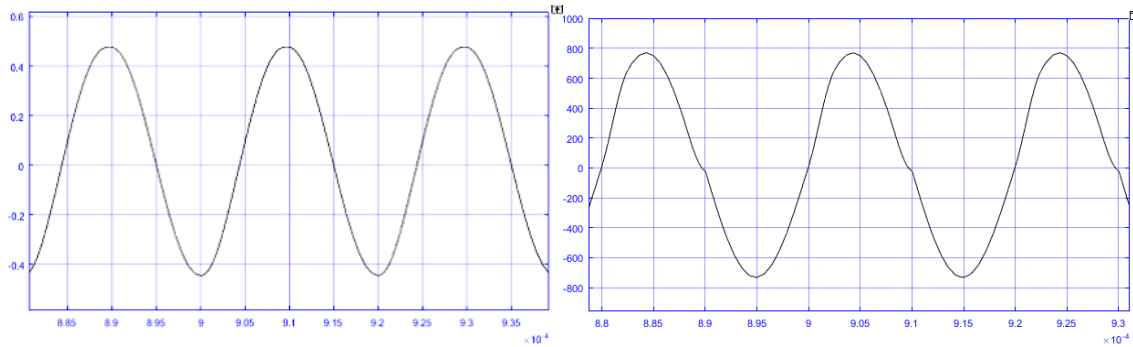


Figure 4: Characteristics curves of inverter circuit
(a) output current (b) output voltage

A fully controlled RL bridge is designed to control the degree of distortion and harmonics in the output voltage. The bridge circuit is capable of buck-boost the voltage, resembling as two auto-transformers connected by a polarised capacitor in the tapping nodes (Fig. 3(b)). Transformer ratio is either greater or less than one for an autotransformer that steps up or down the voltage respectively. The total amount of reactive power remains almost constant in the two windings of an autotransformer. Hence, considered to be more economical and requires less conductor material in comparison to two-winding transformers (Lu 2003:767-76).

Electrical conductor design of the system is calculated to ensure a negligible loss. Power is supplied to the loads in estimation that the cable loss is very low. An important

challenge is to design a conduction grid that overcomes the conduction material loss that is released as heat energy and decreases the temperature of live conductors. Therefore, power transmission is being drastically degraded in systems for long-range conduction and essential to design a custom power transport path holding three to four households in rural or semi-urban areas.

5 Result and Discussions

Paper summarized the observations separately for the two circuits in two sections as follows:

Power Inverter Circuit

- Circuit operates in transferring the power from primary to secondary winding.
- DC voltage is periodically switched to produce an output AC voltage and current of $\pm 50V$ and $\pm 0.45A$ (Fig. 4).
- Frequency and time delay of these circuits are 50kHz and 10 μs .
- Pulse width of the switches is 50% of the duty cycle and is responsible to switch the input DC voltage to a partially sinusoidal voltage.

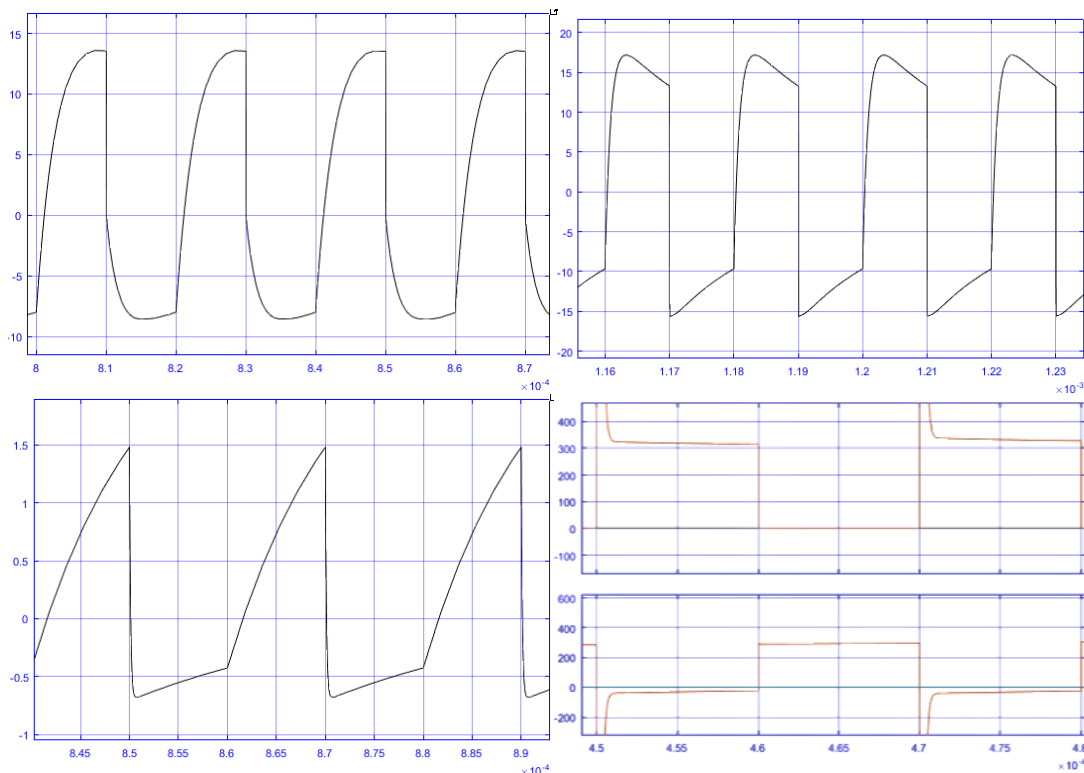


Figure 5: Characteristics curve of power bridge (a) output AC voltage (b) control negative steep voltage (c) control triangular voltage (d) switching curve

Power Bridge Circuit

- Snubber RC circuits are connected in parallel and RL circuits in series to protect from dv/dt and di/dt conditions respectively (Fig. 3(b)).
- An increase in capacitance between the two parallel arms of the bridge increases the pulse width of output voltage from discrete to continuous (Fig. 5(a),(b)).

- Sinusoidal output voltage fluctuates, can be controlled to triangulate, time-shift, change in degree of shape and size and regulation of positive and negative steepness (Fig. 5(a), 5(c)).

6 Conclusion

Solar based power converters would modify the power quality. Specifically, the solar inverter produces a power with minimum ripple and switching of these semiconductor switches have little effect in the inverter output. Solar inverter resembles a part of the solar bridge circuit that has a wide voltage variety as the magnitude of connected passive elements vary. A change in inductance and capacitance impacts the current or flux linkage and voltage build in two nodes of the circuit. Such a large bridge with different nodal control signifies a tremendous variety of power from a universal solar bridge. This fabrication of circuit in bus power electronic system brings versatile parametric manual control.

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CREATING A SELF-HELP PARAMETRIC DIGITAL-WORKBENCH PROTOTYPE FOR ASSAM VILLAGE DEVELOPMENT

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Abstract: *The context for this paper is the rural sector in the State of Assam, North-west India and the opportunities for villagers to plan their villages with greater sophistication than has been previously possible. We report on our investigations using emerging digital technologies to prototype a 'digital workbench' to help villagers explore for themselves viable social and geospatial organisation for new settlements, as well as the modification and densification of existing villages. The proposed digital workbench takes into account a broad set of competing parameters that require significant trade-offs against each other including local economic metrics, environmental impact, resource availability, and cultural drivers. The digital workbench offers villagers the opportunity to test 'what if...?' scenarios of their own devising through which viable solutions informed by local data would be suggested and tested for appropriateness and fit.*

The research method we used was to build a prototype digital workbench, and test it with a range of hypothetical scenarios, selected results of which are reported on here. The prototype is shown to be both robust and scalable. Our next steps would be to assemble data for real communities working directly with them to calibrate and fine-tune the digital workbench for practical purposes, which is beyond the scope of this paper.

Keywords: *Mass Customisation, Self-help Community Village Planning, Self-help Housing, Sustainable Rural Development, Energy Efficiency.*

1 Towards Assam Villagers' Greater Self-determination in How to Create, Expand, and Develop Their Villages

Like all communities with a greater proportion of rural citizens – in the case of the State of Assam, 86% of the population (Government of Assam 2017) – new approaches are required to afford householders and village elders greater potential to make the best possible decisions on how to create, expand, and develop their villages such that the entire community can benefit.

Although the economic outlook for Assam overall has improved in recent years, great disparity still exists between rural and urban citizens (Government of Assam 2018). That the rural population is disadvantaged is well-recognised by the Government of Assam which in 2016 endorsed the policy framework *Assam 2030: Our Dream, Our Commitment* (Government of Assam 2016). This framework adopts, and repurposes for the local context, the *United Nations Development Programme's Sustainable Development Goals* (SDG) to reduce the rural-urban divide and improve the living standards of rural Assamese (United Nations Development Programme 2015).

'Critical challenges' identified within *Assam 2030* point to the need for greater self-determination of rural dwellers in the development of their villages (Government of Assam 2016), and emphasise:

- A. Positioning communication as integral to promoting harmonious development that includes stakeholder from all sections of society;
- B. Promoting sub-state level governance that devolves decision making and engagement to promote bottom-up engagement;
- C. Recognising it is essential to identify all stakeholders, understand their motivation, and support building of their capacity;
- D. Compensating for a 'dearth of credible and adequate data, and weak internal monitoring & evaluation systems'.

A self-help 'digital workbench' that encapsulates village development through an interactive, accessible, and intuitive parametric model can address these challenges through engagement of, and communication with, stakeholders at the village level to produce actionable insight.

Such a bottom-up approach to participative planning and ideation has successful precedent. Notably, the *PedCatch.com* online software tool for inclusive pedestrian accessibility modelling using animated service area simulation has been effectively used at the community level to communicate local street network design scenarios, develop consensus, and engage stakeholder feedback (White et al. 2018).

Further, Burry et al. proposed and tested a framework for community engagement in 'design-as-wicked-problem' scenarios through which satisficing of real-world complex adaptive systems might be attempted (Burry et al. 2018). The framework incorporates a reactive scripting approach (Boussinot and Hazard 1996) to insert human input into an otherwise self-referential digital model and thus enable bottom-up community input to inform evolution of that digital model.

The approach of Burry et al. was successfully tested at a workshop held during October 2016 in Puerto Baquerizo Moreno, Island of San Cristobal, Galápagos Islands. In this participative workshop, academics, designers, and local residents were able to, through use of the framework, explicate, visualise, and begin to resolve the potentially-rivalrous

relationships between economic, ecological, and experiential (liveability) metrics, arbitrarily chosen as three indicative parameter sets, across local issues including tourism, built environments, economic incentives, and agriculture. This approach to inserting human agency into an iterative parametric digital model for design was shown to facilitate consensus and a better understanding by participants of what issues are important and what connections and trade-offs may exist between them.

This paper details a prototype for further iteration and field testing that encapsulates a process of bottom-up, participative community engagement within a parametric village development digital model.

2 Prototype Digital Workbench Implementation

For the purposes of developing a proof of concept, we have considered the following variables as key factors affecting village development:

- Access to water and local food production;
- Access to the wider world;
- Local topography
- Communication between adjacent houses;
- Sites of significant community ritual;
- Proneness to natural disasters (flooding);
- Prospect and aspect;
- Access to sunlight;
- Access to sanitation services;
- Access to community facilities.

This computational participatory tool encapsulates and expounds the relationships and conditions affecting the design and use of the physical environments of village life for the study site on the island of Majuli, Assam, India, and other locations of rural development. The computational model uses a generative approach to present an interactive experience of community spaces. Its generative methodology is both iterative and additive: it begins with the simplest scenario of a village - road, basic amenities, and fully detached houses on a flat, featureless expanse - and adds layers to and evolves this elementary model to add complexity thereby illustrating the decision-making contexts of the villages involved.

The project is intended to uncover and communicate decision-making criteria and evaluation objectives, and elicit villagers' predilections and show them the resulting ideal model of communal living and land use, one that may serve as a bottom up process. Moreover, the project seeks to demonstrate competing factors that may confound villagers' intentions; these factors are those values or objectives of which the improvement of or satisficing might have a deleterious or inhibitory effect on one or more other intrinsic values or objectives. Other than highlighting these complexities, the Village Schemer 'digital workbench' does not seek to be prescriptive in its outcomes nor didactic in its function, but instead offers a 'play space' of relationships that aids discussion and participation of all householders implicated in a proposed development. It does not provide a prescribed moral lesson in its denouement that would belie its bottom-up intentions.

The tool was developed in the Grasshopper™ visual scripting environment in the Rhinoceros 3D™ modelling application which was chosen for its ubiquity, suitability for rapid prototyping of tools, and support for graphical display of data.

A participatory model can only truly work if its very mode of presentation is not itself a barrier to participation. To counter this we designed our model to incorporate a system of interactive spatio-temporal overlays that support both selection of a level of detail suitable for a given participation scenario, and a narrative of gradual and accessible introduction to this type of participatory consultation and deliberation, especially suitable for people with backgrounds that have not provided them with a high level of digital literacy.



Figure 1: A) left, base layer with simple road network and representative community facilities, B) right, adding houses as an initial, unordered scattering

As a consequence, the first and base overlay in our model must have several features: it must provide a village recognisable as such by a typical participant regardless of the extent of development (the increase in numbers of houses); that the transient village should embody as few assumptions as possible, or at least not impose assumptions through an automatic prominence of any given feature; and it should form an extensible base with sufficient attributes upon which to integrate additional overlays. To satisfy this, the first layer provides basic human interventions on an otherwise featureless landscape: a simple road network made of straight-line segments between selected points; and placement of representative community facilities comprising a shrine, community centre or leaders house, and a water well (Figure 1A). The placement of these framework elements can be selected by participants.

Next, the model can be evolved by the participants inserting a small number of houses around the existing road and amenity features (Figure 1B). To the participants, this initial scattering of houses appears unordered. This seeming randomness of placement is intentional and is imposed to avoid introducing morphological assumptions and to allow structure to be formed only by the participants themselves in the next step. However, an underlying order is captured within the algorithm used to generate placement of houses, whether to show no given order or to act in response to participant feedback. The algorithm uses a two-step generative-discriminative heuristical approach.

The first, generative step determines from the model site conditions for a large number of discrete house sites - these sites are selected for potential only, and without regard for desirability nor self-referential physical limitations such as overlap with other potential sites. The second, discriminative step enumerates and ranks these potential sites by characteristics considered desirable by the participant(s), and the best are selected until either the desired number of houses is reached or the overall quality of a site falls below a given threshold. This prioritisation is useful for community participation as it allows rapid and direct visual feedback over multiple and potentially competing criteria.

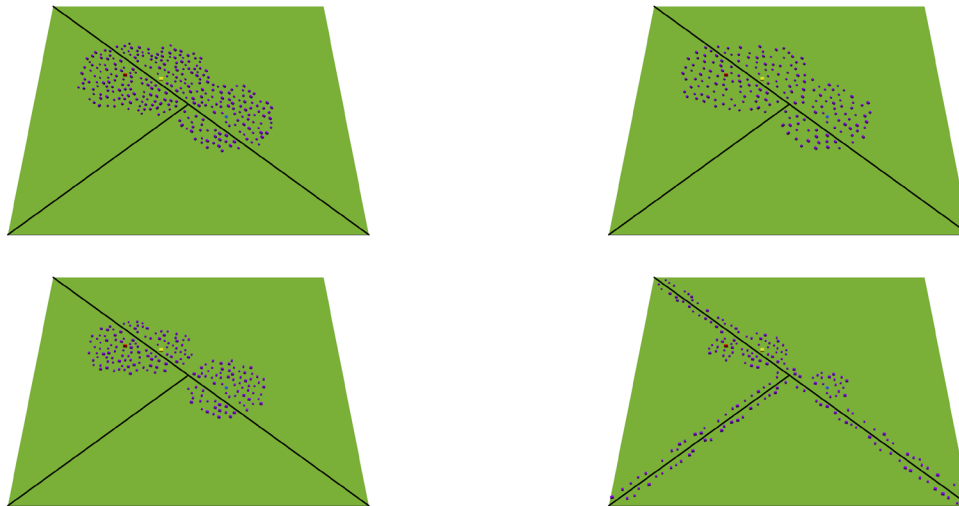


Figure 2: A) top left, setting number of houses, B) top right, adjusting neighbour distance preferences C) bottom left, altering desire for amenity proximity D) bottom right, changing value of road proximity

This selection of potential locations, and subsequent ordering and filtering on the basis of participants' preferences, allows the method to be flexibly used across four participatory overlays of house placement.

1. The number of houses can be dictated and is used as a simple proxy for village population or for showing changes in demographics and migration over time (Figure 2A).
2. Preference for neighbour distance can be adjusted for buffer space required by different 'home compound' uses and social mores, or for infill densification or population depletion over time (Figure 2B).
3. The desire for proximity to different amenities can be set. As well as allowing participants to explicate these preferences, inspection of the resulting layout of houses can indicate need for additional amenities (Figure 2C).
4. The desire for proximity to a road can be set, thus adjusting the value of land by its distance to a road. This relationship need not be linear; for example, land directly on a road and land far back may both be undesirable whereas land in the interstitial 'Goldilocks zone' might be highly valued (Figure 2D).

Given the generative-discriminative approach used, an adjustment to any of these criteria - either to increase or decrease its magnitude or desirability - is seamlessly integrated with or reconciled with each and every of the other adjustments. This provides the participant with an experience of contiguous and continuous response allowing nuance of feedback.



Figure 3: A) left, adjusting building typologies with callout of a single building, B) right, altering solar orientation with callout of a single building

An additional overlay that may be applied to the 'placed' houses - one that less dramatically influences their placement - is adjusting their envelopes for visualisation of representative building typologies (Figure 3A). Adjustment is allowed for building plot ratio (expressed as length divided by width), building plot area, and building height. The first two are linked so that adjustment of either affects the mutual result, and all three may also be offered in the model as predefined sets of combinations giving typological libraries of interest in a given scenario. While the approach to typologies in this prototype is basic, it is effective for simply showing new modes of housing provision across a village, or for showing different kinds of traditional housing forms. This current implementation is limited, but it is easily extensible to more complex and detailed display of housing typologies.

Solar orientation of houses is also included so that design for solar efficiency and amenity on individual-house scale and whole-village scale may be modelled and discussed (Figure 3B). The orientation can combine different factors, such as prioritising facing a road if that road is close versus more freely orienting to the best solar presentation when further way from a road or on a larger plot.



Figure 4: A) left, introducing land uses, B) right, adding topography with roads adjusting to satisfy user preferences of distance and gradient

With houses placed, given typologies, and oriented, land use is added to the participatory modelling mix. In the prototype, two land use types are provided for consideration: forested areas representing revegetation targets, firewood sources and timber stores, and remanent forest; and cultivated areas representing village agriculture (Figure 4A). Areas of influence of these land uses are sketched out through boundaries within the model space, allowing participants to emphasise the value of certain areas over others in accordance with local knowledge and culture. Within these areas, and for each land use type, a hierarchy of priorities can be defined; participants can state, for example, that forest gives way to cultivation, however, in turn cultivation gives way to road. Again, the flexibility of the generative-discriminative house placement algorithm is of great use, as house placement can automatically make way for the newly introduced land uses as those uses are prioritised and added to the algorithm's inputs. The overall result is a flexible framework for participants to explore and capture their preferred land use schemes.

Until this stage the overlays have operated on a flat base plane, however they can also interact with varying topography, and with each other in the context of that topography. A topography overlay is added in this prototype by the simple mechanism of a bitmap height field and a scale factor. As topography variability is introduced, the roads which had initially been straight lines between points begin to curve and realign to meet changing demands of distance and slope (Figure 4B); an algorithm for satisfying multiple subjective criteria balances the participants through a weighting of these factors. This approach allows participants to define what is their 'happy medium' between the two extremes of a shortest path and a path, potentially much longer, that nevertheless

minimises gradient. It is extensible to a range of community consultations and with a potential for real-time analysis of situations relating to built environments and other fields. Such an approach suits cases where subjective or experiential factors mean no optimal solution will result, and instead a 'good-enough' result must be found.



Figure 5: A) left, increasing flood levels with house siting reallocated, B) right, flooding at maximum with roads remapping to preserve accessibility

Assam is regularly afflicted by monsoon flooding, the results of which can also be shown in an overlay too, with flood levels adjustable relative to the topography. As waters rise, housing placement can be optionally remapped to keep houses dry (Figure 5A). With some AI running in the background, the flooding overlay can be used to gauge participants' response to mitigation of flood risks, such as showing how alternative village layouts might keep houses above a 1 in 10 year flood, for example, or how a certain proportion of infrastructure might be kept above a 1 in 100 year flood. Furthermore, as flood levels rise, the computational model can automatically remap road positioning to attempt to keep them, insofar as possible, above flood waterlines, while still trying to satisfy participants feedback regarding slope and distance preferences; in this way, roads can be designed that are still traversable in a given flood scenario and that are acceptable to participants for normal use (Figure 5B).

3 Concluding Comments

The research reported on here is a proof of concept: to what extent can pareto optimisation of the many competing factors influencing ideal village layouts and developments be scaled to the level of an app which household collectives (such as villages in the State of Assam, India) might take control of their needs. Rather than a plan that is imposed upon the community, or worse, one that evolves willy nilly and adapts to adverse circumstances only after the event, the digital workbench proposed allied with an intelligent inclusion of appropriate machine learning (AI) can be used by the villagers to anticipate their needs and offer suggested solutions optimised to their individual and diverse circumstances.

Our ongoing research will firstly build a prototype minimal viable product app for field testing. Our focus will be on user experience and an informed social science perspective on how best to mould this approach to a community completely unused to both the technology, and having a say in how their community might expand and develop with collective prosperity more assured than has typically been the case.

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EMPLOYEE ENGAGEMENT AS: A TOOL OF BUSINESS EXCELLENT

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Abstract: Modern age economy is taking unexpected turns to cope with technological, political, and social factors that are getting uncertain day by day. Making people ready for the sustainable growth of business and economy at a large is the need of the hour for HR-managers. Employee engagement, in fact, can make or break the business bottom line (Lockwood, 2006). Employee engagement is argued to be associated with a sustainable workload and control over business outcomes like profit and sustainability (Sake, 2006). Hence, the maximum level of employee engagement needs to be achieved. The purpose of this paper is to study the relationship between employee engagement and business sustainability in rural area through a sample empirical analysis from rural retail banking sector. The methodology, and model remaining same it can be applied to other industries also. The paper is highly relevant from productivity, sustainability, business growth and profitability point of view. Many research organizations as if Gallup (2004) has found that organizations can only reach their full potential by emotionally engaging employees and customers leading to long-term sustainability. The Gallup organization cites the countless examples in its literatures that increased corporate profitability is due to increased employee engagement while conducting a study on the fortune 500 companies investing in retail sector across the US. In general, the various outcomes of strategic employee engagement initiatives discussed in this paper have made it even more relevant and interesting one.

Keywords: Employee Engagement, Sustainability, Employee Involvement, Profitability

Introduction

Ever since HRM has taken a paradigm shift from mere supporting function to a strategic function, the business leaders have taken keen interest in finding finer aspects of HR to support the cause. The people side of the strategy for business excellence was to be supported by some working tools other than the traditional HR jargons like motivation, job satisfaction, retention management. Of course a lot of scholarly work was done to nurture and acquire talent in late 90s. But the Indian economy was very responsive to rapid changes in the post liberalization era and rural business segment is no exception. Indian economy faced a change in the way business is done in never before manner due to increased competition from global giants in almost every sector. A stronger yet active media creating storm in minds of consumers and new areas like insurance, and banking were privatized aggressively. The increasingly global nature of competition requires companies to utilize all of their available resources in order to sustain and succeed. Higher involvement of human resources in organizational strategy is strongly related to perceptions of human resource effectiveness, and its participation in economic and business decision making. The strategic inputs which were thought up by HR professionals included strategic workforce planning, employee engagement, strategic compensation and benefit planning, retention strategies and succession planning. (Sekhri, 2010). All the terms mentioned earlier except Employee Engagement have been practised for long. Hence it should be observed that Employee Engagement is a concept got more emphasis in late 1990s and considered to be a very strong tool for business sustainability in rural area. This paper is an attempt to study empirically the impact of employee engagement on profitability leading to sustainability of business.

Literature review

Working together with a clear sense of purpose creates a high productive workforce, reinforcing the idea that employees who feel engaged and heard are more likely to go the extra mile. The companies having low overall engagement experienced a decline in their net profit margins, whereas companies having high engagement experienced approximate a 2% increase in their net profit margin. Engaged employees have a sense of energetic and effective connection with their work activities.

Those improved loads of commitment and productivity function to increase the value projection of a firm's service or products to customers, which itself creates customer satisfaction. Satisfied customer become loyal to the firm and, finally, the repeat business generated by those customer drive overall profitability and growth further empower the process by which employees create value. Employees are seen to drive customer satisfaction by achieving operational excellence with regard to everyday losses and inviting to capitalize on business opportunities. It has been also recognized that additional factors of employee characteristics, core capitalization, valued customer act and revenues and costs as interest with the inputs along what they refer to as the value-profit chain. Building profit through people meaning your work force the strongest link in the value - profit chain. Employee engagement is the undeniable document source of competitive advantage at all levels (Schwartz, 2011).

Research suggests that employees are fairly constant in how involved they are in their jobs and organisations, or how alienated they have become. However, it is more realistic to assume that reactions to work fluctuate over a period of time. The link between employee engagement and work performance is explored and profitability and productivity is enhanced (Evans & David, 2010).

Special focus and effort is required specifically on the factors working environment and team and co-worker relationship as they have shown significantly higher impact on employee engagement which lead towards better financial performance. To increase profitability and productivity organisations shall focus on presenting a great environment for employees to work and promote programs that would enhance peer relationships and work as a team (Anitha, 2014).

An auto ethnographic approach provides both emic (insider) and etic (outsider) perspectives on the phenomenon, thus harnessing both the experiences of those involved in employee engagement initiatives (e.g. HR practitioners managing employee engagement and employees being engaged). Such an understanding can help and facilitate more appropriate, authentic and realistic interventions to harness employees' whole self and engagement. (Sambrook et al., 2014). The fit of the proposed measurement and structural models met criterion levels and the structural model accounted for sizable proportions of the variance in engagement/wellbeing (66 per cent), extra-role-behaviour (52 per cent) and commitment (69 per cent) (Albrecht, 2012).

Employee trust in management is an important determinant of their willingness to participate in decision making. Insufficient employee participation in decision making in turn leads to low level of employee job satisfaction and employee commitment. Lack of employee commitment and engagement affects the employee's intention to quit. Results indicate that formal, structured goal setting processes lead to higher levels of employee engagement that higher levels of engagement lead to improved workplace optimism and that improved optimism in turn leads to higher levels of individual performance and reduction in cost (Medlin et. al., 2009). Three themes, those understood to be significant for productivity and profitability, are relationship development and attachment to co-workers, workplace climate and opportunities for learning. Findings highlighted the development of relationships in the workplace, the importance of an employee's direct manager and their role in shaping organisational culture and the critical role of learning are an engaged employee's interpretations of their work. When looking at the relationship between employee satisfaction and store profitability, the correlation is found to be effectively zero. When controlling for the size of store, however, the relationship is found to be positive. (Timothy et. al., 2006).

Employee engagement has other organisational benefits as well. A three-year study conducted by International Survey Resource (ISR) depicted that companies having low overall engagement experienced a decline in their net profit margins whereas companies having right engagement experienced approximately a two percent increase in their net profit margins. (ISR, Engagement Employee Drive the Bottom Line, Research Summary, 2003). More recently employee engagement has been related to gaining firm's competitive advantage. Employee engagement, in fact, can make or break

the business bottom line (Lockwood, 2006). Employee engagement is argued to be associated with a sustainable workload and control over business outcomes like profit and productivity (Sake, 2006). Organisation must ensure that they create and promote an inclusive and open workplace environment. Again perceived support is essential to be and is critical in diverse environments. Minority group after reporting lower levels of perceived support in the workplace and therefore are more sociable to lower levels of employee engagement. This can affect both individual and organisational outcomes: the less engaged employees may find it difficult to achieve organisational and personal success. Jones & Harter (2005) found that, at low levels of engagement, members of different sale days report a lower tendency to remain with their organisation for at least one year than members of same sale days.

Employee engagement leads to high levels of two dimensions of performance: in role and extra role. Perhaps the most widely discussed dimension of an employee engagement is performance. While there are many dimensions to performance, it most commonly refers to the accomplishment of assigned tasks in accordance with the organisations expectation. In role performance, the achievement of these tasks explicitly identified in position descriptions and vaulted in the performance appraisal process. As such assessment of performance includes both qualitative and quantitative dimensions. This engaged employees are high performers. Engaged employees go beyond the minimum requirements specified in job description and performance evaluation and they are outstanding organisational citizens who engage in a wide variety of extra-role performance behaviours (Whittlings 2010). Mortal (2003) is of the opinion that, in order to obtain high performance in post-industrial, intangible work that demand innovation, flexibility, and speed, employers need to engage their employees.

Harter et. al., (2002) meta-analysis of 47,939 business units in 36 countries identified significant relationship between employee engagement and improvements in customer satisfaction productivity profits, turnover and safety records.

Increasingly, studies reveal that organisations with high levels of engagement out perform their competitors. Following a three-year longitudinal study, evidence showed that engaging leadership does, in fact, predict productivity. (Alimo-Metcalfe & Bradley, 2008).

It has been argued by the CIPD (2009) that employers want engaged employees because they deliver improved business performance.

Employee engagement is an undeniable dominant source of competitive advantage at all levels (Schwartz, 2011). Employee engagement functions as a behavioural pathway by which employee's motivational processes contribute to their subsequent workplace performance and productivity (Well born, 1991). Engagements, like commitment, have an affective component encompassing people's emotional reaction to conscious and unconscious phenomena, but it is also aligned in the objective properties of jobs, roles and work context all with the same moments of task performance (Kahn, 1990).

The integration of employee engagement and psychological well-being into the construct of full engagement may provide a practically useful approach to improve organisational effectiveness. Both factors are linked to it is theoretically quite feasible that the combined effect of both factors is greater than each one alone. Inclusion of psychological wellbeing enhances the relationship between engagement and beneficial outcomes. Individuals with higher levels of psychological wellbeing behave differently in ways that would be expected to lead to higher levels of engagement (Robertson & Cooper 2010).

Employee engagement is a key to human capital management because it focuses managing employees to produce for the organisation rather than focusing on what the organisation does to employees. Employee engagement is different from employee satisfaction with the latter, connoting satisfaction and the former connoting energy (Machy & Schinder, 2008). Whilst the specific definition of productivity will have certain sector specific attributes depending on job role, from the perspective of engagement certain features emerge as core. Review of related research combined with practical observation and experience of management suggest that engaged employees are: more likely to give discretionary effort above contractual obligation (i.e. work additional time, 'go the extra mile' in terms of delivery or customer service), more likely to achieve goals set. Engaged employees have fierce ownership feelings leading to motivation for generating profit for the organisation.

If employees get more engaged, they build emotional ties and make obvious sacrifices as they gain sufficient experience (Kaliannan & Adjovu, 2014). Employee engagement results in decline in employees' turnover intentions and increase in innovative work related behaviour and importance should be should be given to employee opinions, opportunities should be provided to them to be heard (Chandani et. al., 2016). Improving employee engagement strategies is essential to an organization's profitability. Banks employees prefer jobs that match their preferences, and they will be motivated to be more engaged by the opportunities that a job provides them opportunities to use their competencies and skills (Shehri, 2016).

Employee commitment towards the organization and image of the company, provision of fair rewards for work, job satisfaction and availability of tools and resources in the organizations have strong and significant positive relationship,(Kazimoto,2016). Disengaged employees will result in reduced workplace productivity and decreased customer service skills (Osborne & Hammoud, 2017).

Methodology

The study applied descriptive and correlational research design. According to Cooper& Schneider,2--- "Research design expresses both the structure of the research problem, the frame work, organization or configuration of the relationships among variables of a study and the plan of investigation used to obtain

empirical evidence on those relationships” This study focused on the employees in the 20 banking organizations representing different cities in Odisha State of India.

In this study convenience sampling method was adopted and structured questionnaires were distributed to 393 employees but finally 240 participants were selected for the study and 12 participants from 20 banking organizations were selected.

To ensure adequate representation of data in this paper, both primary and secondary sources were taken into consideration. To validate and quantify the data collected, some multivariate techniques have been taken into consideration. The routing of the responses (opinions of respondents) was performed with the help of Likert’s five-point scale (strongly agree = 5, agree = 4, neither agree nor disagree = 3, disagree = 2, strongly disagree = 1). Subsequently the data have been piled up, it was treated and analysed through statistical package (SPSS) version 21 to set the cause and effect relationship in order to make the conclusion. Various statistical tools such as: descriptive statistics, correlation and regression analysis were used to analyse the data and for making the paper more realistic and easily understandable.

The formula taken (Charan and Biswas, 2013), for calculation of necessary sample size is: $N = (Z\text{-score})^2 \times \text{Std. Dev.}^2 / (\text{margin of error})^2$

In this study, 95 percent confidence level is taken for which the Z value is 1.96 according to the standard normal distribution table. We have assumed the standard deviation to be .5, and the margin of error of +/- 5%. In order to calculate N, we have assumed (Z-score = 1.96, Std. Dev = .5 and the margin of error = +/- .5. Therefore, $N = \{(1.96)^2 \times .5(.5)\} / (.05)^2 = (3.8416 \times .25) / .0025 = .9604 / .0025 = 384.16$.

Data analysis

The result shows that 60% (144) of the respondents were male and 40% (96) of them were female. Majority (74%) of respondents were aged between 25 - 29 years old, 6% were between 30 - 34 years old, 10% were between 41 – 45 years, 8% were between 35 - 40 years old and only 2% of respondents were above 40 years old.

Employee engagement largely influence cost reduction and profitability leading to sustainability. The descriptive statistics revealed in the Table-I showcases the means, standard deviations (SD) and Pearson correlation coefficient of the independent variables (constructs of employee engagement) and the dependent variable (CRP). The results of the calculated mean reflect the most contributing variable towards cost reduction and profitability (CRP) is “twenty-four hours' operation with a minimum increase in staff strength will rationalize cost.” (V3) as its value is 3.99 which is higher than other variables in the construct. All the respondents identified employee recognition and reward system as an important element of cost reduction and profitability as the mean scores of most of the items under this are above 3.0. The value of standard deviation is less than 1 in all the variables. The independent variables (V1 to V13) have better positive correlation with the dependent variable (CRP) at a significance of .01 levels.

The table gives the value of the coefficient of determination (R^2), which is the proportion of variance of the dependent variable (CRP), explained by the independent variables. In this construct (CRP), the value of R^2 is 0.804, which implies that 80% of the variance in the dependent variable is explained by the predictor variables. Adjusted R^2 is modified measure and it indicates the fitness of the model, its value should ideally be equal to or near the value of R^2 . In this model, the value of adjusted R^2 is 0.792, which is close to the value of R^2 (0.804), thus indicating the fitness of the model. A standard error of .544 is good enough to imply reliable prediction of the model. The value of F is 89.44 is significant ($p < 0.001$), which makes the model statistically significant. Table-II showcases the regression coefficient and a range of unstandardized and standardized beta coefficients. The standardized coefficients refer to how many standard deviations a dependent variable will change when the standard deviation increases for each independent variable, as all the independent variables have been standardized so that their variance are 1 (Hair et. al., 2010).

In the Table-II, the results depict that all the variables are significant at $p < .001$. The highest beta coefficient of the variable “managerial attention helps in avoiding wastage of productive time” (V10) is 0.912 with a significance of 0.000. The beta values of all the variables are positive which indicates that the direction of the influence for maximum predictors is positive. The t -statistics indicates a measure of the precision with which the regression coefficient is measured. The highest t -value in this table is for V10 followed by V4 & V7.

TABLE I

R	MN	SD	CRP	V1	V2	V3	V4	V5	V6	V7	V8	V9	V 130	V 131	V 132	V 133
CRP	3.62	0.88	1.00													
V1	3.11	0.67	0.45**	1.00												
V2	3.40	0.62	0.54**	0.27**	1.00											
V3	3.99	0.53	0.66**	0.17**	0.54**	1.00										
V4	3.79	0.41	0.64**	0.09	0.00	0.26**	1.00									
V 5	3.18	0.58	0.66**	0.01	0.04	0.10	0.62**	1.00								
V 6	3.69	0.49	0.44**	0.05	0.02	0.06	0.35**	0.41**	1.00							
V 7	3.43	0.69	0.55**	0.08	0.21**	0.03	0.23**	0.44**	0.71**	1.00						
V 8	3.66	0.45	0.40**	0.12*	0.25**	0.19**	0.21**	0.28**	0.60**	0.81**	1.00					
V 9	3.74	0.45	0.54**	0.21**	0.35**	0.33**	0.15*	0.15**	0.45**	0.47**	0.65**	1.00				
V 10	3.62	0.78	0.87**	0.05	0.06	0.02	0.02	0.01	0.10	0.26**	0.15**	0.01	1.00			

V 11	3.98	0.68	0.48**	0.06	0.00	0.00	0.14*	0.05	0.01	-0.07	-0.07	-0.05	-0.16**	1.00		
V 12	3.86	0.49	0.50**	0.02	0.16**	0.15*	0.22**	0.10	0.27**	0.06	0.08	0.19**	-0.02	0.07	1.00	
V 13	3.70	0.42	0.44**	0.21**	0.35**	0.33**	0.15*	0.15**	0.45**	0.47**	0.65**	1.00**	0.01	-0.05	0.20**	1.00

*Significance at .05 level, **Significance at .01 level, R=.896, R2=.804 , Adj. R2=.801, Std. Error=.544, F=89.44, Sig.=.000

TABLE II

Model -	Unstandardized Coefficients		Standardized Coefficients		Sig.
	B	Std. Error	Beta	t	
(Constant)	0.064	0.171		0.374	0.708
V 1	0.005	0.032	0.004	0.146	0.001
V 2	0.675	0.025	0.000	0.001	0.000
V 3	0.015	0.031	0.017	0.484	0.000
V 4	0.044	0.030	0.052	1.457	0.000
V 5	0.005	0.042	0.005	0.122	0.000
V 6	0.037	0.043	0.034	0.860	0.001
V 7	0.046	0.044	0.046	1.067	0.000
V8	0.026	0.050	0.031	0.512	0.000
V9	0.037	0.045	0.045	0.825	0.000
V10	0.912	0.039	0.899	2.312	0.000
V11	0.008	0.026	0.009	0.318	0.000
V12	0.004	0.011	0.011	0.395	0.001
V13	0.643	0.029	0.000	0.002	0.000
Dependent Variable DV (CRP)					

Regression model

$$\text{CRP} = 0.064 + 0.005(V1) + 0.067(V2) + 0.015(V3) + 0.044(V4) + 0.005(V5) + 0.037(V6) + 0.046(V7) + 0.026(V8) + 0.037(V9) + 0.912(V10) + 0.008(V11) + 0.004(V12) + 0.643(V13) + e.$$

Independent Variables (Employee Engagement Constructs) Influencing Dependent Variable (CRP)
Least damage by employee who are involved mentally with the organization (V1)
Multitasking approach reduces cost (V2)
Twenty-four-hour operation with a minimum increase in staff strength will rationalize costs(V3)
Number of supervisors can be reduced (V4)
Assignment of right task to the right person is an important aspect of cost reduction (V5)
Rationalization of jobs will enhance efficiency (V6)
Low employee turnover leads towards cost reduction (V7)
Job errors are avoided through training (V8)
Employees are encouraged to add value to the decision making process (V9)
Managerial attention helps in avoiding wastage of productive time (V10)
High level of employee performance, reduce costs & increase profitability (V11)
Ownership feelings lead to attachment with the job, hence higher profit through longer stay in the job (V12)
Revenue generation directly related to profitability, which is a consequence of more involvement (V13)

Discussion

Rural retail banking sector is facing a lot of challenges in retaining the talented workforce because it is expanding in an unprecedented speed. Keeping in view the big size of work force and low return on investment the rural retail banking sector is unable to design a satisfactory pay structure or lucrative career plans for employees affecting overall sustainability of the business and the sector at a large. Hence, HR was in search for a tool to create staying intentions and creating a sense of ownership feelings

among employees. Advent of a concept called employee engagement creates a great respite among managers. As retail banking sector is a manpower intensive business the employee engagement practices were thought to be very useful for this to give thrust to the organisational growth

Organizational profitability is very abstractly related to employee engagement. The engaged employee works with an ownership feelings and reduce the cost. As profit is a function of cost, employee engagement relates to it. The factors examined by this study are efficiency through training, participative management, cost reduction through involvement etc. Schwartz (2011) has told that employee engagement is an undeniable dominant source of competitive advantage at all levels. Well born (1991) has stressed on productivity. The other scholars we have followed are Kahn, (1990), Robertson and Cooper (2010). Testing results shows a very strong relationship between profitability and employee engagement, which acts as an intermediary for organizational stability.

Managerial implications

The study has shown an empirical view point on impact of employee engagement on organizational sustainability. The managers in practice should identify constructs of employee engagement and use them as a tool for enhancing profitability and a continuous practice of employee engagement initiatives can see a sustainable business growth and stability. It is also very important that the managers should properly identify the elements of employee engagement through extensive research which really affect the profitability of business.

Limitations

A limitation of the research design was a sample size of 393 respondents. The strength of the study lies in data triangulation, which was obtained through a mixed method approach, a survey and structured focus group interviews. There are theoretical implications for the construct of employee engagement. There seems to be a construct contamination from the fields of employee satisfaction, employee commitment and employee involvement, which is beyond the scope of this paper. Future studies in India may look into this area and construct an independent scale of employee engagement, focusing on the antecedent variables and testing them for theoretical underpinnings. Topic being comparatively new to the research world, dearth of quality literature was felt. Hence it was very difficult to find sufficient literature support. As banking industry is a customer centric business it was very difficult to find time to interact with the employees during business hours leading to late hour discussions after the office hours.

Conclusion

Sustainability of rural business has always been studied from the marketing and finance perspectives. The contribution of HR towards the growth and profitability of business has always been under emphasized. It has been felt of late by the business think tanks that sustainability and profitability cannot be a subject of study without considering the people side of the organization who all can make or break an institution by their insights. With this dimension in mind the strategists at the top of the hierarchy tried to explore the concepts which will be instrumental in shaping the insight of the people for sustainability of business. Employee Engagement is one of those concepts which has proved that it can lead to people mind set for longer sustainability. Empirical studies through this study has proved it right. Though the paper has studied rural banking sector in specific the methodology and the study process can be used in other sectors of rural area and facilitate the new strategies.

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Is JAM enough to ensure financial inclusion of the rural economy

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Abstract: India saw big gains in financial inclusion with the implementation of the Pradhan Mantri Jan Dhan Yojana. JAM (Jan Dhan-Aadhaar-Mobile) trinity, an initiative by Government of India to link Jan Dhan accounts, Mobile numbers and Aadhaar cards of Indians to directly transfer subsidies to beneficiaries and eliminate intermediaries and leakages, is nothing short of a social revolution. The schemes which have followed since then have not only aimed for financial inclusion but also to ensure inclusive growth. There is a strong correlation between financial exclusion and poverty and inequality. Till late 2013, according to Ministry of Finance, 45% of urban and 52% of rural households did not have bank accounts. However, financial inclusion is not just about opening of bank accounts but also access to credit from formal sources. In India with a large rural population, financial exclusion has both geographic and social dimension. Although financial inclusion initiatives started in 1955, gathering momentum with nationalization of private banks in 1969 and 1980, the objective of nationalization was limited to extending bank activities to the unbanked population. Many other factors such as poverty, low-income, distance from bank etc., restricted the rural and vulnerable sections including women from getting access to formal banking system. According to the Census 2011, nearly 73% of farm households did not have access to formal credit sources. However, some 300 million new bank accounts were opened under the Jan Dhan Yojana.

Keywords: *financial inclusion, Pradhan Mantri Jan Dhan Yojana, social revolution, rural economy.*

Introduction

Financial inclusion has been the central theme of India's development policy for years. The country's structure of financial system plays a vital role in smooth and efficient functioning of the economy. There have been constant efforts by the government along with the Reserve Bank of India (RBI) and National Bank for Agriculture and Rural Development (NABARD) to enhance financial inclusion in India – increasing the number of bank branches, expansion of formal financial services, increasing banking outlets, extension of ATM services, encouraging Micro Finance Institutions (MFIs), promoting SHGs – Bank linkage, use of Business Correspondents, easing of 'Know-your-customer' norms, use of mobile technology and emphasis on financial literacy. The objective of financial inclusion is to transform the lives of vulnerable people, mainly poor, by providing them access to banking finance and enabling them to generate stable income (Reddy, 2017). Financial inclusion promotes savings, particularly in rural areas and it brings vulnerable groups into the formal banking services.

In the previous decades, few initiatives were undertaken but the formal thrust came in 2008, after adoption of recommendations of the Report of the Committee on Financial Inclusion (C.Rangarajan, 2008). With the aim of making door step banking facilities available to the unbanked population RBI during 2010-2013, identified villages with a population of more than 2000 and allotted them to different banks for extending coverage through various modes of banking like branch banking, BC, ATMs, mobile vans etc.

Thus, to ensure smooth flow of the financial services in the rural areas and to improve investment climate in rural economy, the present government has taken new steps under its modified financial inclusion programme called the *Pradhan Mantri Jan Dhan Yojana* (PMJDY) with effects from August, 2014. The main features of PMJDY include Rs. 5000 overdraft facility for Aadhaar-linked accounts (which has been doubled to Rs. 10,000) and a RuPay debit card with inbuilt Rs. 1 lakh accident insurance cover (now raised upto Rs. 2 lakh)¹ and a life insurance cover of Rs. 30,000. With the JAM (Jan Dhan – Aadhaar - Mobile) trinity the government has pushed for a comprehensive financial inclusion plan to provide banking services to all households in the country with a strong focus on the use of technology (Department of Financial Services , 2018). Hence, with this

¹ Expanded accidental insurance cover for new RuPay card holders raised from Rs 1 lakh to Rs 2 lakh for new PMJDY accounts opened after 28.8.2018

mission, households will not only have bank accounts but also there will be direct transfer subsidies to beneficiaries and eliminate intermediaries and leakages. In recent years, after the launch of the JAM initiative, the reach of banking sector has been extended to 95 percent of households. As on June, 2016, 4,52,151 such villages have been provided banking services, with majority being covered through Bank Correspondents (Charan Singh, 2018).

This paper begins with an assessment of the JAM in terms of its impact on improving access to banking. The second section of the paper sheds light upon the need of financial inclusion in India. The third part of the paper discusses the impact of the JAM trinity and its benefits. And the fourth section of the paper discusses the way forward to achieve greater financial inclusion.

Need of Financial Inclusion for Rural India

The rural India has been financially excluded for many years despite every possible effort. Till late 2013, as per Ministry of Finance, 52 percent of the rural households did not have bank accounts. The dependence on unorganised form of credit also poses a big challenge to the financial efforts of the government, as a large section of the rural population still go for open unregulated channels of financing including money lenders and brokers at a higher rate of interest.

In a country like India, where nearly one-fourth of the population is illiterate and below the poverty-line, financial inclusion is a challenge. The financial inclusion becomes more relevant for the rural economy due to its population size, potential market and changing income levels and consumption patterns. So, there are many reasons why financial inclusion is necessary for the development of the rural economy of India.

First, a bank account implies access to formal credit i.e. availability of financial resources at reasonable rate of interest. People without bank accounts are often the most vulnerable and impoverished. Not having a bank account excludes them from simple credit facilities, compelling them to informal moneylenders leaving them in perpetual debt. The presence of banking services and facilities will also inculcate the habit of savings among the rural population. It is for this reason that the government has been making efforts

since the beginning of planning era to ensure that a large number of people are covered under various schemes of financial inclusion.

Second, accessing financial services can contribute towards improved and sustainable economic development of the country. It can be a critical step towards reducing both poverty and inequality. The objective of JAM is to ensure easy availability of financial services. Availability of adequate and transparent credit from formal banking channels shall allow the entrepreneurial spirit of the masses to increase outputs and prosperity in the rural areas. The access to financial services facilitate poor and low-income households to improve their productivity and create jobs, enlarge and diversify their business, and increase their incomes.

Finally, for a growing economy like India, to ensure that the growth process is equitable and sustainable, different sections of the society (especially the poor and marginalised section of society) must be to be included in the development process of the country. The financial inclusion can facilitate the government to provide financial services such as Direct Benefit transfer, insurance services, loans etc. directly to the needy by eliminating intermediaries. It can bring down the leakages and corruption. In the long run, it can reduce poverty and income inequality and add value to country's sustainable and inclusive growth. Thus a key component to promote balanced, inclusive and sustainable growth.

All these efforts require a more efficient banking system which can reach out to a larger population. Therefore, there must be a push towards a financial inclusion.

The JAM Initiative

JAM (Jan Dhan-Aadhaar-Mobile) trinity, an initiative by Government of India, is nothing short of a social revolution (The Business Standard , 2017). This is to link Jan Dhan bank accounts, Mobile numbers and Aadhaar cards to directly transfer subsidies and eliminate intermediaries and leakages. There has been constant effort to be as inclusive as possible to reach the remote areas of the country. The Jan Dhan – Aadhaar – Mobile (JAM) based DBT helps in two ways – firstly, to exclude ghost beneficiaries and secondly, to help transfer money into the targeted

individual's bank account directly. The major goal of the JAM initiative is (i) to progressively expand the coverage to those who have remained financially excluded (ii) encourage the use of Information Communication Technology (ICT) (iii) Linking the Microfinance to formal financial sector to bring broader participation of banks and expand the access of credit market.

Impact of the JAM on the financial inclusion in rural India

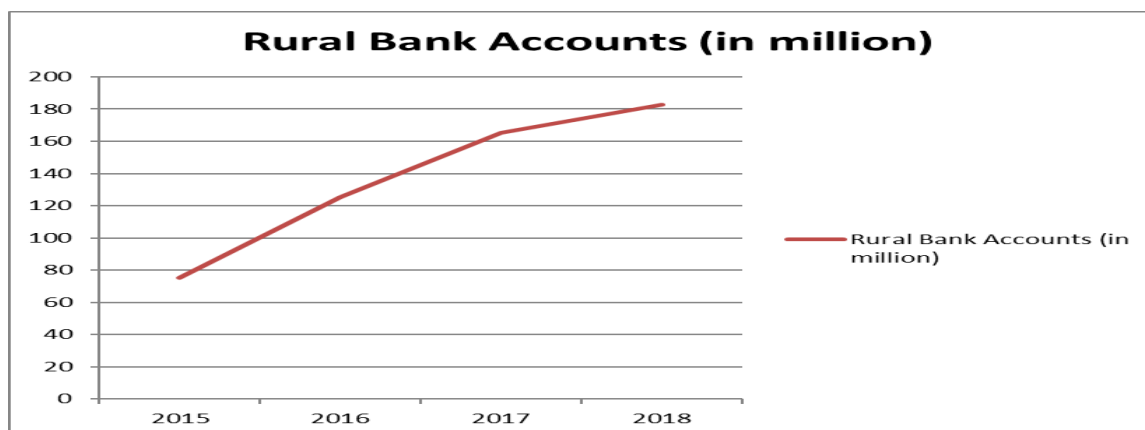
To understand whether the Jan Dhan Yojana, Aadhaar and Mobile Banking has been able to achieve financial inclusion in rural India, there is a need to understand the impact of each of the elements of the JAM trinity.

a) Pradhan Mantri Jan Dhan Yojana

With the Jan Dhan Yojana, the government has pushed for a comprehensive financial inclusion plan. It aimed at giving every household access to the banking facilities by offering them zero-balance accounts across all commercial banks. Apart from bringing them into the banking system, it has also pushed for improving the access to banking facilities such as ATM transactions, short term credit and insurance, overdraft facilities etc. However, to understand the impact of PMJDY, there is need to assess whether there has been any improvement in terms of financial benefits such as access to credit in the rural society with the inception of the PMJDY.

(i) Coverage

Figure 1: Trends in rural bank accounts



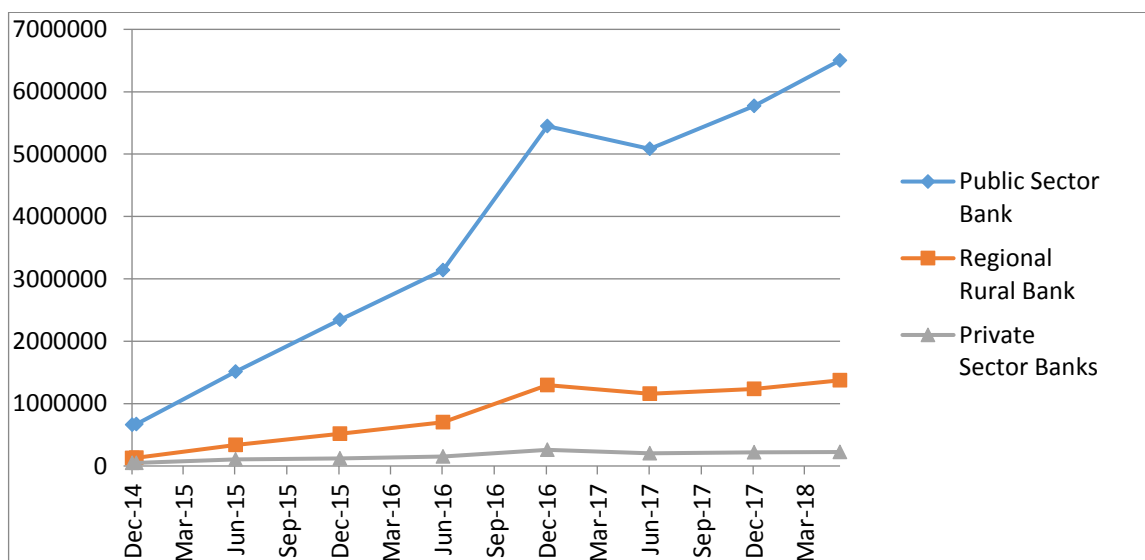
Source: RBI

There has been an upward trend in access to the rural bank accounts in India from 75 million in 2015 to 182 million in 2018 with the implementation of the PMJDY (fig. 1). The percentage of adults having bank accounts in India has increased from 53% in 2014 to 80% in 2017 (The World Bank, 2017). According to the Global Findex Report, this sharp rise in the bank account is attributed to the progress of the Jan Dhan Yojana. While there is definitely an increase in the number of bank accounts, however one cannot say how many accounts are unique and new accounts.

Along with the issue of double accounts, there is another issue of zero balance or dormant accounts. According to the Global Findex Report, around 38% of the bank accounts are still inactive or dormant accounts i.e. no deposits or withdrawals using these accounts. This suggests that many Indians are still not integrated into the formal banking system. Also, about 17% of the PMJDY accounts are still zero balance, which indicate a low usage of the accounts (Rohit Azad, Dipa Sinha, 2018). However, the recent data has shown that the 'zero balance' accounts have come down considerably from 75% in 2014 and 25% in 2016. This is definitely a positive indication towards financial inclusion.

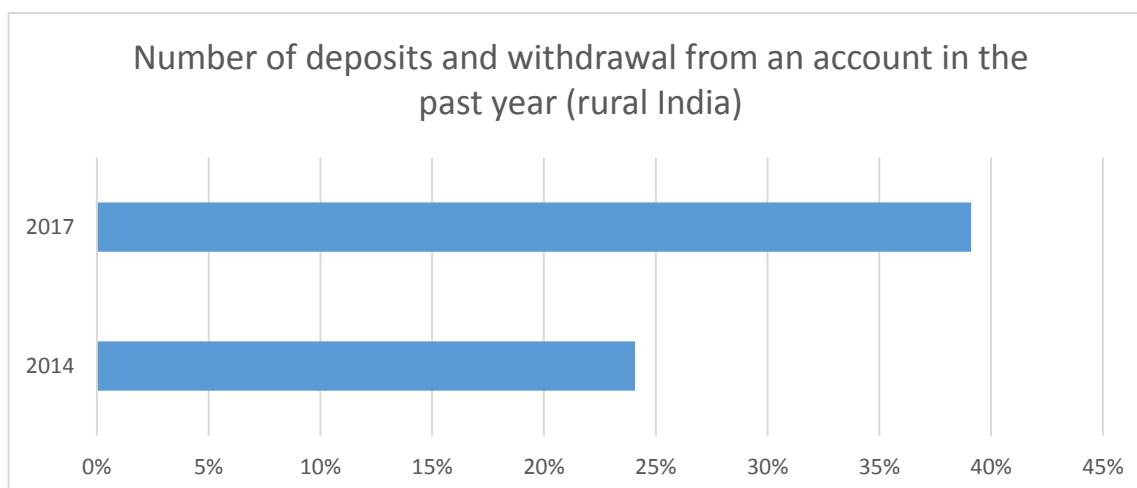
(ii) Deposits and withdrawals

Figure 2: (a) Average Deposits from various banks



Source: Data compiled from PMJDY website (pmjdy.gov.in)

Figure 2: (b) Number of withdrawal and deposits in rural India



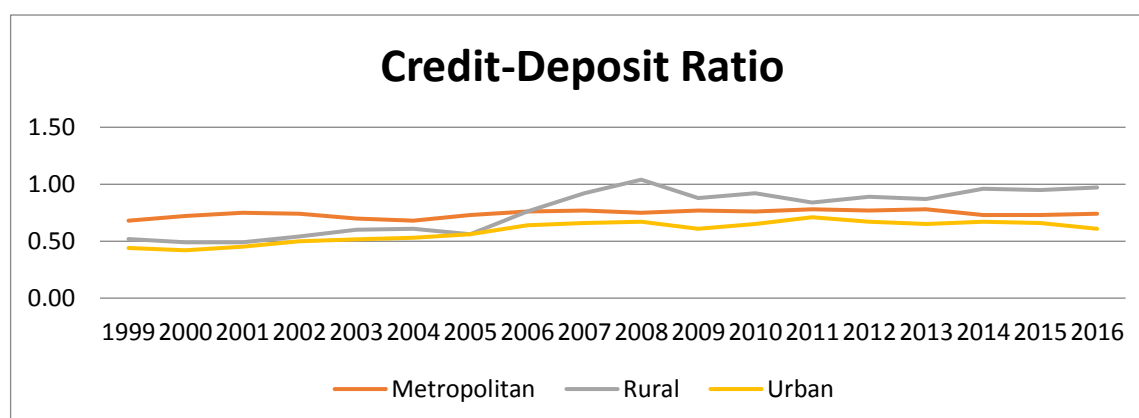
Source: Global Findex data, World Bank

On the whole, the government has done the herculean task of opening a large numbers of bank accounts. It is evident that there has been increase in the average deposit and withdrawal in the rural parts of the country (fig.2.b) There has been a rise in the rural banking in terms of both withdrawal and deposits from 24% in 2014 to 39% in 2017. Post demonetization public sector banks saw highest deposit along with regional rural banks and private sector banks (fig.2.a). As there has been rise in average account deposit over time this explains that there has been increase of trust among the population towards formal banking. The access to financial services will open the doors for families, allowing them to smooth out consumption and invest in their future through education and health. The formal banking can eventually eliminate the informal money lending which usually traps the vulnerable in poverty cycle.

(iii) Access to credit

The financial inclusion is not only limited to the opening bank accounts or deposits, but it is also important that poorer section have access to the formal credit. The formal credit is generally offered at a cheaper term as compared to informal credits. In light of this, one of the major questions is, whether the JAM initiative has changed the formal credit scenario for the poorer section of population. The category of rural and semi-urban population is an important criterion to understand the access to formal credit for the rural poor.

Figure 3: Credit-Deposit Ratio



Source: RBI Basic Statistical Returns of the SCBs

One of the ways to assess the access to formal credit for the rural population is by the credit-deposit ratio, which tells us how much credit can be availed per Rs. 100 of bank deposits by a particular group. The credit-deposit ratio for the rural population has increased from 41 in 1999 to 66.9 in 2016 (Rohit Azad, Dipa Sinha, 2018). Since 2014, it has been more or less stagnated in rural areas. The only category where there has been an improvement in access credit since the implementation of PMJDY is in the metropolitan centres of the country, suggesting that many rural Indians are still not integrated in the formal banking system. There is still a lower level of engagement with the formal banking sector beyond withdrawals and deposits. This suggests that universal account ownership does not ensure financial inclusion unless there is effective use of the banking services.

b) Aadhaar

Aadhaar is the world's largest publicly run digital identity database and it continues to grow (State of Aadhaar Report 2017-18). The use of Aadhaar is seen as a key reform by the government to improve the delivery of various social protection schemes. There are two ways by which the Aadhaar can act as a facilitator to increase the usage of bank accounts. First, it can help to increase the usage of microATMs through the Aadhaar Enabled Payment System (AEPS) and secondly, DBTs can be paid using the Aadhaar Payment Bridge System (APBS)²

² The role of the Aadhaar as a facilitator for financial inclusion (*State of Aadhaar Report 2017-18*)

While Aadhaar seeding and authentication for social protection programmes are rising, various reports emerged this year of these processes leading to denial of benefits to genuine beneficiaries, combined with other inconveniences (Jean Dreze, 2017). Therefore, the main issue that emerges is whether the Aadhaar has been able to deliver as per expectations, in the process of financial inclusion of the rural economy.

(i) Use of microATMs in the rural economy

The Aadhaar enabled microATMs offer financial services with help of Business Correspondents (BCs), to individuals who do not live close to the brick-and-mortar bank. These microATMs can reduce the barriers to access a bank account and thus lead to more active usage. There has been a significant increase in the average size of a transaction from ₹1,400 (\$22) a month in FY 2016-17 to ₹2,527 (\$39) a month in FY 2017-18 (State of Aadhaar Report 2017-18, p. 20). In addition, the number of BCs in rural areas has been slowly increasing, with the total number growing by 2% between 2016 and 2017 (from 531,229 to 543,472) (RBI, 2017). About half of the BCs use microATMs to conduct transactions (Mehrotra, 2018).

However, the study by MicroSave has also highlighted some of the major issues with the microATMs in the rural areas such as uncertainty of a successful transaction, problems in maintaining liquidity, service downtimes faced by the BCs, etc. Most of the BCs also do not offer services to customers of other banks. Thus, in order to encourage microATMs in the rural economy, the branchless network need to be improve.

(ii) Direct transfer benefits

Research suggests that receiving DBTs into one's bank account can increase account usage; not having a bank balance is a key contributor to account dormancy (State of Aadhaar Report 2017-18). The Government of India has stated that ₹90,013 crores has been saved in the last 4 years from FY 2014-15 to FY 2017-18 because of Aadhaar, DBT, digitization, and other initiatives. APBS allows government agencies to transfer funds to citizens using only their Aadhaar number and bank account. This system has helped the government to maximize the bank account usage by encouraging DBT payments with APBS and Aadhaar-seeded bank accounts.

There has been an increase of 2.5 times (Rs. 1.91 lakh crore in FY18 from the previous year) in the transfer of subsidies and other benefits to the beneficiaries through the direct benefit transfer (DBT). This jump in the DBT has been largely due to the increased use of the Aadhaar-enabled DBT platforms, mostly as cash paid to their bank accounts but also in-kind benefits (such as fertilizer subsidy distribution). The removal of fake beneficiaries has helped in the savings in the various DBT schemes such as Public Distribution System, MGNREGA, LPG-PAHAL scheme etc.

The government have laid a strong foundation for the integration of the Aadhaar into the process of financial inclusion. However, strong additional efforts may be needed to fully realize Aadhaar's potential for financial inclusion. There are several instances where the biometric authentication failure has resulted in the exclusion of the genuine beneficiaries. So, there must be a provision of alternative identification mechanism in case of failure of the biometric authentication. It must be effectively enforced and widely advertised.

According to the State of Aadhaar Report 2017-18, microATMs can offer better experience than banks and could enhance the reach of formal banking services. But there is a need to address some of the implementation issues of the BC model. The poor cost recovery, inadequate commission structure, heavy workload etc. are some of the issues which need to be address properly for better efficiency. There is a dire need to encourage more women population in the rural areas to participate formally in the formal financial system. The growth in female rural Bank Correspondent agents will encourage earlier unbanked women to use their bank accounts meaningfully. This will help them create their own credit history and access other financial services.

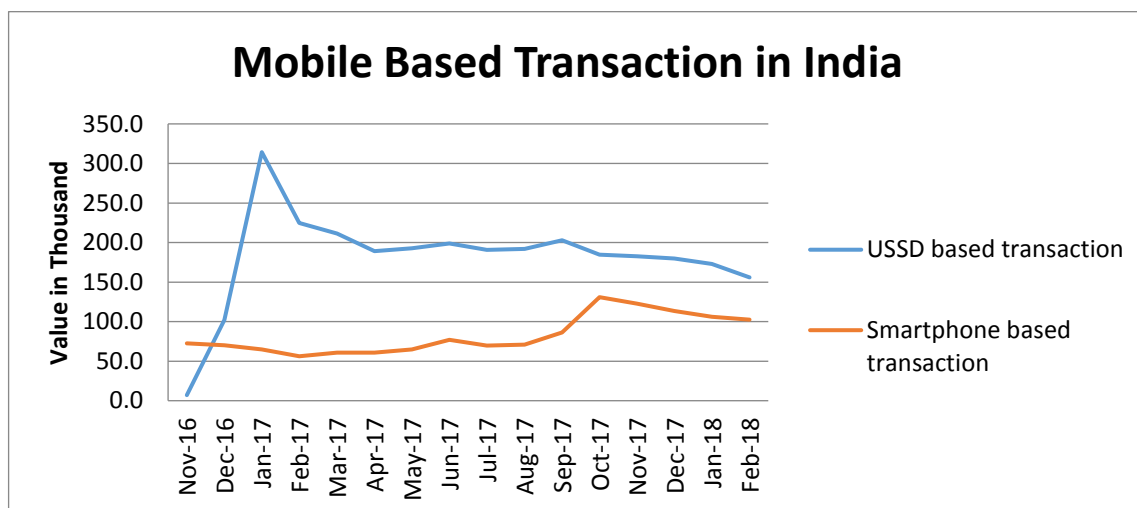
c) Mobile Banking

The Mobile banking in India is seen as a catalyst in achieving the goals of financial inclusion. The mobile banking in India is either smartphone-based or USSD-based. The internet based services include fund transfers, bills and credit card payments, accounts and loan statements, request for cheque books, filing of complaints, and management of insurance policy or portfolio among others (Arora, 2015). On the other hand, the USSD (Unstructured Supplementary Services Data) based mobile banking services is available on basic featured phones which does not require the use of internet, thus making it

accessible for lower income earning individuals to access the banking services. Despite the availability of mobile-banking services, very few account holders are using facilities available to them (Global Findex Survey, 2018). This raises doubts on the improvement of financial inclusion in India.

In 2017, 5 percent of Indian population have accessed a financial institution account from their phone or the internet, and 2 percent of the population owned a mobile money account. (The World Bank, 2017). In terms of digital payments, India is still lacking behind most developing countries with just 29 percent population making digital payments. While more adults in the developing countries are moving towards financial inclusion and capitalising on the growth of digital finance, the same cannot be said about India.

Figure 4: Mobile Banking Transaction



Source: RBI

There has hardly been any growth in the volume of transactions using mobile banking in India (fig. 4). The most significant growth in the mobile based transactions was during the demonetization period when there was a big push for a cashless economy. Post demonetization, there has not been much growth in the mobile based transactions. One of the major reasons that has discouraged the growth of the mobile banking is the lack of digital and financial literacy among the low-income groups. The USSD-based mobile banking is meant to cater the needs of the low income population who cannot afford smartphones (Renita D'Souza, 2018). However, most of these individuals are informally employed. They operate within the informal economy which is predominantly dependent

on cash. Another limitation is that the transaction cost involved in the mobile based transactions unlike cash transactions. This creates a risk of monetary loss in case of incorrect transaction.

The Indian population has not yet experiencing the benefits of mobile banking. The poor access to electricity and internet penetration hinders the connectivity issue in India, which is a major reason for the slow adoption of mobile banking. There is also a lack of trust particularly in rural India in terms of transaction through mobile banking or digital mode of payment.

There is a huge gap in rural-urban areas in respect to internet penetration. In December 2017, 65% of urban households had an internet connection compared to 20% in rural India (IAMAI, 2017). Although there has been a radical increase in internet penetration in urban areas, it has been slow in rural areas.

The use of mobile banking and digital payment requires a level of technical literacy, which is quite less in rural and low-income areas of India. There is an education gap between mobile account access and digital payments. The access to mobile phones does not ensure the use of financial services. The rural India cannot rely on technology alone for formal banking services unless there is a greater push for financial literacy.

Conclusion and Recommendation

The JAM initiative is definitely a stepping stone towards greater financial inclusion. As seen above, it has played a major role in opening bank accounts as well as in transfer of subsidies and other direct transfer benefits. The access to bank accounts have however not ensure sufficient financial inclusion in the rural economy as there is still low level of engagement with the formal banking sectors beyond deposits and withdrawal.

To facilitate greater financial inclusion in the rural economy, the following factors need to be considered.

- The JAM initiative has been successful as a financial strategy especially for the women, in the rural area. (Charan Singh, 2018). The gender gap in ownership of bank accounts has been reduced to 6 percent in 2018, with 83 percent of the men and 77 percent women having an account. Also,

among the MUDRA loan beneficiaries, women account for almost 75 percent. This reveals that how the JAM is expanding the financial inclusion in India and has a huge potential to improve the account usage. The SHGs and Bank Correspondents can play an important role in expanding JAM trinity and in extending credit in rural areas. It can also create additional employment for the rural livelihood.

- The internet penetration and development of IT is a necessary for proper implementation of the JAM initiative in rural areas. So far the poor electricity is a major cause for the connectivity issue in rural India. Technological issues like frequent machine breakdowns are still common which hinders the process of financial inclusion. These issues must be address for a better financial inclusion.
- There is a transaction cost of INR 0.5 per transaction on the USSD based mobile banking which must be either subsidised or completely waived off altogether, in order to attract a larger rural population.
- There is a need to promote digital literacy in the rural economy by training people to use the internet. Unskilled or semi-skilled workers, school dropouts and self-employees must be made aware of how digital literacy can help them build skills and gain knowledge to improve their economic situation.
- SHGs can play a major role in encouraging more rural women to act as Bank Correspondents to improve the usage of bank accounts. They can also provide training for Bank agents in skill development and also contribute towards capacity building.

Thus, there is still a long way to go to bring the rural population under the formal financial system. To extend the benefits of JAM and ensure financial inclusion in the rural economy, there is a need to improve the financial literacy for rural population.

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Rural development through ecotourism, nature conservation and environmentally sustainable design (ESD)

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Abstract: Many rural communities located in, or near to, landscapes possessing high ecological value, in both developed and developing countries, have embraced ecotourism (ET) as a means of income generation and local capacity building. This form of tourism relies on nature conservation for its success due to the fact that the unique landscapes, and the plants and animals that inhabit them, typically form the primary tourism attraction. Associated cultural elements can also function as attractions, for example the vernacular architecture of an area. The design of eco-tourism developments often incorporates principles of ecologically sustainable design (ESD), which is in keeping with the philosophy of ecotourism. This can take many forms, including use of alternative sources of energy production for power, use of sustainable and/or local building materials for construction and the installation of low environmental impact appliances for their operation. Initiatives for capacity building with respect to training residents of destination communities for employment in ecotourism-based industries, such as nature guides, are offered by some ecotourism enterprises. This paper reviews some key features ecotourism developments often embody, including those associated with ESD design principles, biophilic design and nature conservation, as exhibited by a selection of examples of ecotourism developments from various places around the world, primarily in developing countries. These developments have incorporated in one way or another ESD principles in their designs, nature conservation initiative and capacity building programs for local communities. How these types of features are promoted in advertising ecotourism resorts to prospective guests is also touched upon. The paper concludes with suggestions for what an ideal ecotourism resort development should include.

Keywords: *Ecotourism, Ecologically Sustainable Design, Community Economic Development, Nature Conservation, Biophilic Design*

1 Introduction

What exactly is ecotourism? Ecotourism (ET) is simply a form of tourism that caters to tourists who are interested in experiencing natural environments and elements of those environments, such as wildlife, and who may also want to learn about an area's natural environments and sometimes also the local traditions and customs of the inhabitants. The International Ecotourism Society (TIES) defines ecotourism as: "responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves (nature) interpretation and education" (TIES, 2015). It is a form of tourism that seeks to promote responsible travel to areas of high ecological value and the conservation of the landscapes, and the plants and animals they possess, which form the primary tourism attraction. In addition, many ecotourism enterprises try to improve the well-being of local inhabitants and provide opportunities for income generation (Bluwstein, 2017, Mayett-Moreno et al., 2017). Since ecotourists often want to experience "authentic" lifestyles and cultures of the host communities, preservation of those traditions is also encouraged. This can offer economic development opportunities for host communities through job creation. Any type of tourism development can, however, result in negative social and environmental impacts, particularly at construction sites, as witnessed in many places around the world (Green, 2005; Irazabal, 2018). Ecotourism, however, if implemented and operated properly, can help to increase economic diversification, generate foreign exchange earnings and provide employment opportunities for the host communities, which is particularly important for low-skilled labourers and women (Lonn, et al, 2018). It can also help promote infrastructure development (Chirenje, 2017; Mensah, 2017).

Ecotourism resorts and associated facilities are typically set in the context of natural environments of high ecological, aesthetic and recreational value (Walter and Sen, 2018) and designed to have low impact on the environment. There are various methodologies that have been developed to assist with the siting of ecotourism facilities (Santarem, et al., 2018). This can also involve raising environmental and cultural awareness with respect to the tourism distinctions. Many such establishments provide tourists with opportunities for education about local environments and attractions. And many ecotourism developments embody EDS principles in their design, construction and operation to help minimise environmental impacts. They can also offer interpretation of local natural environments and associated features, such as indigenous wildlife and plants, for tourists. Many of them are also concerned with conservation of cultural features, such as vernacular architecture, which is frequently reflected in the design of the tourism facilities and architecture (Blapp, and Mitas, 2018).

Principles of ecologically sustainable design (ESD) incorporated into the design of ecotourism resorts, and associated facilities, are typically concerned with alternative energy generation and use, wise use of water, selection of sustainable materials for their construction and the management of waste, both during construction and in their later operation. As mentioned above, both conservation of natural environments and building capacity for employment within host communities, aimed at preparing residents for employment in jobs associated with ecotourism, are also key features of many ecotourism resort developments. The following discussion explores some principles associated with best practice ecotourism development and how these considerations have been incorporated into various ecotourism resorts located in a range of locations, mostly in developing countries.

2 Incorporating ESD Principles

As mentioned above, ecotourism resorts often incorporate principles of ecologically sustainable design (ESD). In broad terms, ESD seeks to minimise negative environmental impacts through the wise use of renewable resources to result in low environmental impacts in terms of the design, construction and operation of the developments. Incorporating ESD principles in the design of ecotourism facilities should be aimed at reducing their environmental impacts while simultaneously conserving, and where possible enhancing, the natural environments in which they are set.

Ecologically sustainable design (ESD) principles incorporated into the design of ecotourism facilities is in keeping with the philosophy of ecotourism and can be done in ways that not only decrease environmental impacts but also make these types of design features visible to the users, thus sending a message that they are “sustainable”. This can take many forms, including incorporation of principles of water sensitive design (WSD) in the landscapes, relying on visibly obvious alternative sources of energy for power (e.g. solar, wind, etc) and the use of sustainable and/or locally sourced materials for their construction. But such efforts can sometimes result in what has been termed “greenwashing” where the development looks “sustainable” but is not necessarily actually effective at limiting environmental impacts of facilities. A lack of consensus among designers on how to incorporate sustainability features in the design of ecotourism facilities has led to different results with varying degrees of success. However, there is often a disconnection between the actual performance of ecotourism resorts and how the users perceive them. The user public often will use different criteria, such as signs of visible sustainability features, such as solar panels, in judging the sustainability of facilities, which is different to that used by designers in assessing their performance. This has led to some ecotourism resorts that are not necessarily highly ecologically sustainable being perceived by the users as being so. This has led, in some cases, to ecotourism resorts winning architectural awards for their designs, yet they are not actually very environmentally friendly,

3 Biophilic design

What has been termed “biophilic design”, which is a design approach that aims to connect people with the natural environment (plants and animals) within constructed environments (Kellert, et. al., 2008), can also be incorporated into the design of ecotourism facilities. Biophilic design has been shown to be able to increase the health and well-being of users simply through increasing their contact with natural environments and features (Kellert, 2005). This design approach can play a critical role in the design of ecotourism developments, which would logically benefit from nature conservation and incorporation of natural element into the design of facilities. Conservation of the natural environment, including the plants, animals and other elements of the natural world, such as geological features (Soliman, and Abou-Shouk, 2017), in which an ecotourism resort is located, works best if it also aims to generate long-term positive relationships between people and the natural world. This is where education about, and interpretation of, local natural environments can benefit not only the natural environment but also the tourists and host communities (Jimenez., et. al, 2017). Maintaining, and increasing where possible, connections with nearby natural landscapes and the plants, animals and other natural features they possess, is in keeping with both ecotourism and biophilic design.

The ideal ecotourism resort development

The ideal ecotourism resort would effectively link ESD principles, nature conservation and biophilic design in a way that can provide optimum environmental protection, social cohesiveness and economic opportunities for the host communities and be economically successful for the operators. The construction, operation and marketing of such establishments should improve the everyday environments and lives of the people in the host communities as well as the tourists with whom they should be able to co-exist. This requires that the local residents' views be taken into consideration in site selection, construction and management of ecotourism developments (Lee, and Choi 2017). Such developments should also provide long-term market driven income generation opportunities for the host communities based on conserving natural environments, and associated plants, animals and other landscape features they possess, as these represent the primary elements attracting ecotourists (Haque, et, al. 2016). The sites selected for ecotourism developments should ideally be places that possess high ecological, aesthetic, cultural and recreational value yet be developable with as little environmental impact as possible.

Ecotourism can also provide a means of conserving local traditions and cultural heritage values. Places set in natural environmental settings that also possess features of cultural interest, for example vernacular architecture, can enhance the attractiveness of such destinations, and their likelihood of success. Ideally, features of cultural value will be integrated with the natural environmental settings in which they occur. Cultural traditions and local artistic traditions, such as traditional dance and crafts, can be used to further generate interest among tourists and provide additional opportunities for employment within local communities. This approach of blending natural and cultural attractions is critical for the success of ecotourism enterprises.

In many respects, ecotourism is about selling natural, and often cultural, landscapes as these are the primary tourist attractions. As such, there is often strong incentives for both the conservation and enhancement of natural environments, as well as local cultural heritage features and traditions associated with the landscapes in which the ecotourism facilities are located. In places that have limited income generating options, possession of both cultural elements that hold interest for tourists, in addition to natural environments of high ecological and aesthetic value, represent the most promising income generation opportunities and incentives for conservation of both the cultural and natural landscapes in which an ecotourism establishment is set.

5 Ecotourism promotion

The promotion and advertising of ecotourism resorts and associated facilities often relies on “selling” to prospective tourists the landscapes, and the biological and geological features they contain, as well as associated cultural features. These are typically the primary attractions. Promotion of these types of features often takes the form of conveying them to prospective tourists through photographs, moving images, textural descriptions and other means that display elements with the highest ecological, scientific, cultural and aesthetic value, as well as the design features that make the built features associated with resorts environmentally friendly, specifically ESD and biophilic design principles. This can include promoting features associated with the sustainability of not only the resorts themselves, including accommodation, dining and other facilities, but also the landscape settings and associated infrastructure developments, for example roads that provide access to them and which can be used to allow tourists to experience nearby cultural and natural environments. The success of such advertising relies on these representations enticing potential tourists to visit the tourism destinations and the resort establishments. Of course, these are only vicarious representations of the destinations and the features they possess, and can be used deceptively as they are

typically presented in ways in which they will be perceived as being most attractive to potential tourists (Buscher, et. al. 2017). Sometimes the images portrayed in advertising do not always match reality and in the long run this can have negative impacts on the economic success of such establishments.

6 Ecotourism as income generation

There are numerous examples of rural settlements located in, or nearby areas of high ecological value, where ecotourism facilities have been established as a way of generating income for local communities. In many cases these have been highly successful in generating income for communities that have few other options for income generation. By building local capacity and creating employment opportunities, ecotourism can be an effective vehicle for empowering local communities, particularly those in developing countries, as one way of alleviating poverty while also achieving conservation of natural environments and greater sustainable development of infrastructure for rural settlements in which they are located.

7 Examples of ecotourism Facilities

Ecotourism enterprises that have sought to incorporate principles of ecotourism with environmentally sustainable design and nature conservation as well as education and interpretation of natural environments and cultural traditions of the host communities for the tourists can be found in many developing and developed countries. The following are some ecotourism establishments, mostly in developing countries, that have successfully linked these three objectives in various ways. Some of them have been successful financially, and are truly environmentally friendly, and also help to educate their guests about the ecological, and sometimes cultural, features associated with the resorts and their environmental settings.

Ecocamp Patagonia, Torres del Paine, Patagonia, Chile. The design of this ecotourism facility was inspired by traditional *Kawesqar* huts that were built by bending branches and covering the structures with guanaco and sea lion skins, which could withstand wind speeds of more than 180kmph. The design minimizes external surfaces that come in contact with the cold exterior environment. Each of the units have raised domes with living spaces linked by raised boardwalks to minimise impacts to the local environment. All energy is derived from alternative sources, including micro-hydroelectric, solar and wind power. Significant amounts of GHG emissions are therefore offset every year. Guests must carry out most of the waste they produce, with the remaining being separated, compacted, stored and eventually sent to Santiago for recycling. This was the first ecotourism company in Chile to receive the prestigious ISO 14001 Environmental Management System certification from a third-party certifier (*Societe Generale de Surveillance*, SGS Switzerland).

Banyan Tree, Seychelles. This Banyan Tree resort was founded on the core value of driving sustainable development. It was the winner of "Green Planet Award" and is sited near UNESCO World Heritage Sites, including the *Vallée de Mai*, which is home to extraordinary bird and tortoise colonies. Used cooking oil is converted into biodiesel for use by the resort. It is located near fragile wetlands so a very strict wetlands management plan was implemented to minimise impact from the construction and tourists.

Misool Eco Resort, Indonesia. This eco-resort used indigenous natural materials for the buildings, derived entirely from salvaged driftwood and free-fallen trees that were collected in the Raja Ampat area and the nearby island of Seram. The construction

and operation of the resort has been meticulously engineered to minimise environmental impact with on-site energy efficiency in mind. Solar and wind power are used to generate electricity. Recycled water is used in irrigating gardens to minimise consumption of potable water. The labour force is drawn largely from the nearby village of Yellu, and workers are provided with good working conditions, health benefits, job training, and are offered English lessons.

Teniqua Treetops, South Africa. The buildings of this resort incorporate passive heating/cooling designs to minimise GHG emissions. Natural, locally sourced materials were used in the construction. Rain water is harvested and stored and grey and black water are treated and recycled. An integrated biofiltration system (organic water recycling) is also used. Dry toilet systems are also used to safely and efficiently process human waste without threatening the sensitive Karatara catchment area.

Satwa Elephant Eco Lodge, Way Kambas, Sumatra. This eco-lodge is set within the Way Kambas National Park, which enables visitors to gain an understanding of the flora and fauna that surrounds the resort. The lodge helps in protecting endangered species, especially the Sumatran Elephant and the rare Sumatran Rhino and Tiger, species of which are all on the verge of extinction. This is done through a partnership with various conservation programs aimed at protecting the area's wildlife. Guided tours and activities allow visitors to interact with surrounding wildlife and learn about the natural environment. The entire facility is powered by solar energy.

Paradise Bay Eco Escape, Whitsundays, Queensland, Australia. This eco-tourism establishment is located on the fringe of the Great Barrier Reef Marine Park. All lighting, hot water and electrical equipment are solar powered. Buildings are small to minimize impact on the environment and are designed as opened-aired structures to provide natural cooling of the rooms. All waste materials (plastic, glass, paper) are separated and recycled. Waste water is treated and utilized for irrigating the gardens. All buildings have rain water tanks installed to collect water for use in the rooms. The use of hybrid electric cars and the replanting of trees was used to off-set GHG emissions. Primarily indigenous, and some native plants, were used in the landscape.

Couran Cove Island Resort, Stradbroke Island, QLD, Australia.

The aim of this resort is to be simple, sustainable and practical and to reflect Australia traditions and heritage, particularly in terms of its architecture. All building materials were as natural as possible, and sourced locally to be as sustainable as possible. The architecture utilises natural air flows and lighting to achieve an overall reduction of 85% in greenhouse gas (GHG) emissions compared with similarly sized conventional island resorts and a 75% reduction compared with a typical mainland household. The architects used the natural setting of the Couran Cove of South Stradbroke Island to guide their design, incorporating elements of the immediate resort surroundings into the design, including design inspirations derived from the nearby lagoon, surf and forest areas.

8 Conclusion

The types of ecotourism resorts discussed above have, to varying degrees, all made efforts to incorporate principles of ESD, nature conservation and as much as possible be self-sufficient. This is accomplished through the wise use and collection of rainwater, generation of alternative, carbon free energy, integration with the natural environment and training and employment of inhabitants of the destination communities.

Ecotourism developments can take many forms but all should aim to incorporate as many of the design and planning principles as outlined above into their design, construction and operation as possible. This should also include education for tourists about local natural and cultural environments and provide them with ways for exploring these features that are environmentally, culturally and socially responsible and protecting of local environments, which is what attracts the tourists in the first place. Ecotourism has the potential to provide a reliable form of income for destinations communities in the form of providing accommodation, running restaurants, acting as guides, selling souvenirs and handicrafts and other associated businesses as long as the natural and cultural resources that initially attract ecotourists to an area are not destroyed or degraded in the process and ideally enhanced.

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REVIEWING ORGANISATIONAL BUYING DECISION-MAKING AND MASS CUSTOM DESIGN MECHANISMS FOR SUSTAINABLE HOUSING DELIVERY

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Abstract: In 2015, the United Nations set 17 Sustainable Development goals under the Transforming our World: the 2030 Agenda for Sustainable Development. Climate change accompanied by global warming issues necessitates homes to be more environmentally friendly in production and operation, while the drastic hike of energy costs and today's socio-economic diversity demand housing to be more affordable and customisable than ever. Homes need to accommodate the social, economic and environmental sustainability. Back in 1987, the revolutionary notion of *sustainable development* was introduced through by the United Nations' Brundtland report. Coincidentally, the *mass customisation* concept emerged as a means to customise end-user products without sacrificing the production efficiency, effectiveness and low cost. The Sustainable Development encompasses complex tasks and actions, and the ambitious goals may not be realised without multidisciplinary collaborations facilitated through organisational decision-making processes. As homebuilders can be considered as organisational buyers, whereas a house is attributed to a series of procurement actions for selecting and obtaining construction labours, materials and systems as well as design services, this paper explores the mechanism and significance of a general organisational buying decision-making process and a specific mass custom design approach being successfully implemented for sustainable housing delivery in both developed and developing countries.

Keywords: *Organisational Buying Decision Making, Building Innovation, Mass Custom Design, Sustainable Housing Development.*

1 Introduction

The United Nations set 17 “Sustainable Development” goals under the “Transforming our World: the 2030 Agenda for Sustainable Development” (or “Agenda 2030”) (United Nations 2015). Towards the Agenda 2030 accomplishment, today’s homebuilders from cross the world may be required to take the complex tasks and bold actions, whereas homes built in both developed and developing countries need to be socially, economically, environmentally and humanly sustainable. The ambitious goals may not be realised without multidisciplinary collaborations facilitated through organisational decision-making processes. Generally, any housing development somewhat involves a certain level of organisational buying decision making actions for the selection and purchase of products (e.g. building materials and systems) and services (e.g. design implementations) that are required for the project realisation. Homebuilders also need to determine whether or not to subcontract out to familiar or unfamiliar sub-contractors (i.e. suppliers) who actually execute the housing projects initiated by the builders. The homebuilder’s decision-making process in such procurement actions may be regarded as critical and complex. The decision-making embraces information acquisition and processing activities, as well as the development of goals and other multiple criteria to be used in choosing among the alternatives. Moriarty and Galper (1978) emphasise that the organisational buying decisions differ from consumer (or individual) purchasing decisions. First, the number of people typically involved in the buying decision is greater due to the differing needs and objectives of participants and the operating functions, which they represent. Second, the major technical complexities related to the product or service being purchased. Third, the length of time involved is typically longer than consumer buying decisions due to the technical complexity of industrial buying decisions, which require more information and longer evaluations, as well as involving more uncertainty about product performance. Fourth, such information, proposals and purchase contracts in the organisational buying process add a formal dimension, which is rarely found in consumer buying. Fifth, the personal and organisational risks generated are much greater, because a larger amount of money is often involved. In addition, the organisational members, who participate in the buying function, are neither purely “economic men” nor purely emotional or irrational men; rather, they are human beings, whose buying decisions and behaviour are influenced by both task- and non task-related variables (Webster and Wind 1972).

Globally, delivering quality affordable products is a requisite for market entry. Nonetheless, today’s socio-demographical diversity emerging in both developed and developing countries is contributing to shifting the concept of quality from a focused need on product reliability to a demand for the customisability. Seemingly, today’s end-user market (including housing business) is no longer satisfied with generic, ready-made products developed based on a minimal standard; rather, it may desire customisable goods and services that can accommodate not only users’ immediate needs but also their demands (Anderson 1997). With the aim to meet this end-user product global trend, a “mass customisation” concept emerged as a means to support the delivery of affordable and customisable end-user products that do not sacrifice the production efficiency, effectiveness and low cost (Dais 1987; Pine II 1993).

Accordingly, the following sections explore the mass customisation concept being applied particularly to housing delivery after reviewing a general organisational buying decision-making platform—i.e. the contextualisation of these mechanisms towards the application to sustainable housing developments in developed and developing countries.

2 Reviewing Organisational Buying Decision-making Platform

As stated above, the organisational buying decision-making process is complex and decisions are influenced essentially by task- and non task-related variables; thus, the organisational buying behaviour models can be also classified into task- or non task-oriented models. Task-oriented models include those that emphasise task-related variables (such as *price*), while non task-oriented models are those that attempt to explain organisational buying behaviour based on a set of variables (such as emotional factors) which have no direct bearing on the specific problem to be solved by the buying task.

2.1 Task-oriented Models

The task-oriented models may be useful for investment justification; however, these models may suffer the disadvantages of incompleteness, due to the absence of non task variables, which are also considered as important determinants of organisational buying behaviour. The “minimum price and lowest total cost” models may well exemplify the task-oriented models regarding monetary considerations, while the constrained choice model stresses the existence of habitual behaviour that many organisations may engage in while making an industrial buying decision (Webster and Wind 1972).

The minimum price model: A firm is often forced to obtain all factors of production at the lowest possible price and to achieve the most efficient methods of operation since a firm is usually motivated to maximise its profit (Webster and Wind 1972). The minimum price model can be considered the simplest organisational buying behaviour model. The lowest total cost model: The lowest total cost model is essentially an elaboration that attempts to achieve the minimum of initial costs (like the minimum price model), as well as of additional operating costs, which are recognised as significant. In other words, the model aims to adjust the initial purchase and reflect the additional costs of product-in-use, while considering the opportunity costs associated with profit opportunities. The constrained choice model: The constrained choice model focuses on the fact that the buyer’s decisions often involve choosing from a limited set of potential suppliers. Webster and Wind (1972) indicate that the potential suppliers in this set are regarded as *in*, while all other potential suppliers are *out*. In addition, Moriarty and Galper (1978) emphasise that the buyer usually views the selection of an “in” supplier for its product or service to be purchased as “low risk” since the “routine purchase” reinforces the buyer’s perception. Thus, any member of the buying organisation may impose constraints on the list of possible suppliers, to reduce the risk perceived by the buyer in the purchasing decision.

2.2. Non Task-Oriented Model

Non-task-oriented models generally concern the *emotional* factors influencing organisational buying behaviour, thus disregarding the rational (or economic) factors as aforesaid. Accordingly, this section focuses mainly on examining the perceived risk model, which reflects the uncertainty associated with the purchasing process. The perceived risk model: Perceived risk is defined as “the uncertainty that consumers face when they cannot foresee the consequences of their purchase decisions” (Schiffman and Kanuk 1999). The perceived risk model was originally proposed by Bauer and is regarded as a useful framework within which to consider organisational buying behaviour from the viewpoint of the individual (Webster and Wind 1972). Furthermore, Webster and Wind (1972) explain perceived risk as follows: “Perceived risk is a function of uncertainty which an individual has about the outcome of a given course of action and the consequences associated with alternative outcomes. The individual may be uncertain either about the goals that are relevant in the buying situation or about the extent to which a particular course of buying action will meet those goals.” Furthermore, they also defined the two types of

consequences (“goal identification uncertainty” and “goal/purchase matching uncertainty”) regarding them as important determinants of the amount of risk perceived by the organisational buyer in a given buying situation.

In general, the major types of risk that buyers somehow perceive when making a buying decision include performance risk, financial risk, psychosocial risk, and time risk (Webster and Wind 1972). The ‘performance risk’ can be considered as the risk that the product will not perform as expected or the risk to self or others that the product may be harmful. The ‘financial risk’ is the risk that the product will not be worth its cost. The ‘psychosocial risk’ represents the risk that a poor product choice may result in social embarrassment or damage to the consumer’s ego or self-esteem. The ‘time risk’ is the risk that the time spent in product search may be wasted if the product does not perform as expected.

Webster and Wind (1972) indicate that organisational buyers may adopt several strategies for reducing the amount of perceived risk. First, the buyers may simply avoid a decision. Second, they may remain loyal to “in” suppliers to maintain their *routine* purchase. Third, they may extensively gather and evaluate additional information in the search of new products or services. Fourth, they may do business with well-known, reputable, established suppliers—this also reflects *brand loyalty*. In addition, they also introduced a unique approach to avoiding uncertainty during the organisational buying action—i.e. “split orders”. They said that “Another strategy used by organisational buyers to reduce risk is to split orders between two or more vendors, although single sourcing (especially from well-known suppliers) was found to be more common practice...” (Webster and Wind 1972). This approach may help buying organisations venture to apply more innovative products that meet their demand, while they can reduce risk by splitting the orders between two or more suppliers. In this case, buyers may be able to choose “in” and “out” suppliers not only for conventional products, but also for innovative products. The weight given to each of the suppliers for their products or services that will be purchased may vary according to the buying organisations’ needs and demands for them.

The amount of uncertainty surrounding the purchase of a new product may be reduced through a series of “problem-solving” activities. However, the type of problem solving adopted depends on the task at hand. It is classified into two buying situations: programmed and non-programmed (Fig.1).

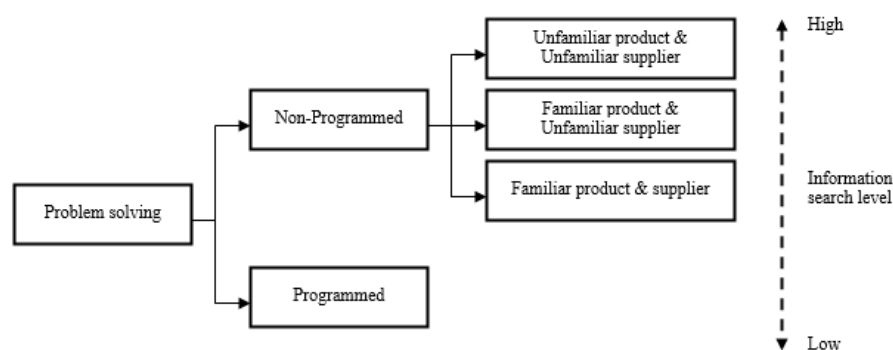


Figure 1: Programmed and non-programmed problem solving pathways

A 'programmed' decision reflects a habitual (or *routine*) purchase, and it may lead almost immediately to a purchase, while a 'non-programmed' decision may require more time (which can be also considered as a cost relating to the search) for the acquisition and processing of information on a product to be purchased (Blythe 1997). Information search usually comes from an *internal* search from memory and an *external* search from outside sources (Blythe 1997). The extent of the external search for information depends on a range of factors that relate to the buyer's situation, the value and availability of the information, the nature of the decision being contemplated, and the nature of the individual (Fig.2).

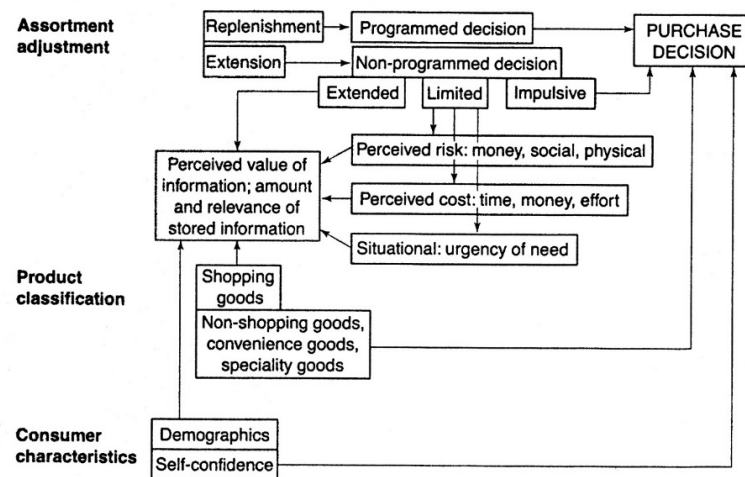


Figure 2: Factors affecting external search
(Source: Blythe 1997)

3 Evolution from Mass Production to Mass Customisation

Prefabrication is rooted in standardisation of parts and components, or entire units; thus, the end-user products can be manufactured in the way of 'mass production' where material and labour costs are likely reduced through economies of high volume work. Nevertheless, in consideration of today's depressing economic climate, growing demographic diversity, and global warming issues, house-builders are becoming keener on pursuing not only housing cost reduction strategies, but also the social and environmental sustainability. In the 1920s, the gravity of mass produced houses was widely propagated in the architectural society by Le Corbusier with the aim to create new housing stipulations of the Machine Age. In 1956, Walter Gropius envisaged the paradigm shift, drawing attention to the necessity of standardizing and mass producing not entire houses, but only their components. Potentially, the practice of combining standardized housing design elements leads to mass customizing houses through economies of scope without compromising the production efficiency, effectiveness, and cost. In this scenario, housing quality that to some extent needs to harness eco-friendliness nowadays is defined based on home-users' choice of standard design options given. Within this context, users can make design decisions in view of their economic constraints and housing needs and demands of today and in the future. In 1987, this paradoxical concept of 'mass customization' was formally launched by Stanley Davis, while the United Nations manifested the significance of "sustainable development." Japanese prefabricated house-building industries are in the forefront of mass customising homes for sustainable development. The business has been growing over the last decades. Today, the prefabricators tend to deliver zero energy mass custom homes (or ZEMCHs) with the aim to satisfy the wants and needs of individual

consumers and society. Incorporating of customer needs and preferences into the development of a product is not a new idea.

3.1 Mass Custom Design System Model for Housing

One of the successful mass customisation approaches that can be applied to the homebuilding process is the modularisation of housing components. Furthermore, the variations accomplished through the mass customisation process can be quantified in the light of Set Theory, a branch of mathematics developed by Georg Cantor. The total number of possible ordered pairs (or combination) of given standard housing components can be simply calculated. To bring the concept of mass customisation into effect, a total coordination (or systems) approach to considering products and services within the housing delivery process need to be considered since to design, build and market a home requires consideration of these two aspects. In short, mass customisation, when it is considered as a set of systems for designing, producing and marketing a product, is impossible if either customisable products or communication services are absent. To formulate the means to mass-customise homes, the system model was developed (Noguchi 2008). To discuss the potential applicability to the delivery of quality affordable homes, this generic mass custom design system model was first introduced at an internal symposium on urbanism, which was entitled *Prospectiva Urbana en Latinoamerica* held in Aguascalientes, Mexico, on 31st August 2001 (Noguchi 2001). This televised symposium was organised by the local government and over 500 audience members from the academia, construction industry and government joined the discussion.

The mass customisation (MC) was visualised simply by making use of a conceptual analogue model as follows:

$$MC = f(PS) \quad (1)$$

In this model, the *service* sub-system (S) concerns communication techniques that lead users to participate in customising their new home while the *product* sub-system (P) covers production techniques that aim to encourage housing suppliers to standardise housing components for mass production.

3.1.1 Service Sub-system

In mass-customising homes, user participation is vital; therefore, housing suppliers need to offer design support communication services to their clients. Design-consulting staff and appropriate communication tools are required to facilitate user choice of standard components (Noguchi and Friedman 2002). These fundamental design service factors can also be integrated into a comprehensive model:

$$S=f(l, p, t) \quad (2)$$

In this model, the service sub-system (S) is supported by the existence of location (l), personnel (p) and tool (t) factors.

Location factors: During the design stage, clients need to participate in customising their new home, and the design consulting service normally takes place in the company's office. The company's show home may also function as an exhibition and consultation base, where experienced staff can make specific proposals concerning the external appearance and floor plans of a customised home by making use of advanced computer technology. Clients may see and touch the samples to confirm the superior qualities of the company's products; moreover, they learn more about the company's suggestions regarding housing

facilities. In consequence, such visual information, visits, and individual consultations with housing experts may increase the clients' faith in the reliability of the company and its products, and thus increase the likelihood that the client will select the company, when purchasing a home.

Personnel factors: To alleviate consumers' anxiety caused by the combination of high risk and limited experience in purchasing a home, housing suppliers may strengthen their local network of housing business by locating sales staff across the country in question. These salespeople directly contact clients, to market, as well as design their products. Sales staff can be considered as the company's greatest assets in reaching clients, and they are trained to assist clients in designing their custom homes by making use of various communication tools (e.g. catalogues and digital communication tools) that contain various options of standard housing components.

Communication tool factors: Client needs are often difficult to conceptualise and articulate; however, interaction with possible prototypes can help identify these needs. Housing suppliers may be able to use various types of housing catalogues showing possible prototypes. This enhances client involvement, offering the client a great choice of housing types and components. The catalogues play a variety of roles in advertising and educating clients. In terms of client participation at the design stage, the catalogues mainly function as design tools for the housing supplier and its client. Through consultation with housing experts, clients can choose the housing type and components from the catalogues to design a custom home that meets their needs. Clearly, catalogues can be regarded as synthesised information sources that integrate and simplify extensive data through an inductive process.

In Japan, housing suppliers (mainly, prefabricators) tend to accommodate two kinds of housing catalogues to help the client choose the housing type: a general housing catalogue and a housing style catalogue (Noguchi 2016). The former contains information on all the company's products to communicate general information about the company, while the latter offers more detailed information about specific types of products. Such housing style catalogues explain the characteristics of each commodity in terms of the design concept and technology. Moreover, housing component selection catalogues are also emerging globally contributing to mass customisation practices in the home-building industry. The mass custom design component selection catalogues are designed to correspond to housing types, helping clients to select various standard housing components for exterior and interior arrangements. The catalogue elaborates in detail on each component in terms of material, size, colour, texture, and functions. Such catalogues tend not to contain the price of each component, so that the client will choose an item according to its use—not its cost. However, a cost estimate can be offered by making parallel use of a computer with these catalogues under consultation. The selection catalogues are visually integrated to compare building components for clients' design decision. Physical and/or digital models help visualise the actual configurations of housing in response to user design choices (Fig.3). The construction of knowledge in the design decision making process requires the use of instruments that will enable efficient and effective communication between users and housing suppliers.

The use of a CAD system is important in the creation, modification, analysis, or optimisation of a design, allowing consumers to customise their choice in housing. Most housing suppliers today may use a CAD system as a digital communication tool to offer flexibility in design. The benefits derived from applying a CAD system in the design stage include the short time elapsed between the receipt of a consumer order and the delivery

of the proposal, the accuracy of material and cost estimates, and the standardisation of drafting and documentation. Ease of visualisation of a drawing boosts the client's comprehension of the layout of their new home. The interactive CAD system basically contributes to the creation of line drawings; however, advanced geometric modelling, such as solid modelling in three dimensions with shade and colour, helps to display more information on the graphic screen. Another advantage of a CAD system is data communication. The purpose of data communication is to transfer data between a computer and its peripherals that can be defined as any input or output device.

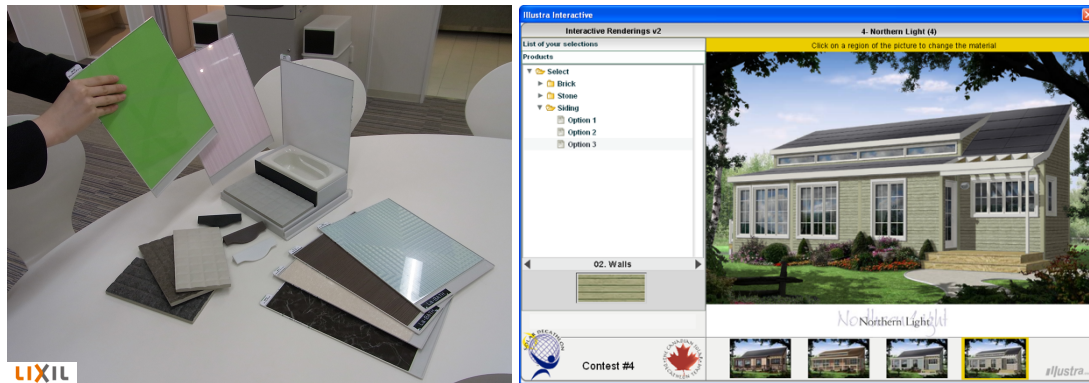


Figure 3: Adjustable physical and digital housing component catalogues for mass customisation

3.1.2 Product Sub-system

Even though these elements are necessarily interrelated, most homebuilders and housing manufacturers have already been applying these during the design stage. An important part of mass customisation is that the user directly determines the configuration of their home from choices given as client input during the design stage. However, this cannot be achieved without the standardisation of housing components for the volumetric, exterior and interior design arrangements. These components should be organized in a visually attractive way in a component selection catalogue that enables clients to easily choose from many options given—as well, the value of each component choice may need to be explicit.

Basically, housing components can be divided into three categories: volume, exterior and interior. These can be considered the main elements of the product sub-system (P) which can be explained by the following conceptual model:

$$P = f(v, i, e, o) \quad (3)$$

The volume (v) components are used to configure the space of housing that determines the number and size of each room while the interior (i) and exterior (e) components serve to co-ordinate decorative and functional elements that customise a home. In addition, 'o' denotes other optional features such as air conditioning, home security system, emergency call buttons, handrails, dishwashers and other electrical appliances. Some optional features can be offered before or after occupancy with due consideration of inclusive design approaches to housing the elderly and disabled users.

4. Conclusions

Under the Transforming our World: the 2030 Agenda for Sustainable Development, the United Nations set 17 goals. These ambitious global goals may not be realised without multidisciplinary collaborations facilitated through organisational decision-making

processes. In this study, homebuilders, which are required for procurement actions to select and obtain construction labours, materials and systems as well as design services for the project accomplishment, were considered as organisational buyers. To envisage strategies to incline the organisational buyers to adopting innovations for sustainable development, a general organisational buying decision-making process was reviewed. This study led to identifying the significance of *programming* decision making processes to lessen buyers' burden on exhaustive information search for new procurement actions that accompany perceived risks. A paradoxical notion of mass customisation was also reviewed and the contents of an existing programmed *mass custom design* system model applied for quality affordable housing delivery were identified. The mass custom design approach enables housing components to be mass-produced, yet volume, exterior and interior components of the home to be built, as well as the other optional functions, can be customised according to the users' direct choices of the standardised elements. This study contextualised the applicability potentials of these models towards sustainable housing developments aligned with the 2030 Agenda. Nonetheless, the scope of this study was limited to the theoretical reviews; thus, the further case studies are required to justify the universality and magnitude, as well as to identify unforeseen drawbacks for continuous improvement of the application.

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