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Innovative Design for Societal Needs

Proceedings of NERC 2022

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Foreword

It is a matter of great satisfaction for me that the Indian Institute of Technology Guwahati successfully hosted the North-East Research Conclave (NERC) 2022 on May 20−22, 2022. The NERC 2022 was conducted on the theme "Sustainable Science and Technology". Concurrently, Assam Biotech Conclave (ABC) was also organized on May 21–22, 2022. Both events attracted huge participation from policy-makers, researchers, industrialists, the army and students. Even the participation of schoolchildren was overwhelming.

NERC and ABC had many events including panel discussions, exhibitions, keynote lectures, competitions and paper presentations. Presentation of technical papers forms the core of any research conference. NERC attracted 879 research papers on various themes covering science, technology and humanities. Out of these, some select papers have been published by Springer Nature in the form of 15 volumes. These papers have been peer-reviewed and thoroughly edited by IIT Guwahati faculty members. I am sure that these volumes will prove to be excellent resource material for research. Most of the papers presented in these volumes highlight the special needs and aspirations of eight states of North-East India. I congratulate and thank authors, reviewers, editors and publisher for bringing out proceedings.

The motivation for organizing NERC came from none other than the Honorable Minister of Education, Government of India, Shri Dharmendra Pradhan Ji. It helped to bring policy-makers, researchers, industrialists, academicians, students and children into one forum. It is perhaps the rarest Conclave covering almost all possible research themes. For better readability, the Proceedings have been divided into 15 volumes, but each volume reflects diversity in terms of topics and researchers. The only common thread is the sustainable development of North-East India. Invariably, Sustainable North-East India is a prerequisite for sustainable India and the whole world. In that sense, these 15 volumes will serve guiding and stimulating light for all the

stakeholders of the development. I am pleased to dedicate these volumes to the nation as a part of Azadi ka Amrit Mahotsav.

T. G. Sitharam
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Preface

Human Society and culture can be considered a continuously evolving, complex, and intelligent system. It is incredibly challenging to bring sustainable change in such a complex system without innovative new ideas. In the modern complex world, human social needs have become highly volatile, dynamic, and critical for human survival in an ever-changing challenging environment across all social domains, such as education, health, environment, politics, economy, spirituality. The social needs of humans today are exacerbated by extremely unbalanced regional economic development and cultural identity crises across the globe and within the states.

The innovative design practices focused on meeting social needs have become the need of the hour and an inevitable part of modern human life. Today's complex problems need critical thinking and execution of ideas into reality to propose effective solutions to social needs. Innovative design solutions based on a thorough understanding of societal requirements can bridge the gap between privileged and underprivileged strata of society, promote global peace and harmony, and provide a better place to live and survive. Innovative social innovation shall be everywhere from grass root level to the top administrative levels. It must possess the ability to create what's new and lead to various changes through the creative design process. It will connect, integrate, simplify, identify, and convey meaning to visualize the unimaginable; to build and introduce order through beauty and elegance to cater to diverse human social needs.

Social change requires modifications to human relationships, behaviors, and societal institutions. Design is uniquely positioned to support social change through its methods, philosophies, and focus on innovation. Designers and design researchers work on understanding socio-cultural phenomena to identify the right societal problems to solve. They develop innovative social programs, services, and policies using tools of creativity and empathy. This edited book presents cutting-edge research on how design innovation can be leveraged to bring sustainable and meaningful social

change. It also provides novel directions for future researchers interested in exploring the impact of design innovation and designerly thinking on human society.

Guwahati, India

Sougata Karmakar
Pratul Chandra Kalita
Urmi R. Salve
Sharmistha Banerjee

About IIT Guwahati

Indian Institute of Technology (IIT) Guwahati established in 1994 has completed 25 years of glorious existence in 2019. At present, the Institute has 11 departments, seven interdisciplinary academic centres and five academic schools covering all the major engineering, science, healthcare, management and humanities disciplines, offering B.Tech., B.Des., M.A., M.Des., M.Tech., M.Sc., and Ph.D. programmes. The institute presently offers a residential campus to 435 faculty members and more than 7500 students at present. Besides its laurels in teaching and research, IIT Guwahati has been able to fulfil the aspirations of people of the North-East region to a great extent since its inception in 1994. The picturesque campus is on a sprawling 285 hectares plot on the north bank of the Brahmaputra, around 20 km from the heart of the Guwahati city.

IIT Guwahati is the only academic institution in India that occupied a place among the top 100 world universities—under 50 years of age—ranked by the London-based Times Higher Education (THE) in the year 2014 and continues to maintain its superior position even today in various International Rankings. IIT Guwahati gained a rank of 37 globally in the 'Research Citations per Faculty' category and an overall 384th rank in the QS World University Rankings 2023 released recently. IIT Guwahati has retained the 7th position among the best engineering institutions in the country in the 'India Rankings 2021' declared by the National Institutional Ranking Framework (NIRF) of the Union Ministry of Education. IIT Guwahati has been also ranked 2nd in the 'Swachhata Ranking' conducted by the Government of India. Recently, IIT Guwahati has been ranked as the top-ranked University in 2019 for IT developers by HackerRank in the Asia-Pacific region.

Among other frontier areas of research and innovation, IIT Guwahati is working towards augmenting critical science research initiatives in Genomics, Developmental Biology, Health Care and Bioinformatics, Flexible Electronics, Advanced Functional Materials, Sustainable Polymers, Rural Technologies, Renewable Energy, Artificial Intelligence, Disaster Resilience and Risk Reduction, and Water Resources and Management. In its silver jubilee year, IIT Guwahati is poised to scale newer heights through all-round growth and development.

Indian Institute of Technology Guwahati has dedicated itself to the cause of improving and empowering Northeast India through cutting-edge research, region relevant projects, innovations, individual and multilateral collaborations, and special initiatives. Being the only IIT in the entire Northeastern region, IIT Guwahati has an immense amount of responsibility to develop the region and empower the people of the region.

While the entire country is celebrating the 'Azadi ka Amrit Mahotsav'—75 glorious years of Independence, and the great pride with which our nation of more than a billion people has been steadily growing today, IIT Guwahati is strongly committed to supporting that pace of growth for the entire NE so that we can keep pace along with the rest of the country. The specific areas of focus where IIT Guwahati has been contributing immensely to the region are:

(a) Infrastructure development across multiple sectors.
(b) Providing solutions for multiple natural disasters such as recurring floods, landslides, earthquakes, cyclones, hailstorms and other natural calamities.
(c) Improving the education sector and creating opportunities for employment.
(d) Internet, telecommunication and cultural integration.
(e) Technological intervention in interdisciplinary areas.
(f) Healthcare services and education.
(g) Renewable energy generation (solar, wind, biomass, hydro, geothermal).
(h) Overall industrialization, refining fossil fuels and setting up biorefineries.

Besides bringing in state-of-the-art technical know-how for most of the above sectors, the institute has been partnering with the local governments and enhancing the technological and educational interactions such that the next generation of youth is empowered with knowledge, skills and necessary entrepreneurial ability. These measures in Assam as well as all other northeast states will usher in a new era of growth and the opportunities it will provide for interaction with the ASEAN countries as part of the Act East Policy of the Government of India will bring prosperity to this region.

Prof. Parameswar K. Iyer
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North East Research Conclave-2022: Toward Sustainable Science and Technology

It is extremely important and imperative to have knowledge-driven growth based on innovation in the case of academic higher education institutes of high repute. The North Eastern region endowed with rich biodiversity comprises eight states. However, the climatic conditions, limited connectivity, lack of research infrastructure/institutes, territorial conflicts and the mountainous terrain of these regions are major impediments to the research ecosystem in the North-East. Quality higher education focusing on industry-academia collaboration and translational research is extremely beneficial for society. It has also been rightly pointed out by the Hon'ble Prime Minister Shri Narendra Modi that, "*India cannot develop till Eastern India develops*".

With this idea and as India marks 75 years of Independence, Indian Institute of Technology Guwahati organized "The North-Eastern Research Conclave" from 20 to 22 May 2022. This grand event was jointly conducted with Science, Technology and Climate Change Department and the Department of Education, Government of Assam at IIT Guwahati Campus.

The mission behind the conclave was to showcase the best R&D activities from educational and research institutions across North-East India and to create an environment, conducive to development of local indigenous technologies and innovations, creating the scope and laying the foundation for entrepreneurship.

In order to attract people and spread awareness about the event, a roadshow was initiated from IIT Guwahati on 7th May 2022 in order to reach all the partnering academic institutes and make them an integral part of the mega event. The Director, IITG waved the NERC-2022 flag and sent off the road show vehicle from the institute. More than 400 students, staff and faculty participated actively in the roadshow.

A huge response was received by participants from throughout the country. The total number of Participating institutions in this conclave included 7 IITs, 10 NITs, 5 IIITs and other CFTIs, 23 Research Labs, 17 Central Funded Universities, 47 other Universities/Institutes along with about 100 schools. Eminent personalities from industries, start-ups, research councils and PSUs also joined in.

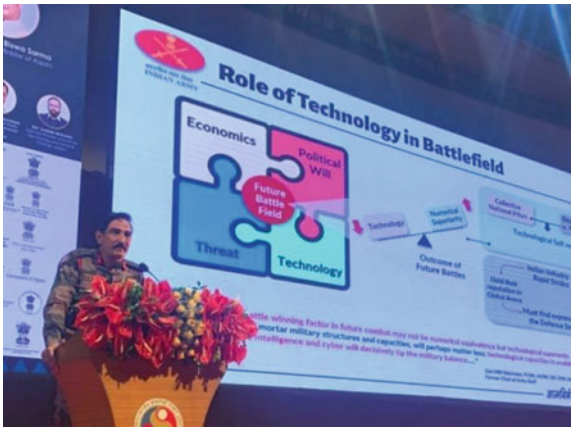
The presence of dignitaries from important Ministries was observed such as Shri Dharmendra Pradhan, Hon'ble Union Minister of Education and Minister of Skill Development and Entrepreneurship, GOI; Dr. Himanta Biswa Sarma, Hon'ble Chief Minister of Assam State; Dr. Ranoj Pegu, Hon'ble Minister of Education, Government of Assam; Dr. Rajkumar Ranjan Singh, Hon'ble Minister of State for Education,

GOI; Dr. Subhas Sarkar, Hon'ble Minister of State for Education, GOI; Shri Keshab Mahanta, Hon'ble Minister of Science Technology and Climate Change, Government of Assam and many more.

The inauguration ceremony of the conclave was followed by the signing of an MoU between IIT Guwahati and the Government of Assam to establish 'The Assam Advanced Health Innovation Institute (AAHII)'. This MoU would prove to be a unique partnership between the Government of Assam and IIT Guwahati in order to set up a Research Institution to leverage advanced technologies to transform medical science. This joint venture company will be able to invite participation from intending parties including corporates/businesses/research institutions and philanthropic organizations.

The third edition of Assam Biotech Conclave 2022 was also held as part of NERC 2022. It brought together the Biotech Entrepreneurs, industry leaders, researchers, academicians, Government Representatives, policymakers, innovators and investors together on one platform to explore the possibilities of Biotechnology in North-East India and to discuss the new opportunities in the transition.

Officers from the Indian Army also actively participated in the Conclave. A talk on "Atmanirbhar Bharat—Indian Army Initiatives towards Self Reliance" was delivered by Lt. Gen. D. S. Rana AVSM, YSM, SM General Officer Commanding, Gajraj Corps on 21st May 2022. The talk was aligned with the vision of the apex leadership of the Government of India and initiatives undertaken by the Indian Armed Forces with a focus on the integration of civil-military establishment in the field of self-reliance. He also elucidated that institutions such as IIT Guwahati which has many running research projects and elaborate student exchange and joint collaboration setup with a large number of Countries have the wherewithal to take up defence-related R&D and also facilitate delivery with Industry Partners. He also invited IIT Guwahati to participate in EAST TECH Symposium planned at Kolkata in July 2022. This led to the signing of an MoU between Indian Army Eastern Command and IIT Guwahati on 7th July 2022 during East Tech 2022. This would further impetus to Indigenisation and Raksha Atmanirbharta.



Royal Society of Chemistry, Global battery experiment was performed by more than 1300 students in three sessions starting from 20 May to 22 May at IIT Guwahati. Along with the Global Battery Experiment, Creating Skilful Educators (Teacher training programme) was also conducted in parallel sessions. Students had arrived from various schools across Assam and other North-Eastern states.

The Guwahati Declaration was launched at the valedictory ceremony of the conclave by Shri Lok Ranjan, Secretary, Ministry of Development of North Eastern Region (DoNER), in the presence of Shri Kailash Karthik, Deputy Commissioner, Kamrup. The Declaration is intended to create a set of guidelines, through which individual as well as a collective responsibility to promote and encourage innovation at the grass-root level and strive to stimulate and execute indigenization and entrepreneurship, can be taken up.

Science, education, research and innovation are the four pillars on which the development, as well as the work culture of a nation, rests. This was well articulated by the promising number of Exhibitors being seen participating from all across the NE states in the NERC 2022. All the NITs, CFTIs and CFIs were allocated two stalls each, where the delegates showcased the working models of their inventions. Distinctive pavilions were arranged for IIT, NIT, CFIs and CFTIs. Excellent response was obtained from the Start-Ups all across the NE states. Federation of Industry Commerce of North Eastern Region (FINER) had partnered with NERC-2022 as an Industry Partner and they showcased 50 start-ups as a part of the Exhibition under the FINER Pavilion. Other significant organizations that came forward to showcase their allied R&D start-ups were the Oil and Natural Gas (Oil and Natural Gas Pavilion), Indian Army (Defense Pavilion) and NE-Railway (NE-Railway Pavilion).

Multifarious research work on topics of societal relevance was presented by researchers from different organizations/institutes. The presentations were conducted in oral and poster presentation modes. The thematic areas for these presentations were part of some of the Sustainable Development Goals (SDGs) such as SDG-3: Good health and wellbeing; SDG-7: Affordable and Clean Energy; SDG-9: Industry, Innovation and Infrastructure; SDG-11: Sustainable cities and communities and SDG-12: Responsible consumption and production. Some of the papers highlighted environmental sustainability, efficiency and management issues, which are important to be presented in the case of North East regions. Two awards were given under each technical category for these presentations. Overall the technical sessions were a grand success due to the active cooperation from editors, chairpersons of all the sessions and student volunteers of IITG.

The government of India has taken various steps to encourage women in the field of science and technology. In this line, the IIT Guwahati Woman Researcher Award was approved to recognize the contribution of women Faculty members of IIT Guwahati fraternity. This prestigious award was conferred to Dr. Latha Rangan who is a Senior Professor in the Department of Biosciences and Bioengineering, Indian Institute of Technology Guwahati, India. Professor Rangan has played a key role in Plant Biotechnology and Sustainable development and especially in the areas of energy security, food security and medicinal crops.

The Conclave paved the way for creating mass awareness of Research and Innovation for developing a sustainable society. There was knowledge exchange and dissemination that led to the establishment of Centres of Excellence in Translational Collaborative Research and Innovation. This mega event led to the bridging of the gap between Industry-Academia and Creating Hand holding Pathways for setting up long-term collaboration for R&D innovations towards the goal of establishing sustainable NE India. The Conclave brought together over 8000 participants including Hon'ble Ministers, Official Bureaucrats, Eminent Professors, Scientists, Renowned Industrialist, School Children/Teachers and Others delegates. This revolutionized the R&D road map of all the NE states through various dissemination of policies which will benefit the sustainable development of all NE states in near future.

It is an honour and a moment of extreme pride for getting the NERC proceedings published in the prestigious Springer volumes. We would like to thank and acknowledge the globally active publisher Springer for helping us being able to publish the

articles on 15 broad areas. We would also like to thank all the authors for their contribution to the grand success of NERC 2022 and wish them great success in all of their future endeavours.

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From the Desk of Chairman of Technical Committee of NERC 2022

North-East Research Conclave 2022 was successfully organized on May 20−22, 2022 with the participation of thousands of delegates. A total of 879 oral and poster papers were presented at the conference on 16 different tracks. The theme of the Conclave was Sustainable Science and Technology, which is very pertinent in the modern era of globalization. Science and technology has to address economic, environmental and social problems of the world. Technology and sustainability are not incompatible. In fact, technology can achieve the goal of sustainability, which also includes preserving our rich cultural heritage. Concurrently with the North-East Research Conclave (NERC), the Assam Biotech Conclave 2022 was also organized on May 21–22, 2022. These mega-events were organized at the Indian Institute of Technology Guwahati (IITG) in physical mode after two years of the pandemic period. Along with IITG, Science, Technology and Climate Change Department and Department of Education, Government of Assam, were also organizers of these events under the patronage of Shri Dharmendra Pradhan Ji, Honorable Minister of Education and Minister of Skill Development and Entrepreneurship in the Government of India, and Shri Himanta Biswa Sarma Ji, Honorable Chief Minister of Assam.

It is a matter of great pleasure that Springer Nature is publishing the select papers from the conclave in 15 volumes. These are Advanced Functional Materials, Low-Cost Manufacturing Technologies, Agro and Food Processing Technologies, Artificial Intelligence and Data Science-based R&D interventions, Conservation of Biodiversity in the North Eastern States of India, Disaster Management, Healthcare Research and Related Technologies, Innovative Design for Societal Needs, Policies for Research and Innovation, Research and Innovation for Sustainable Development Goals, Sustainable Environment, Sustainable Energy Generation and Storage, Sustainable Transportation and Urban Development, Teaching and Learning Technologies, Technologies for Rural Development. These volumes are useful archival and reference materials for policy-makers, researchers and students.

As the Chairman of the Technical Committee, I am thankful to all Editors of all volumes, reviewers and student volunteers who have put tireless efforts to review, select and edit the papers of respective divisions, overcoming the time constraints.

Support provided by Convener, Prof. Vimal Katiyar, Dean R&D, IITG, and Co-conveners Prof. Subhendu Sekhar Bag, Associate Dean R&D, IITG and Shri Kailash Karthik N., IAS is commendable. It is difficult to express words of gratitude for the Director, IITG, Prof. T. G. Sitharam who has been motivating and guiding all the teams of NERC 2022 and ABC 2022.

Uday S. Dixit
Professor
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About the Editors

Dr. Sougata Karmakar is a Professor and HoD of the Department of Design at the Indian Institute of Technology (IIT) Guwahati, India. He gained research expertise in the field of Ergonomics/Human Factors from DIPAS, Defence Research, and Development Organization (DRDO), Delhi (November 2004–November 2009) and received the Ph.D. degree for his work on 'virtual ergonomics using digital human modeling.' He received P.G. Diploma in Management (Specialization-Human Resource Management) from Pondicherry University. He is associated with a well-equipped 'Ergonomics Laboratory' at the Department of Design, IIT Guwahati, and continuing his research work in Ergonomics/Human Factors. His research interests include Physical Ergonomics (Product and Workstation design), Cognitive Ergonomics (Information processing), Design and work environment, Design, and Occupational Health, Virtual Simulation (CAD and Digital Human Modeling), etc. Total ten (10) research scholars/Ph.D. students have been awarded Ph.D. degrees, and another eight (08) students are presently pursuing their doctoral research under his guidance. Dr. Karmakar has conducted many workshops/webinars related to Ergonomics/Human Factors, Occupational Health and Safety, and Industrial Design in India and abroad. He has published 44 research papers in international journals and 48 research papers in various referred international conference proceedings with ISBN. He is contributing as reviewer for various international journals of repute. One (01) US patent and 12 Indian patents (2 utility patents and 10 design registrations) have been granted for his IPR work.

Dr. Pratul Chandra Kalita is a Professor in the Department of Design at the Indian Institute of Technology (IIT) Guwahati, India. He has widespread Industrial and Academic experience in the field of design, technology and management. He obtained Ph.D. in Design from Indian Institute of Technology Guwahati in the area of Design Management. He did Bachelor of Engineering in Production Engineering and Management from National Institute of Technology, Jamshedpur, followed by Master of Marketing Management from Pondicherry University (Central University). He served for JMT Auto, Jamshedpur in CNC manufacturing and control; BOC India (now Linde Group), in design and erection of air separation and hydrogen plants.

He is one of the founder members of Acumen Consultancy Services, Kolkata. Prior to IITG, he was an assistant professor in Assam Institute of Management, Guwahati with focus area of Management Research Methodology, Product Design and Development and Operations Management. He has been instrumental in establishment of industry institute partnership in the North Eastern region of India. He has provided consultancy services to the Government of India, Government of Assam and many private organizations of repute. At present he is engaged in number of research and consultancy projects. Recently he has completed the diagnostic Study on Weaver's need in respect of Eri and Muga Silk' under the World Bank financed Assam Agribusiness and Rural Transformation Project (APART). The world Bank is keen to implement the design management strategies formulated in the study. He has provided design management consultancy to the Ministry of Textiles at Sivasagar Mega Handloom Cluster Development project. He has done prestigious IMPRINT project sponsored by MOE and ICMR on system design for Tuberculosis Programme Administration. His recent projects include Impact Assessment Studies for Roads, Bridges and Irrigation projects funded by NABARD, Prime Minister Entrepreneurship Generation Programme, Prime Minister Rozgar Yojna, Swarna Jayanti Shahri Rozgar Yojna, etc.

Dr. Urmi R. Salve is an Associate Professor in the Department of Design at the Indian Institute of Technology (IIT) Guwahati, India. She obtained Ph.D. in Science (Ergonomics) from Calcutta University and has expertise in Human Factor Engineering, Research Methodology, Cognitive Ergonomics, Occupational Health Related Problem, Human Physiology, etc. She has more than ten years research experience in the field of ergonomics and human factors engineering in different research bodies including TIFAC–CORE NITIE, National Institute of Industrial Engineering, Mumbai, India. She further worked in the field of Occupational Hygiene at National Institute of Miners' Health, Department of Mines, Government of India. She has more than 60 full study and abstract publication on the national and international journals and conference proceedings. She has attended and organized numerous conferences and workshops, written study materials on the concerned subjects and lectured on various institutions.

Dr. Sharmistha Banerjee is an Assistant Professor in the Department of Design at the Indian Institute of Technology (IIT) Guwahati, India. She obtained Ph.D. is in Design for Sustainability in the arena of scale-appropriate agricultural equipment design from IIT Guwahati. She did her bachelor's in Industrial Design from IIT Guwahati and master's in Integrated Product Design from Technical University of Delft, Netherlands. She is a co-founder of the Sustainability and Social Innovation Lab at Department of Design, IIT Guwahati. The lab focusses on creating systems for sustainable human consumption and production through a complete revamp of the consumption structure with design interventions. In the past few years, she has worked in India, Bangladesh and Netherlands with companies like Philips, Infosys, MIDCO, VU Medical University Amsterdam, Conpax Verpakking, Beat Belly, Botanische Tuin Delft, ACC Ltd., educational institutes like IIT Guwahati,

MIT Institute of Design Pune, IDC, IIT Bombay and L'Ecole de Design (Indian Operations), Nantes-Atlantique, France and NGOs like International Development Enterprise Bangladesh.

Innovative Hand-Tool Design for Cleaning of Slippery Floor and Broken Glass Pieces in Shopfloor of FMCG Sector

Gurdeep Singh and Sougata Karmakar

Abstract The effective housekeeping and management of the slippery wet floor is a tedious and challenging task generally witnessed in the Fast Moving Consumer Goods (FMCG) manufacturing units engaged in manufacturing personal care products, viz., detergents, shampoo, oil, etc. The context-specific particulates like broken pieces of glass resulting from bottles falling from conveyor belts add to the housekeeping staff's miseries. In the wake of inadequate tools for such tasks, housekeeping workers resort to collecting oil-drenched glass pieces with traditional trash lifting tools, which are not efficient for handling such mixed trash. The broken glass pieces tend to hurt the housekeeping personnel by injuring their hand and forearms with sharp cuts and injuries. As such, there lies a dire need to devise innovative tools for this context-specific housekeeping activity of prime concern on the FMCG shopfloor. In the current research, by deploying a proactive participatory design process for context-specific product design and development, the researchers have come up with an innovative hand tool that can provide feature-rich help and aid, particularly in the effective management of wet slippery floors engaging broken glass pieces. It can act as a mitigating solution to the existing safety concerns and promote safety thereof in specific FMCG work activities/tasks. This paper thus can act as a ready reckoner for industrial designers/engineers to devise other such innovative tools and apparatus for catering to the need for specific work activities related to the FMCG shopfloor.

Keywords Industrial ergonomics · Kaizen · OHS · Industrial safety · Innovative design · Product innovation

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1 Introduction

In a developing country like India, addressing social needs through design innovation is the need of the hour. To ensure better Occupational Health and Safety (OHS) and the common people's social well-being, including those engaged in diverse industrial sectors, the innovative hand tool design or context-specific device/apparatus may prove beneficial and highly relevant. Such hand tools considering task requirements while ensuring comfort and decent work through design intervention are highly encouraged to provide a quality life.

In modern times, across the globe, the Fast Moving Consumer Goods (FMCGs) fulfill the daily consumption needs of the vast population with their varied products ranging from food, beverage, household goods, etc., that are better known as groceries [1]. The FMCG sector provides firm support to each country's Gross Domestic Product (GDP) growth and employs the vast majority of the population within their respective nations [2]. In developing nations, the FMCG manufacturing units tend to be highly labor-intensive, witness cumbersome man-machine interfacing and are prone to several ergonomic stressors and OHS issues emerging due to the ill-planned/maintained man-machine interface [3].

Specifically, in the Indian scenario, most FMCG manufacturing lies in personal care product manufacturing, viz., hair oil, shampoo, detergents, etc., that are generally filled in pouches, sachets, plastic, or glass bottles. In addition, the Indian FMCG industry engaged in food processing items like jams, squash, sharbat, etc., utilizes glass bottles for packing liquid content [2]. These products are manufactured on extremely high-paced assembly lines, often being run at a pace exceeding the human capabilities to produce a large number of products on day to day basis. Such a scenario leads to deteriorating worker health and other OHS issues. Moreover, the peculiar work activities of the FMCG sector are prone to other work-related ergonomic stressors and OHS issues [1]. The FMCG manufacturing units engaged in manufacturing liquid-filled pouches/sachets, plastic bottles, and glass bottles of varying sizes often witness the liquid spills over the shop floor as a result of vibration, turbulence, knocking of bottles with each other being fed over the assembly line at a pace of 140 bottles per minute (bpm) or more. In the case of glass bottles being fed at such a high pace, sometimes, bottles get broken by falling from the conveyor on the shopfloor while the inspection worker tries to take out the defective glass bottles (half-filled, bubble-filled, improper labeled bottles) swiftly out of the running assembly line. At packing stations, the falling of glass bottles is quite common. It leads to slippery floors mixed up with broken glass pieces [3].

In general, managing the slippery wet floor is a challenging task for factory management as there lies a paucity of context-specific tools for cleaning oiled surfaces. Along with the particular case of broken glass pieces, it becomes a tedious job to manage and leads to OHS issues. In the wake of inadequate tools for such tasks, housekeeping workers resort to collecting oil-drenched glass pieces with traditional trash lifting tools, which are not efficient for handling such mixed trash [3]. The broken glass pieces tend to hurt the housekeeping personnel by injuring their hand

and forearms with sharp cuts and injuries. As such, there lies a dire need to devise innovative tools for this context-specific housekeeping activity of prime concern on the FMCG shopfloor.

Several researchers have proposed to design and develop various context-specific innovative tools to cater to the needs of the varied work activities in several domains [4–7]. These tools shall thoroughly consider ergonomic and design principles to develop an efficient mitigating solution for OHS issues identified. In the current paper, the researchers by means of one case study, have elucidated the complete process of design and development of an innovative tool for the effective management of wet slippery floors drenched with broken glass pieces. The intended research goal is especially interesting for industrial engineers, safety engineers, and factory management looking for ergonomic design-related planning and execution to promote better OSH and workplace productivity. This paper can act as a ready reckoner for industrial designers/engineers to devise other such innovative tools and apparatus for catering to the need for specific work activities related to the FMCG shopfloor.

2 Brief Methodology

Initially, the survey of several FMCG industries within northeast India was conducted to understand the peculiar work activities of the FMCG sector. Several work activities prone to OHS risks and other ergonomic stressors were identified. Discussions were held among the various stakeholders, viz., workers, supervisors, and higher factory management, to prioritize and understand the areas of concern. 21 housekeeping workers and 09 safety managers from 05 different manufacturing units were interviewed, and questions related to injury occurrence, the severity of the injury, currently adopted measures for the medical ailment, etc., were asked. The area of concern was prioritized based on insights gathered from these interview data. Post-prioritization, distinctive needs, and requirements of the intended features to be incorporated into the probable design interventions were brainstormed among all the stakeholders. Post-brainstorming number of concepts were generated/conceptualized by the researchers based on user needs (identified earlier) by developing the morphological chart [8]. The researchers did further concept selection and screening by comparing, evaluating, and screening the concepts generated earlier using the Pugh concept selection matrix [9]. Afterward, the digital prototype of the finally selected concept was developed in Computer-Aided Design (CAD). Further, the virtual ergonomic analysis for various parameters was conducted using Digital Human Modeling software (DHM) to determine its user anthropometric and biomechanical compatibility [10, 11].

3 Innovative Tool: Design and Development Process

In general, a product development process is a set of several systematically performed activities deployed to conceptualize, design, and commercialize a new product [12]. It generally consists of two broad phases, viz., "ideation" (consisting of customer need identification, concept generation, and concept selection) and "prototyping" (consisting of detailed design, prototype testing, refinement, and final production). The present research has deployed a user participatory design approach [13] to design and develop an innovative housekeeping tool named "glass shard picker" for the FMCG shopfloor. The researchers have proactively used the participatory design approach's basic fundamentals, viz., public information, design workshop, and feedback throughout the design and development process [14]. The activities performed in this journey are discussed in detail in the following sub-sections.

3.1 Initial Survey of the FMCG Shopfloor and Understanding the Work Parameters

Foremost, the information regarding the FMCG manufacturing units proactively working in North-east India was gathered from electronic sources (government websites, e-gazettes, electronic reports, etc.). The noticeable FMCG units were identified and approached for conducting ergonomic audits to identify prevailing ergonomic stressors and operational bottlenecks to productivity. Formal permissions with the execution of Non-disclosure Agreements (NDAs) were obtained, and rigorous ergo-audits were conducted for six months, deploying a participatory approach. With the active involvement of various stakeholders (workers, safety managers, factory management, etc.), several work activities prone to OHS risks and other ergonomic stressors were identified. Effective housekeeping of wet slippery FMCG shopfloors drenched with glass shards was one of the most common and critical work activities that required immediate attention and mitigating solution to improve the existing working conditions. The housekeeping activities were minutely observed to identify the key work parameters to better understand the nature of work, cause of the incidents, and safety risks involved, and have insights for probable solutions. Figure 1 describes the key work parameters and various stages involved in such activity.

Generally, the FMCG products (jams, jellies, squash, juices, detergents, hair oil, shampoo, etc.) are prepared/made on high-speed assembly lines and packed in glass bottles and plastic bottles, pouches, sachets, etc. As such, FMCG manufacturing is alternatively known as the "make and pack" industry. For several reasons, the falling of filled glass bottles from high-speed assembly lines is quite common upon the FMCG shopfloor engaged in filling up the liquid/semi-liquid content within the glass bottles (Fig. 1a). Once the glass bottle falls upon the shopfloor it breaks into fine glass particles and shards, and the liquid content contained within it spoils and

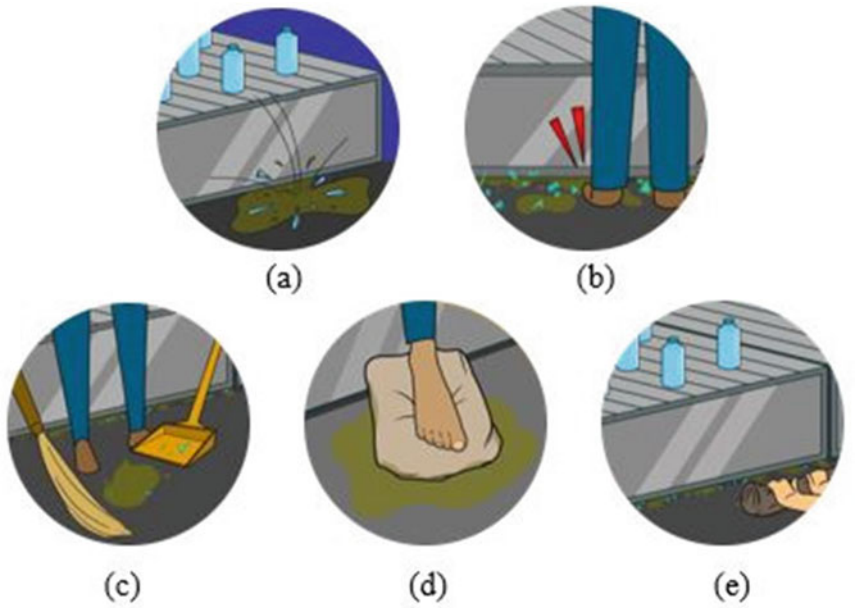


Fig. 1 A typical housekeeping activity at the FMCG shopfloor. *Source* Author

drenches the glass shards (Fig. 1b). This drenched solid trash collection and disposal becomes a major challenge for the workers engaged in housekeeping tasks as no standard and dedicated apparatus/tool exists for such scenarios. In the absence of a dedicated tool for this peculiar activity, the housekeeping staff is compelled to use the traditional methods of trash collection and floor cleaning, viz., dustpan and broom (Fig. 1c). With a dustpan, the bigger broken glass pieces are collected; however, the finer glass pieces still remain in the liquid spilled on the floor. Further, the fine mopping for wiping out the spilled liquid containing fine pieces of broken glass is required. The housekeeping staff tends to clean and mop with the wet cloth in several ways as per ease (Fig. 1d, e). These traditional methods adopted are often ineffective and lead to several safety issues like cuts and injuries to the hands, forearms, etc., of the workers due to sharp-edged glass shards.

In such a situation, it is apt for the researchers and other stakeholders to thoroughly examine this critical activity and propose context-specific apparatus/tools as a mitigating solution. A proactive participatory design process (actively engaging all concerned stakeholders at various stages of the design/development of an innovative product) may help in devising context-specific interventions that may be behavioral, organizational, or design related. Especially in product-related interventions, the systematic and intelligent incorporation of various design and ergonomic principles may lead to devising an effective solution for improving the existing conditions.

Table 1 Qualities/functions desired in an anticipated product

Desired qualities		Desired functions	
· Easy operability · Easy to transfer from one place to other · Easy maintenance (in-house) · Non-contaminating (rustproof) · High effectiveness · Commercial viability (mass production) · Ergonomic posture adoption · Safe to use (no sharp edges, critical high-speed moving parts) · Unisex usage	· Lightweight · Easy to store · Easy to assemble/ disassemble · Lesser wear and tear · Vibration less/high stability · Durable · Aesthetically designed · Simple in construction (not many complex mechanisms) · Cost-effective – Rs. 500–1000 for non-powered apparatus – Rs. 3000–5000 for powered apparatus	· Convenient glass shard picking · Effective cleaning of wet/oiled surfaces · Easy to maneuver · Easy to engage/ disengage · Splash proof · Easy collection of drenched trash · Easy operation–standing/ bending	· Effective temporary collection of the trash (before throwing it away at designated places) · Easy to grip · Easy to hold and lift · Capable of reaching under confined spaces · Less force consumption · Easy working (unskilled worker)

Source Author

3.2 User Need Identification

In order to devise an effective, innovative apparatus/tool as a mitigating solution, it is of utmost importance to thoroughly understand the need and requirement of the task under consideration. A minute and careful assessment of the elements involved in performing the task within the intended system is essentially required. At the pre-conceptual stage, an in-depth understanding of the intended use pattern, desired qualities, desired functions/capabilities, etc. helps generate a wide variety of probable solutions for the problem under consideration.

For this purpose, several brainstorming sessions, interviews, and formal/informal discussion sessions were held among the stakeholders (to decide and affirm the intended features of the "glass shard picker" to be developed. Table 1 depicts the intended product's mutually agreed upon desired qualities and functions.

3.3 Concept Generation

Having insights from the key understanding of the essential work parameters involved, desired qualities, and function, the overall required functioning of the intended "glass shard picker" was fragmented into further required sub-functions deemed necessary to fulfill the overall desired function. For the current product under consideration, six sub-functions were identified as: (1) Glass shard collection,

(2) Oiled surface cleaning, (3) Intermediate storage of the trash, (4) Mobility of the apparatus, (5) Hold and reach, and (6) Energy source for apparatus action.

To fulfill these sub-functions, different options had to be accessible. The options available for each of the sub-functions were then identified and recognized as sub-components. Based on these, a Morphological chart (Fig. 2) depicting various sub-functions and options available to perform that sub-function was developed. Such a chart was developed for ideating the various concepts of the "glass shard picker".

The amalgamation of different sub-components under different sub-functions to come up with the "glass shard picker" is shown in the Table 2. The morphological chart and the amalgamation of sub-components proposed twelve new concepts (Figs. 3, 4 and 5) of the intended "glass shard picker". For example, concept sketch 1 was developed by the following amalgamation: (1,1) + (2,4) + (3,3) + (4,3) + (5,2) + (6,3).

As depicted, each of the concepts was obtained from a combination of one option (sub-component) for each sub-function. A brief description of each concept is given below:

- **Concept 1**: This is a handheld telescopic stick-based concept. It has two sticks merged with one another at the point of the telescopic junction. The front stick has the trash collection tray at the bottom end of the stick capable of lifting trash,

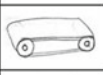
Sub Function \ Solution		Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6
Glass Shard Collection	1	 Tray	 Conveyer Belt	 Tape Roll	 Power Suction	 Heating Pad	 Rotary Suction
Oiled Surface Cleaning	2	 Fixed Rollers	 Detachable Rollers	 Wet Mop Sponge	 Wet Cloth	Heat Pad	
Intermediate Storage of Trash	3	 Integrated Tray Box	 Detachable Tray	 Separate Tray Box			
Mobility of the Apparatus	4	 Wheels	 Rollers	 Stick Lifting	 Handle Hold		
Hold and Reach	5	 Fixed Length Stick	 Telescopic Stick	 Vacuum Pipe Case	 Direct Handle	 Press/ Pull Stick	
Providing Energy for Apparatus Action	6	 3 Phase Power	 DC Power	 Manual Effort			

Fig. 2 Morphological chart. *Source* Author

Table 2 An amalgamation of a matrix for conceptual sketches

Concept	Amalgamation of the matrix for conceptual sketch
Concept sketch 1	(1,1) + (2,4) + (3,3) + (4,3) + (5,2) + (6,3)
Concept sketch 2	(1,1) + (2,3) + (3,3) + (4,3) + (5,5) + (6,3)
Concept sketch 3	(1,1) + (2,4) + (3,3) + (4,3) + (5,1) + (6,3)
Concept sketch 4	(1,1) + (2,1) + (3,3) + (4,3) + (5,5) + (6,3)
Concept sketch 5	(1,1) + (2,1) + (3,1) + (4,2) + (5,1) + (6,3)
Concept sketch 6	(1,1) + (2,2) + (3,1) + (4,1) + (5,1) + (6,3)
Concept sketch 7	(1,3) + (2,1) + (3,2) + (4,2) + (5,2) + (6,3)
Concept sketch 8	(1,2) + (2,1) + (3,2) + (4,1) + (5,5) + (6,2)
Concept sketch 9	(1,1) + (2,5) + (3,1) + (4,1) + (5,3) + (6,2)
Concept sketch 10	(1,6) + (2,1) + (3,2) + (4,1) + (5,2) + (6,1)
Concept sketch 11	(1,4) + (2,1) + (3,1) + (4,1) + (5,3) + (6,1)
Concept sketch 12	(1,5) + (2,5) + (4,4) + (5,4) + (6,3)

Source Author

and the rear stick has the provision for hanging wet cloth for floor mopping. It requires a separate box for collecting trash once that is lifted by the trash lifting tray attached to the front stick. Figure 3a depicts concept number 1.

- **Concept 2**: Figure 3b depicts the push–pull stick-based handheld apparatus for the collection of trash and mopping using two separate attachments. Initially, the tray mechanism can be loaded on the stick to collect the trash, and then a separate trash box is required for temporary storage. Then the other attachment loaded with a wet sponge can be used for mopping the cleaned surface.
- **Concept 3**: In concept 3 (Fig. 3c), the push–pull stick-based apparatus is shown. It has a trash collection tray mounted on the end of the push–pull stick, and a wet cloth can be mounted on the other ends to clean the surface by lowering the stick and collapsing the trash collection tray once the trash is lifted. It requires

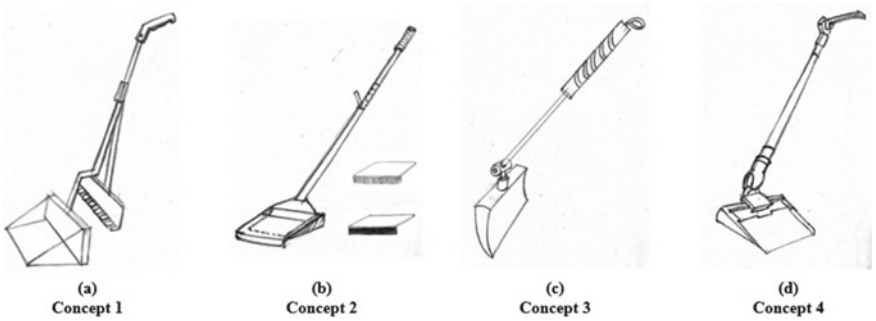


Fig. 3 Concepts generated. *Source* Author

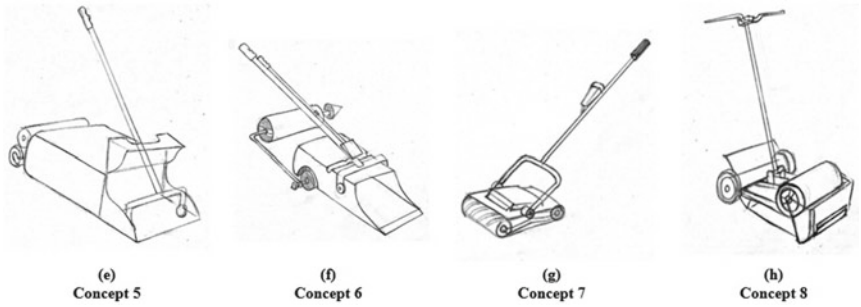


Fig. 4 Concepts generated. *Source* Author

a separate trash collection box for intermediate storage of the collected trash for dumping away at a designated place.

- **Concept 4**: This concept is based on a push–pull stick to be held in hand to collect the trash using its trash collection tray. The trash needs to be collected into a separate box before dumping. It has a fixed roller attached to the rear end of the trash collection tray for mopping purposes. Figure 3d depicts one such apparatus.
- **Concept 5**: Figure 4e describes the handheld fixed-length integrated trash box-based cleaning apparatus. It uses fixed rollers for cleaning the wet floor and the movement of the integrated trash box. Once the trash box lifts the glass shards, the attached rod is vertically pulled up, which changes the orientation of the integrated trash box, and engages the rollers on the floor to mop it easily. The integrated trash box is attached with hinges to a fixed-length stick that helps the box to move up vertically upon pulling the stick up.
- **Concept 6**: This is an integrated trash box-oriented hand-operated apparatus (Fig. 4f) meant for glass shard picking and mopping the cleared surface by engaging/disengaging the varied size rollers that can be loaded upon it by means of the roller loading stick provided with one of its wheels being used for propelling the apparatus. A specially crafted groove is provided on the top of the integrated trash collection box to affix the roller loading stick into it when the roller is not loaded into it. The smaller trash collection dustpan is affixed on the fixed-length stick of the apparatus that can be used to sweep the glass shards well into the integrated tray box.
- **Concept 7**: Figure 4g describes the telescopic stick-based handheld apparatus utilizing the tape roll mechanism to pick up the glass shards and collect those in the detachable tray box. It can be propelled on the fixed rollers, and it utilizes them for mopping the cleared surface too.
- **Concept 8**: A DC power-operated conveyor belt-based apparatus is illustrated in this concept (Fig. 4h). It utilizes the conveyor belt mechanism for glass shard picking while moving upon the wheels meant for the device's mobility action. A press-pull stick is provided to operate the apparatus in the required direction. The collected trash is stored in a detachable box that can be emptied once the job is completed.

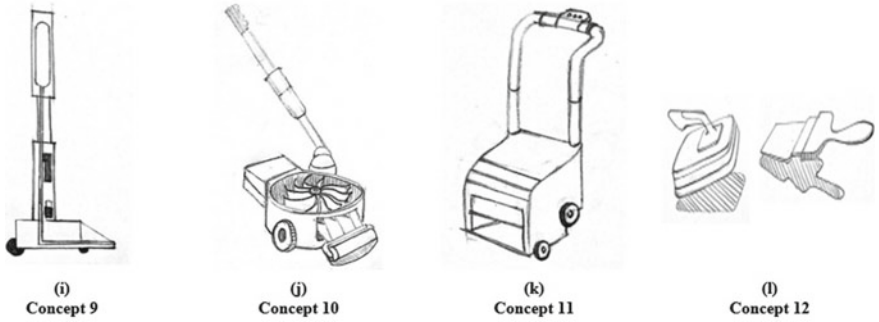


Fig. 5 Concepts generated. *Source* Author

- **Concept 9**: Figure 5i describes the DC power-operated vacuum pipe case-based apparatus used for glass shard picking. The trash can be picked up by means of its trash collection tray attached at its bottom end, and that is collected into its integrated tray. The apparatus is capable of moving on the wheels and utilizes the heat-based warm air blowing for quick drying of the wet floor.
- **Concept 10**: It is a high-power-based apparatus that is loaded with a rotary suction mechanism for the swift collection of solid trash by its rotary suction duct at the front end. A roller for cleaning the wet surface is provided there to clean the cleared surface. The trash is collected in its detachable box that can be thrown away at the end of the task. It moves quickly over its wheels to cover large surfaces. It can be operated on 3-phase power. Figure 5j describes one such mechanism.
- **Concept 11**: This concept (Fig. 5k) is a 3-phase power-operated powerful cleaning apparatus propelled upon the fixed wheels. It utilizes the power suction for sucking in the solid trash lying in front of its integrated trash collection box provided at the bottom end. It uses a vacuum pipe case as its stem and integrates it to the upper end used to hold it. The fixed rollers at its bottom mop the cleared surface.
- **Concept 12**: Concept number twelve depicted in Fig. 5l is a heating-based product meant for collecting glass shards. It has a direct handle-based pan within which the heating mechanism is provided, and the clay is provided on the bottom surface. Once the heating mechanism within the pan is heated using an external mechanism to heat, the clay softens, and the pan is kept on glass shards, and those get stuck in the clay. Another handle-based pan with a heating mechanism is used to dry the cleaned surface.

3.4 Concept Selection

Post-concept generation lies in the critical stage of concept selection. In the product development process, the concept selection stage relates to the selection of the most appropriate concept and elimination/screening of non-appropriate concepts as per

Table 3 Pugh chart

Selection criteria	Weight	Concept number											
		1	2	3	4	5	6	7	8	9	10	11	12
Easy hold and Maneuverability	**4**	–	–	–	–	**DATUM**	+	S	–	–	+	+	+
Manual operation	**3**	S	S	S	S		S	S	–	–	–	–	S
Ease of disposing trash	**3**	–	–	–	–		+	–	–	–	+	+	–
Access zone	**2**	+	+	+	+		+	S	–	S	S	–	+
Ease of maintenance	**2**	+	–	–	–		+	–	–	–	–	–	–
Cost	**1**	+	+	S	S		+	–	–	–	–	–	–
Weighted SUM of +		+5	+3	+2	+2	0	+12	0	0	0	+7	+7	+6
Weighted SUM of −		−7	−9	−9	−9	0	0	−6	−15	−13	−6	−8	−6
Net value		**−2**	**−6**	**−7**	**−7**	**0**	**+12**	**−6**	**−15**	**−13**	**+1**	**−1**	**0**

Source Author

the design objectives framed by the design team. The design team consisting of all the present stakeholders met together to evaluate and screen the several concepts generated for the intended product devolvement. The design team chose the concept "5" as the "DATUM" or reference. A Pugh Chart was deployed to evaluate the various concepts, and a decision matrix was prepared thereof. Table 3 depicts the Pugh Chart Matrix for the current evaluation.

Eventually, it is evident from the Pugh Chart that the concept "6" received the highest score of "12" and was decided to develop further as Computer-Aided Design (CAD) model and for subsequent virtual ergonomic evaluation.

Figure 6 depicts the initial concept sketches of the final selected concept. It will be taken up further for CAD model development, and the process employed is described in further sub-sections.

3.5 Virtual Mock-Up Creation

Further, the CAD development for concept "6", the best concept conceived for the intended purpose of glass shard picking and wet floor moping, was taken up as the next step in the present product design and development process. Figure 7a–c shows the various views of the product. Figure 7a depicts the "glass shard picker" in its initial position when the roller is not engaged. The rod for holding the roller (1) rests within the dedicated slot/cavity grooved upon the upper part of the trash collection

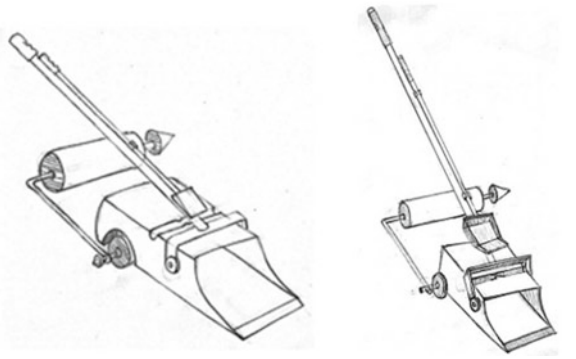


Fig. 6 Concept selected (initial sketches). *Source* Author

tray (2). Figure 7b shows the "glass shard picker" with the roller (3) attached to it for wet floor cleaning purposes. Figure 7c demonstrates the exploded view of the product developed.

For the intended purpose of the glass shard picking, this "glass shard picker" mounted on the wheels is dragged closer to the glass shards (Fig. 7a). The dustpan affixed to the smaller stick (4) mounted on the main (larger stick) (5) is used to sweep in the glass shards properly into the integrated trash collection box/tray (2) fixed on the axle moving through wheels. Varied size rollers (3) can be attached to the roller loading rod/stick (1) that touches the floor while the roller loading stick is in a disengaged position. The loaded rollers (3) move on the cleared surface to mop the wet floor and suck the greasy liquid (Fig. 7b). The trash box (2) can be lifted up in a vertical position to carry the collected trash for disposing it away at designated places. For lifting it up, the larger stick (5) is pulled upwards by means of a U-frame hinged on a trash collection box (2) that lifts up the trash box in an upward direction. Once the required job is over, this apparatus can be stored conveniently in an upward direction while the trash collection box (2) rests on its base and the roller loading rod/stick (1) is stuck into its resting slot. At the same time, the dustpan fixed to a

Fig. 7 Glass shard picker (virtual prototype). *Source* Author

smaller stick (4) also rests in its hanging slot provided on a larger stick (5). As such, this "glass shard picker" is easy to operate, handle and store.

3.6 Virtual Ergonomic Evaluation

A rigorous ergonomic evaluation is necessary for product appraisal from an ergonomic perspective and assessment of the compatibility of the developed product with its intended user population. The virtual ergonomic analysis helps evaluate and understand human factors issues (while using the product) even before developing the hardware prototype [15]. It helps to validate the design concept using Digital Human Modeling (DHM) software for a prescribed population.

The DHM analysis for the "glass shard picker" was conducted in the current research. DELMIA human modeling software was used to create digital human models/manikins using Indian civilian anthropometric data [16]. A female and male digital manikin representing 5th and 95th percentile anthropometric data respectively were developed using Indian anthropometric data. Another male model was created corresponding to 50th percentile pooled data of the Indian population. Further, the comfort joint angles of the DHM were defined using the available comfort databases [17–19]. After defining the joint angles, color coding was imparted to indicate the postural comfort and discomfort by the "green" and "red" colors, respectively. The virtual model of the "glass shard picker" was already developed as described in previous sub-sections. Digital representations of human manikins were inserted into a simulation or virtual environment and were interfaced with the virtual model of a "glass shard picker" to conduct the virtual ergonomic analysis (Fig. 8a, b).

The conceptualized "glass shard picker" model was evaluated for various ergonomic analyses, viz., vision analysis, spinal load analysis at L4–L5 intervertebral disc, balance analysis, comfort analysis, etc. The three most "to be adopted postures" while using the actual product were simulated and evaluated using all three manikins for various analyses. These postures include posture adopted while moving the "glass shard picker" in the forward direction to look for glass shards and pick those up (posture 1). The intermediary posture adopted while sweeping the glass shards into the collection tray of the "glass shard picker" using a smaller stick-enabled dustpan was labeled as Posture 2. Posture 3 corresponds to the position when the user lifts up the "glass shard picker" once the glass shards are filled up in the trash box tray.

For the vision analysis, the vision evaluation tools like vision window and vision cone were used to analyze visual requirements (Figs. 9 and 10).

The analysis revealed that the comfortable complete view of the "glass shard picker" is visible for posture 1 for all three manikins (Fig. 9a–c). It indicates that while using the present product, a varied range of populations will be able to locate and lift the glass shards lying in front of the "glass shard picker". Similarly, for postures 2 and 3, the entire portion within the trash box was visible to a varied range of populations (Fig. 9d–i). As such, the devised "glass shard picker" is capable of

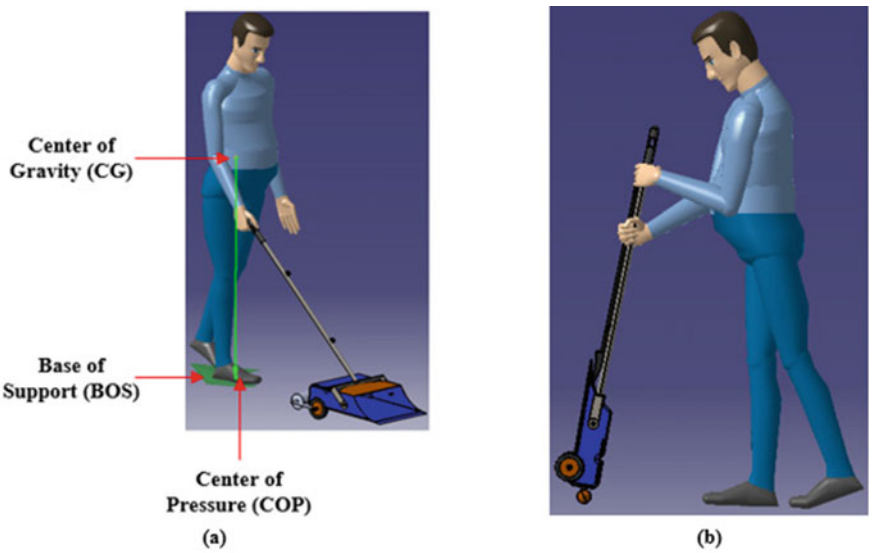


Fig. 8 Digital manikin and virtual prototype interfacing. *Source* Author

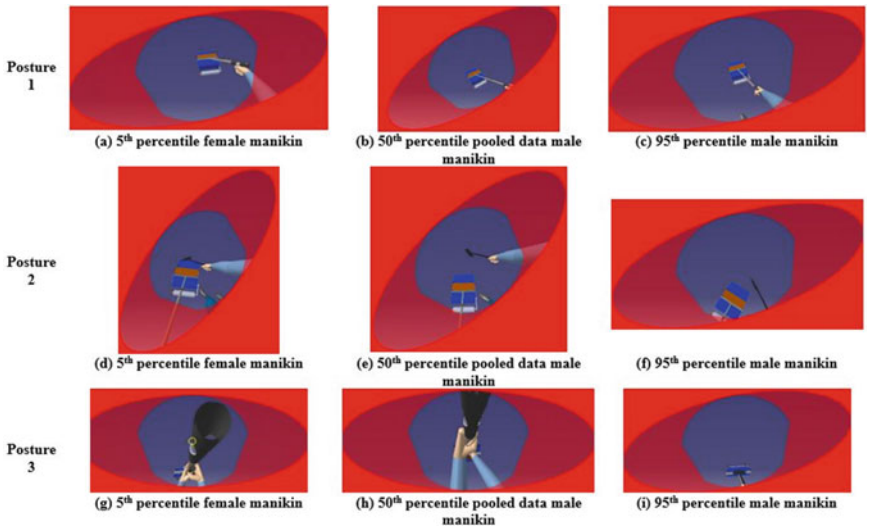


Fig. 9 Vision window for varying manikins. *Source* Author

serving the large population segment with ease. Similarly, the virtual ergonomic analysis conducted for all three postures using 15° view cone (Fig. 10a–i) revealed that the users would be able to comfortably view the glass shards lying in front of

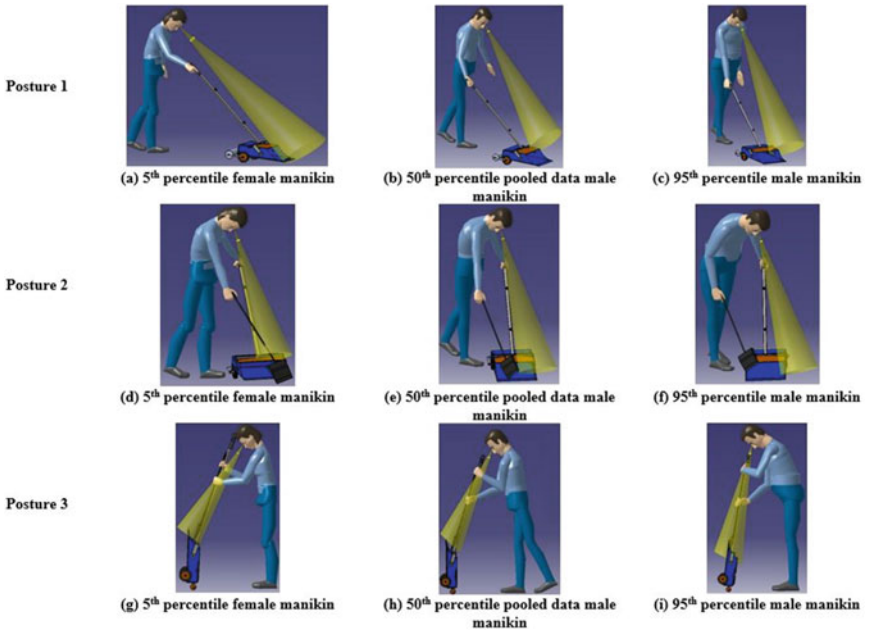


Fig. 10 15° view cone for varying manikins. *Source* Author

the "glass shard picker", and they can work comfortably using the newly developed "glass shard picker".

Mechanical load on the lumbar spine is a contributing factor to disorders of the back, including low-back pain. For early detection of the effect of biomechanical stresses, lower back compression forces, shearing forces, etc., on the intended user population, the spinal load analysis at the L4–L5 intervertebral disc can be performed in DHM. The biomechanics single-angle action analysis feature in the DELMIA software was used to perform the spinal load analysis for postures 1, 2, and 3. Figure 11 depicts the values of L4–L5 compression and L4–L5 joint shear values for all these postures for all three human manikin populations. All these values are within the permissible limits and indicate that a varied population will be able to use the product with safety and ease.

Further, the balance analysis and comfort analysis were conducted for all three postures in virtual ergonomic analysis mode.

While conducting virtual ergonomic analysis, the balance analysis can be performed to quickly find out the probable postural imbalances that might occur to the user population while using the product. DHM analysis determines the postural balance/imbalance by means of detecting the center of gravity (CG), the center of pressure (COP), and the base of support (BOS) while digital manikin is interfaced with virtual product in the intended posture under evaluation (Fig. 8a). In the current evaluation, it was found that adopted postures do not lead to any postural imbalance

Posture	Biomechanical Parameter	5th percentile female manikin	50th percentile pooled data male manikin	95th percentile male manikin
Posture 1	L4-L5 Compression	767 N	1021 N	1587 N
	L4-L5 Joint Shear	16 N	16 N	14 N
Posture 2	L4-L5 Compression	760 N	1446 N	2642 N
	L4-L5 Joint Shear	22 N	38 N	71 N
Posture 3	L4-L5 Compression	659 N	1261 N	2198 N
	L4-L5 Joint Shear	08 N	18 N	45 N

Fig. 11 L4–L5 compression and joint shear values. *Source* Author

for all the manikins as the center of pressure is within the base of support. Similarly, the comfort analysis revealed that all the manikins could perform the simulated actions without discomfort. Figure 12 illustrates one such scenario, wherein the comfort analysis conducted for postures 1 and 2 using 50th percentile pooled data male manikin reveals that the user population can comfortably use the "glass shard picker". The body parts were found to be within the comfortable zone (green color) for various degrees of freedom, viz., rotation, flexion/extension, adduction/abduction (Fig. 12a–f) for both postures.

4 Discussion and Future Scope of Work

4.1 Insights from Design Development Process

Preliminary ergo-audit conducted upon the FMCG shopfloor provided insights about the critical context-specific work activities and tasks pertaining to FMCG that are prone to OSH risks and need immediate attention of the researchers and designers, engineers to devise innovative mitigating solutions to improve the working conditions thereof for worker well-being. The current research demonstrates that the minute and careful study/observation of work parameters of the task/job under consideration leads to a better understanding of the exact needs and requirements of the user population. Based on identified needs and requirements, effective, innovative products can be designed and developed by implementing design and ergonomic principles. A detailed product design and development process, ranging from conceptualization to virtual product development and its virtual ergonomic analysis, has been demonstrated in the current research. The presently adopted methodology is in substantiation to other innovative product development techniques [12, 20]. A proactive user participatory approach was instrumental in keeping all the stakeholders involved in the brainstorming session and having their suggestions, feedback, and opinions in

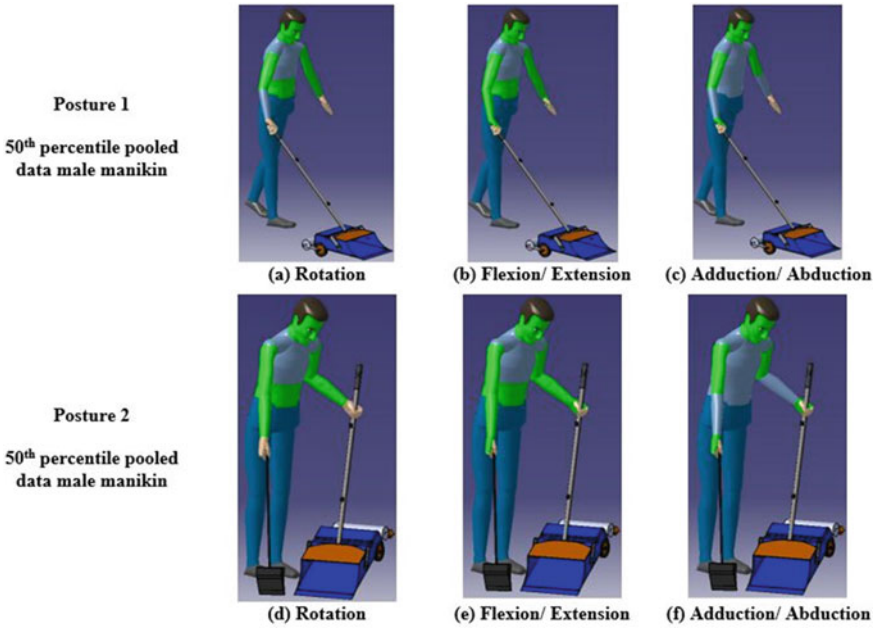


Fig. 12 Comfort analysis for posture 1 and 2 using 50th percentile pooled data male manikin for varying degrees of freedom. *Source* Author

the current research. It helped generate optional ideas for each of the sub-functions and sub-components of the intended "glass shard picker". Using a morphological chart, many concepts were possible in the given time, and the Pugh Chart successfully revealed the best concept out of the twelve concepts of "glass shard picker" generated earlier. Similar systematic scientific endeavors encompassing Morphological and Pugh charts have been successfully deployed by the designers/researchers in varied domains [21–23].

Careful consideration of anthropometric and biomechanical parameters has been incorporated while designing and developing the present "glass shard picker". Various anthropometric parameters like grip length, grip diameter, etc., were considered for designing the proper handle grip design while developing the virtual model of the product. The grip length (114 mm) corresponds to the palm length of 95th percentile Indian male population data. The handle grip diameter (24.5 mm) corresponds to half of the grip inside diameter of the 50th percentile Indian male population data since the power grip is not essentially required to hold the larger stick. Biomechanical considerations were carefully thought of while designing the product to keep the wrist posture in the neutral position so that no Ulnar or Radial (lateral or medial) deviation of the wrist occurs while using the intended product. The adopted method of selecting anthropometric and biomechanical parameters for product development is in corroboration to other innovative product development studies [10, 24].

In the current research, the virtual ergonomic analysis using DHM was successfully deployed to analyze the "glass shard picker's" compatibility with the wide range of intended user population. As the product is unisex in appeal and is supposed to be used by both male and female populations, the various ergonomic analyses were conducted using three different human manikins, viz., 5th percentile female, 50th percentile pooled data male, and 95th percentile male representing the smallest and largest samples of the Indian population. From the various ergonomic analysis performed using DHM, the overall body posture was found comfortable as most of the body joint movements during operation/execution of task were found within the comfortable range of motion. The product's compatibility with the varied range of the Indian population was established. The adopted methodology corroborates well with the other such studies conducted for product evaluation in virtual mode [5, 25]. In furtherance, as the developed product addresses the user needs and uses context, it is expected that the proposed product will be highly beneficial for the targeted users, as opined by the intended users (housekeeping workers) and supervisors, while the simulated CAD model was presented to them.

4.2 Limitations

Although the researchers in the current research had aptly implemented the participatory design process from problem identification to virtual ergonomic analysis, there lie a few limitations with the current study. The current research is limited to the development of the innovative product in virtual form, and the subsequent ergonomic analysis was carried out in virtual mode as well. As the virtual ergonomic analysis was conducted, the current research is prone to the limitations of the DHM software. The development of physical mock-ups and field trials may yield better insights for product evaluations on conducting repeated trials and improvisations. Intellectual Property Rights (IPR) of developed innovative products may further be obtained for commercialization purposes [6, 7, 26, 27]. However, those methods will incur huge time and money. Secondly, the present study focuses on providing the mitigating solution to the "after the fact" event occurrence, i.e., the situation arising after the glass bottle fall and further consequences. The efforts can be made to devise methods to minimize the event occurrence and its associated negative consequences, i.e., methods to minimize the glass bottle fall or alternatives may be explored.

4.3 Future Scope

As discussed in the "limitations" section, rigorous efforts might be initiated by the shopfloor workers and factory management under their regular Kaizens to identify the root cause of glass bottle fall and suggest effective ways to prevent them from falling and breaking so as to avoid the further negative consequences happening in

present times. Similarly, the alternatives to the glass bottle filling and their feasibility for their product compatibility may be explored by the respective manufacturing units' production, operation, and safety departments. Overall, the rigorous in-house explorations in the discussed context will really be a boon to the concerned manufacturing units. Although limited to virtual design development and analysis, the present research has demonstrated a systematic approach to devising context-specific innovative design interventions in Indian FMCG manufacturing units. Similar approaches may be used by the designers, engineers, safety professionals, and factory management in other industrial sectors to improve the OSH condition to promote worker well-being.

5 Conclusion

By deploying, a proactive participatory approach on the FMCG shopfloor, the researchers have come up with an innovative hand tool in the form of a "glass shard picker". It can provide feature-rich help and aid, particularly in the effective management of wet slippery floors engaging broken glass pieces. It can act as a mitigating solution to the current safety concerns and promote safety thereof in specific FMCG work activities/tasks. The presently followed approach considering various ergonomics aspects in a virtual environment to develop an innovative "glass shard picker" would be very much beneficial to address the OHS-related issues of the worker population in diverse industries and thereby enhancing and uplifting their social well-being.

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A Sustainable Design Solution for Providing Drinking Water by Harnessing Floating Solar PV-Based Generation in Rural India

Abhijit Sen and Sougata Karmakar

Abstract Globally, about 2 billion people lack access to safe drinking water. In India, this is a major challenge for rural communities on account of falling levels of water table in two-thirds of the districts, lack of piped water facilities, and presence of harmful chemicals in groundwater. Sustainable Goal 6 of the UN targets the "availability and sustainable management of water and sanitation for all" by 2030. Therefore, there is an urgent need for sustainable decentralized drinking water systems that can be operated and maintained by rural communities. In recent years, floating solar PV (FSPV) projects have been installed in large numbers because of their varied advantages such as land neutrality, reduced evaporation, carbon savings, negligible effect on water quality, and feasibility on various water bodies. India has a water surface area of 18,000 km^2 and rural areas have a huge potential for installation of floating solar plants. This paper proposes a sustainable design solution for providing drinking water by harnessing the power generated from FSPV projects. A literature review with the search terms "floating solar" and "drinking water" was carried out using the bibliographic databases of Scopus, Web of Science & Science Direct wherein similar concepts or designs were not reported. The benefits include the 24×7 availability of safe drinking water, water conservation, monetization (battery swapping, charging of e-devices, etc.), and employment generation for local people. This study will be useful for policy makers, planners, designers, financial institutions, and local self-governments. The future scope includes the implementation of the proposed design solution through a pilot study.

Keywords Drinking water · Floating solar photovoltaics · Design · Sustainability

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1 Introduction

Sustainable Development Goal 6 of the UN targets the "availability and sustainable management of water and sanitation for all" by 2030. On demand availability of contamination free drinking water is a key indicator of Sustainable Goal 6.1 of the UN. Close to two billion people across the globe lack access to safe water for drinking purposes [1]. Collecting and transporting drinking water from distant sources results in a loss of productivity, may lead to musculoskeletal disorders, and compromises with personal safety [2]. These constraints have economic, social, and implications for health for communities across the globe. The availability of clean and safe drinking water is a major challenge in many parts of India, especially among rural communities. Moreover, the percentages of arsenic and fluoride in the water are above acceptable levels [3]. In addition, there is a depletion of groundwater level in two-thirds of the districts across the country [3] with about 43% of rural households [4] depending on hand pumps, compounding the problem further. A study has shown that groundwater is fast depleting in the basins of Indus-Ganga-Brahmaputra affecting the northern and eastern states [5]. At the same time, the rise in population and climate change is resulting in an increased demand for water. Recognizing these challenging issues, the Ministry of Jal Shakti, Government of India has launched the "Swajal" initiative, a self-sustaining drinking water supply project aimed at 117 districts. Considering these issues, rural community managed drinking water projects have assumed importance. In recent years, floating solar PV projects have been installed in large numbers because of their varied advantages such as land neutrality, reduced evaporation, higher efficiency than ground-mounted solar photovoltaic installations, carbon savings, negligible effect on water quality and feasibility on various water bodies [6–8]. However, most of these projects are of utility-scale for replacing fossil-based generation. Rural India is endowed with a large number of natural lakes and ponds. India has 345968 water bodies with sizes less than 0.5 ha [9]. In the North Eastern States, such water bodies are about 11000 in number [9]. These water storage structures are the lifeline for the rural communities and often the only source of water for daily sustenance. This study proposes an opportunity for the installation of decentralized FSPV-based microgrid units on these water bodies for supplying drinking water on a 24/7 basis. The intervention will be in pursuance of UN Sustainable Development Goals 3 (Good Health and Well-being), 6 (Clean Water & Sanitation), 7 (Affordable and Clean Energy), 11 (Sustainable cities and human settlements), and 13 (Climate Action). The aims and objectives of the present paper are (a) To explore existing FSPV-based drinking water systems if any, (b) To develop a sustainable design solution of a FSPV-powered drinking water system for rural communities, and (c) To estimate the cost economics of the proposed design.

2 Methodology

A literature review was carried out using the search terms "floating solar" and "drinking water" using the online bibliographic databases of Scopus, Web of Science & Science Direct. The period of search was selected between 1950 and 2022. Only papers in the English language were considered. The objective of the review was to determine whether existing FSPV-based designs existed. The PV * SOL software was used to develop a model and circuit diagram for the proposed design. Babuisol village (23.49°N, 87.57°E) located in the Andal block in the district of Paschim Bardhaman in West Bengal State of India (Fig. 1) was selected for implementation of the proposed design. Technical requirements and cost economics were computed after a discussion with FSPV developers.

Fig. 1 Location of the proposed project. (Image source: Google Earth)

3 Results

3.1 Literature Review Findings

The search of online databases resulted in 30 papers from Web of Science, 29 papers from Scopus & 2193 papers from Science Direct. Literature outcomes indicate that solar water pumps have been successfully adopted for providing water for irrigation and drinking in rural communities. A study reports that these pumps are of three types namely surface, floating, and submersible [10], and are an economically viable solution to address local and social needs. These pumps are an alternative to polluting diesel pumps and can be maintained by local people using local resources. The technology for PV-powered pumping was first introduced through a World Bank Program-supported project in 1978. The project was found to be successful in countries where there was sufficient sunshine, fuel cost was high, and water was needed throughout the year [11]. Aimed at agricultural uses, solar pumps were first introduced in India in the year 1992. PV-powered solar pump systems have a life of 25 years and a payback period of four to six years [11]. The provision of drinking water in rural areas with the use of PV-powered pumps was found to be both economically and technically viable [12]. The solar panels powering the pumps are ground mounted. Land holdings in rural areas of India are important assets and judicious use of land and water is important [13]. Therefore, alternative land neutral locations to install solar PV panels like on stationery water bodies can be a more sustainable solution. The review did not elicit any study on floating solar PV-based drinking water system. This establishes a knowledge gap that this paper aims to address. Other papers report the design and development of solar stills which aim at desalination of sea or brackish water which is beyond the scope of this paper.

3.2 Existing Drinking Water System at the Proposed Location

A total of 788 people reside in 183 households in the Babuisol village as per census data of 2011. Considering a daily need for three liters of water per person, a total of about 2400 L of drinking water is required for daily consumption. Presently, a solar powered drinking water system is installed which uses a submersible pump to transfer groundwater into an overhead storage reservoir for providing drinking water. Handpumps supplement the drinking water needs apart from the solar powered system. The existing system is shown in Fig. 2. Limitations of the existing system are the fast depletion of groundwater and lack of filtration. Contaminated water leads to waterborne diseases and compromises with the health and well-being.

Fig. 2 Existing drinking water system at the proposed location. (Image source: Damodar Valley Corporation, India)

3.3 Proposed Design

The FSPV-powered drinking water system consists of solar PV modules floating on a stationary water body (Fig. 3). The renewable energy generated from the system is stored in a battery unit and can power the solar pump and the filtration system which is based on Reverse Osmosis (RO) technology. RO systems have been found to be very effective in producing clean and safe drinking water [14]. The excess water from the RO system is returned back to the water body for recirculation. The incremental power generated can be used for charging electrical devices and battery swapping for running e-rickshaws. Figure 4 shows the circuit diagram.

The components of the system are enumerated in Table 1.

To determine the cost economics of the proposed system, the design was shared with FSPV developers. Inputs were received on the materials required and the installation cost of the different components in India. Under a scheme subsidized by the government, solar pumps are provided at a reduced cost [15]. Utilization of these pumps can bring down the overall cost of the project significantly. The estimated cost is presented in Table 2.

The FSPV system has a life of about 25 years. The cost of maintenance primarily includes cleaning of solar panels, pump maintenance, and replacement of RO filters. In order to recover the running cost, a funding and monetization model is proposed. The system is to be operated and maintained by the local self-government. The proposed design can be financially supported by a subsidized scheme of the Government or by Corporate Social Responsibility (CSR) programs undertaken by various companies/organizations. An important pre-requisite is the selection of a relatively

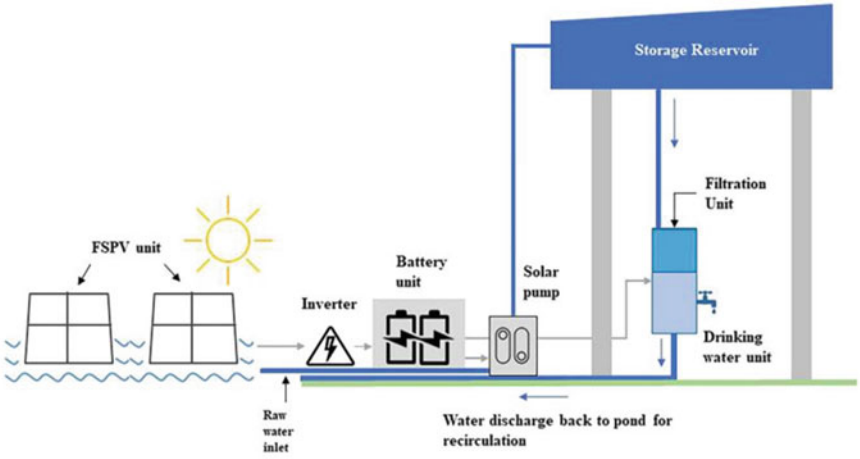

Fig. 3 Proposed design of the FSPV-based drinking water system. (Image: Authors)

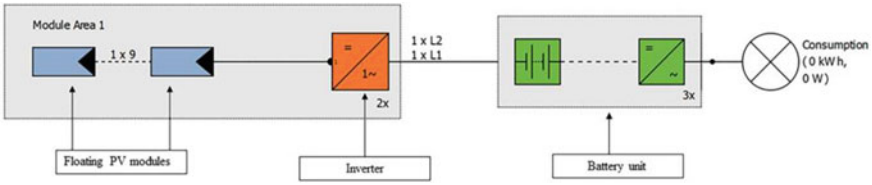

Fig. 4 Circuit diagram of the proposed system. Source: PV * SOL software

large water body so that 2400 L of drinking water can be supplied on a daily basis. Alternatively, two smaller systems of size 2.5 kWp can be installed in two water bodies in the village.

Following the battery swapping system, the additional batteries (refer to S.No. 3 of Table 2) can be used for running small e-vehicles such as e-rickshaws, charging e-devices, and powering small businesses such as food vendors. In addition, it is also proposed for charging a nominal fee for the use of the drinking water so as to prevent wastage and sharing of cost among the consumers. These measures will ensure monetization and faster payback of the investment as well as fund the maintenance costs.

Training of locals in the operation and maintenance of the FSPV system will further empower the rural communities and provide employment. This approach will not only make the proposed design sustainable from an ecological perspective but also financially viable.

Table 1 Overview of the FSPV-based drinking water system

S. No	Component	Particulars
1	Location	Pond
2	Type of system	Stand-alone floating PV system
3	Annual sum of global radiation	1573 kWh/m^3
4	Annual average temperature	26.5 °C
5	AC mains	230 V
6	Number of PV modules	10
7	Efficiency	15%
8	Peak power	500 Wp
9	PV generator output	5 kWp
10	Inclination	15°
11	Primary floats (for supporting the modules)	10
12	Secondary floats (for walkways)	20
13	Inverter	3.4 kW
14	Total battery power	15–20 kWh
15	Solar pump	2 HP
16	Storage reservoir	1000 L
17	Reverse osmosis purification system	100 L
18	Pipes, distribution box, wires, and electrical accessories	As per requirement
19	Civil structure for storage reservoir and RO system	As per requirement

kWh: kilowatt hour; Wp: Watt peak; kW: kilowatt; HP: Horse Power; RO: Reverse Osmosis; L: Liters

4 Discussion and Conclusion

India has a large number of water bodies in the rural areas. Many of these water bodies serve as community ponds for providing water for drinking, sanitation, domestic uses, and miscellaneous purposes. To fulfill the basic societal needs, community managed drinking water system is being considered as the most viable and sustainable solution for rural communities. This study proposes an FSPV microgrid that can be set up on a water body for providing drinking water on a 24 × 7 basis. The electricity generated from the floating solar panels would power the solar pump and the RO system during the day. The batteries would provide the power to operate the pump and RO system at night. The self-sustaining system will lead to the following benefits:

- Availability of 24/7 safe drinking water for rural communities.
- Reduced evaporation from the water bodies on which the FSPV system is installed.
- Utilization of part surface area of water bodies without the need for land acquisition.

Table 2 Estimated cost of installation

S. No	Component	Estimated cost
1	FSPV System	INR 350000
2	Battery unit	INR 24000 (4 × INR 6000)
3	Batteries for swapping	INR 24000 (4 × INR 6000)
4	Solar pump	INR 80000 (after considering a 60% subsidy under the government scheme)
5	Storage reservoir	INR 8000
6	RO system	INR 25000
7	Civil structure	INR 40000
8	Accessories	INR 10000
9	Manpower cost	INR 20000
10	Miscellaneous expenses	INR 5000
	Total cost	INR 586000

- Alternative solution to indiscriminate use of depleting groundwater.
- Minimum water loss after treatment/filtration through recirculation (discharge back to the water body).
- Battery storage allows the running of the RO filtration system at night.
- Conservation and sustainable water use.
- Requires less investment compared to piped water schemes.
- Incremental power can be used for other purposes such as for battery swapping, street lights, small vendors, etc.
- Creation of employment for locals.

The contribution of this study is that it proposes a self-sustainable community managed drinking water scheme harnessing the power of FSPV which is not yet explored. With 11000 water bodies in the North Eastern States of India [9], adoption of this model is likely to have multiplier effects apart from empowering rural communities. This approach can also be adopted across the country since according to a study, India has a water surface area of 18,000 km^2 for installation of FSPV projects [16].

The study is also aligned to five of the seventeen Sustainable Development Goals of the UN. This study will be useful for policymakers, planners, designers, financial institutions, and local self-governments.

5 Limitations of the Study

A limitation of this study is that the design is a conceptual model which has not been tested in field trials. Another limitation is that only articles in English were considered in the literature review.

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Internet Memes Are Impacting Society: Perspectives from Brand Communication to World Peace Promotion

Bhaskar Mishra and Anirban Chowdhury

Abstract The present scenario is a very crucial time for the world due to the pandemic and war. Health and socioeconomic crises are raised, and these consequences change human lives and businesses. Many businesses are drowning, financially fragile, and causing massive dislocation. This research paper provides insights into the revival of small businesses with the help of memes and ways to promote brands using memes. The use of memes for World peace promotion is also discussed in this research paper. Literature surveys were conducted using Google Scholar and Science Direct, and the research publications from the last ten years were searched using keywords like "memes," "dank memes," "funny memes," "humor memes," and "peace memes." Numerous articles were shortlisted and memes for social uses, such as branding and world peace, were explored in this study. Meta-analysis has been conducted, which states that memes convey messages in a humorous or joyful manner. Also, for this study, five volunteer visual designers were chosen, and a total of 80 memes were analyzed to identify the composition (elements and layouts) and meme genres in which brand communication and world peace appear. In addition, the most liked or viral memes in the context of brand communication and world peace were investigated. Memes in brand communication and World peace are still a relatively new phenomenon. Companies have recognized the value of Internet memes and have used them as a marketing tool, using popular topics and characters as meme elements. Furthermore, peace memes guide subjects to feel a certain way and promote World peace.

Keywords Brand communication · Creative memes · Internet memes · Meme marketing · Promotion · Society · World peace memes

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1 Introduction

The present scenario is very crucial for the world as it faces dangerous challenges one after another like the global pandemic of the coronavirus and the Russia-Ukraine war. The coronavirus pandemic has had a significant impact on humans' daily lives. In many countries, the government imposes tight regulations, such as social distancing and staying at home. As a result, humans have reduced travel, shut down many of their businesses, and spent more time at home [1]. So, now there are health, social, and economic consequences as a result of the pandemic [2, 3]. Socioeconomic consequences created short-term disruptions and provoked long-term changes in the way the world lives and does business. Many small businesses fail or are financially fragile, and there is a massive dislocation among them [4]. Now the question is—what steps are being taken right now to resurrect the small businesses that have been drowned as a result of the pandemic? Is there any other way for local vendors and small business owners to promote their products or brands in a unique way in order to revitalize their businesses? Also, this study highlights the efforts made by humans to stabilize peace after an armed conflict. Armed conflict alters the course of a human's life. There are numerous consequences that result from armed conflict. But, after all, humans are naturally peaceful. War is not always present in human societies [5]. So, the question is—what can be done to bring peace to the entire planet? So, is there any interesting way to establish peace?

Yes, there is an intriguing method for discovering the answers to all of the questions, and that intriguing way is through memes and their impact on society. The term "meme" was coined by Richard Dawkins in his book The Selfish Gene, and he developed it from the Greek word mimeme [6–9]. A meme is further defined as "an idea, behavior, style, or usage that spreads from person to person in a culture" [10]. In recent years, the Internet has become the most important part of people's lives. The era of 2.0 provides people with a variety of communication platforms such as vlogs, forums, and chats. People use the Internet to share their ideas, thoughts, and beliefs [11]. The Internet has provided and made it possible for content or data to be spread rapidly from person to person, as well as given rise to Internet memes in the media environment [12, 13]. The Internet meme has been defined as "a piece of culture, typically a joke, which gains influence through online transmission" [14]. The composition of different Internet memes involves various elements such as text, photographs, characters, emojis, and so on. Internet memes are commonly seen on social media platforms such as Twitter, Instagram, and others. Memes convey messages to people in a very simple, humorous, and joyful way [7]. The impact of memes on society is mixed, with the majority of societal effects being positive [15]. Memes are being used in creative ways these days. Various companies use memes as a marketing tool. Additionally, the company hires a team to search and browse popular topics and character-based İnternet memes because creative memes capture the attention of customers [11]. Simultaneously, memes are being used as a tool for peace. Peace memes are a type of ordinary communication, a satirical tool, and a medium for disseminating satirical messages. When peace memes spread, their presence has an

impact, and people begin to think in a certain direction. Peace memes are used to promote world peace. This study answers the following research questions: Q1. How can memes help small businesses revive, and how can memes be used to promote brands? Q2. How can memes be used to promote world peace? Q3. What are the meme elements and layouts associated with brand communication and world peace? Q4. What are the most common communication styles or genres found in brand communication and world peace? Q5. What are the most popular or viral memes related to brand communication and world peace?

The structure of this paper is as follows: This article first describes the various types of memes and then discusses creative memes and their properties. Second, this article discusses the impact of memes on society. There are several contexts in which memes have an impact on society. The first is memes used as brand communication, and the second is memes used as a peace element. Third, this article investigates the elements and layout used recently by memes in terms of brand communication and world peace. Fourth, this article identifies the current genres and styles used by memes in terms of brand and peace. Discover the viral memes in 2022 for brand communication and world peace. Following that, there is a result and discussion. The last one is the conclusion.

1.1 Meme Types and Creative Memes

The types of memes are the following:

1. **Classic meme**—the most general method of presentation [7, 16].
2. **Dank meme**—dank memes are memes that have gone viral on the Internet due to overuse or passing trends. As a result, they lost their value and currency [7, 17].
3. **Normie meme**—these are characteristically memes that grow very big but become classified as dead very quickly [7, 18].
4. **Wholesome meme**—wholesome memes are those that use repeated or re-used images and texts to convey a unique, wholesome message. They are also distinguished by their bold positivity [7].
5. **Surreal meme**—a subgenre of sarcastic memes with aesthetically strange appearances and whose comedy stems from their outlandish manner [7] (Fig. 1).

Every day, a large number of memes are created in a creative manner and distributed among people. Creative memes are those that make use of images, texts, and videos in an interesting and appealing way to users. Only those memes that are creative survive after being copied, remixed, and distributed to individuals [11]. The use of popular topics and characters as meme elements is a key component in memes that have an impact [7]. In comparison to the earliest memes, today's memes are much more complex in terms of language and style, as well fact that they contain many references and require comprehensive background knowledge [19]. Memes are considered creative if they possess the following properties: "novelty, unexpectedness, fertility, surprise, adequacy or correctness" [20].

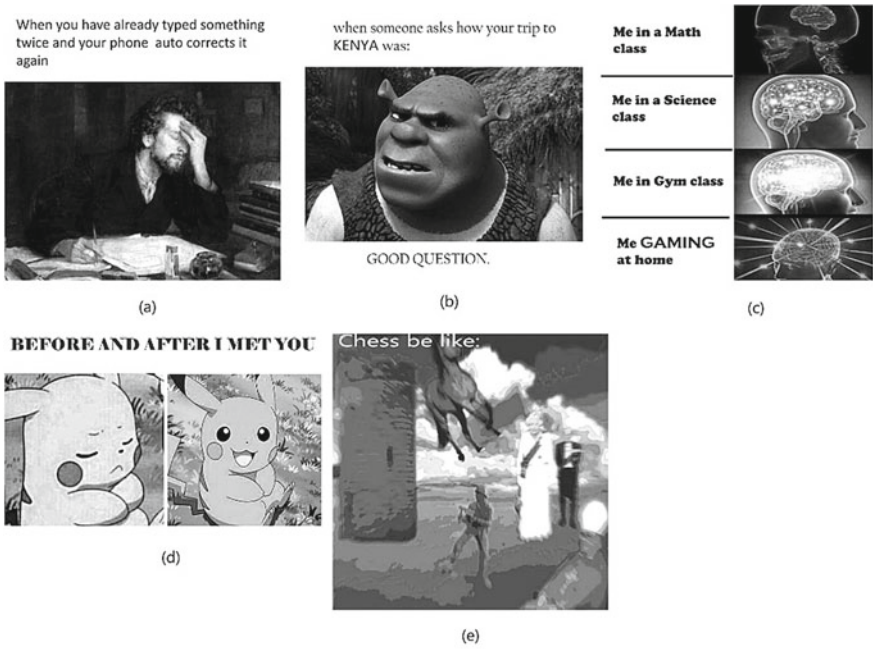

Fig. 1 Examples of different types of memes. **a** Classic meme; **b** dank meme; **c** normie meme; **d** wholesome meme; **e** surreal meme [21]

1.2 Internet Memes Are Impacting Society

Internet memes are media forms that convey a message in a humorous manner while also commenting on society [22]. Internet memes provide satirical commentary on current events [23]. Internet memes can be used in a variety of contexts, including marketing and advertising, aid in stress reduction efforts, cultural education tools, awareness, politics, and so on. The impact of memes on society is mixed. The vast majority of its societal consequences are favorable [20]. Memes are more popular among youth, and they are a popular tool for social media communication as well as a dominant medium for social discussion in a humorous manner. "Memes have become a stand-alone mechanism to change the youth into societally responsible individuals" [24]. Climate change memes primarily focus on the risks that animals and humans face as a result of climate change. Individual intentions for online civic engagement in climate change are increased by exposure to climate change memes. As a result, memes have the potential to address both humorous and serious social issues [25]. During the pandemic, many popular memes are spread across the İnternet, and viewing these memes generates psychological responses such as stronger cuteness responses, higher levels of reported humor, more positive emotions, and lower levels of information processing. As a result, memes have the potential to influence people's COVID-19 stress and coping efficacy [26]. Internet memes are used to communicate

political satire, but they have no effect on people's voting behavior, political opinions, or ideologies. Memes are thought to have been created for the purpose of entertainment [27]. Internet memes are typically thought of as humorous and entertaining items in social communication, but they are also used in secondary education to develop social and cultural awareness. In L2 (language 2) teaching, İnternet memes are used as cultural education tools [28]. Memes with negative intentions, such as attacks on people based on identity, race, gender, and so on, are sometimes created and shared [23]. Memes can have both positive and negative effects on society. If no one pays attention to it, there could be serious consequences. Monitoring procedures must be put in place [29].

1.2.1 Internet Memes and Brand Communication

Brand communication is a component or part of brand management. In addition, it is the combination of activities used to communicate with customers, such as advertising, social media, reviews, and so on. It is essential for the overall development of the brand. Nowadays, brand communication is completely reliant on social media. Social media has become an integral part of many people's daily lives. It has been estimated that as of April 2022, there were five billion İnternet users worldwide. Of this total, 4.65 billion people worldwide use a social media platform at least once a month, and the average time spent amounted to 147 min per day [30]. In an attempt to capitalize on this intense usage, almost every consumer brand is present on social media, and advertisers and marketers are eagerly integrating social media into their digital strategies [31]. Furthermore, social media is the least expensive and most cost-effective marketing communication tool. Memes on the İnternet are today's most effective social media weapon. Internet memes are used not only in casual situations such as conversations between friends or fun-generating discussions but also in formal situations such as closer connections between brands and consumers via social media. Memes as a form of brand communication or meme marketing are the use of meme formats such as humorous photos, gifs, and videos to promote your brand and products [32]. Memes have the potential to alter brand perception among consumers [33]. Furthermore, the most important thing is that the meme elements are relevant to your brand and tickle your audience's funny bone.

Nowadays, marketers use popular or funny memes that are already refreshing, relatable, and have the potential to go viral to promote their brands or products. Marketers and brands must determine the appropriate occasion or moments to adapt memes for their own marketing or promotions [34]. Bury has discussed the use of creativity in memes for advertising in the form of image and phrase juxtaposition to create humor. Marketers use memes to grab the attention of their target audience [11]. Popular topics and characters are used as meme elements by some marketers [7]. Also, eye-catching memes elicit a positive response from buyers. Meme marketing is more than just creating and posting memes; the emphasis should be on the quality of the meme page as well as being a part of or aware of the meme culture. Furthermore,

Fig. 2 Examples of brand communication memes: **a** When you see bun tikki (bun-butter) cost rupees 300; **b** Huge discounts on branded fabrics [21]

marketers must be familiar with and understand how the meme world works. Meme-based marketing has some drawbacks as well. Traditional media-based marketing allows for tight control of the message, whereas with meme-based marketing, the brand may struggle to maintain control of the message [34]. Many brands such as major food delivery apps, and fashion e-commerce companies from India, use memes as a form of brand communication. However, they have yet to fully realize the potential of meme marketing. Here are some examples of brand communication memes (Fig. 2).

1.2.2 Internet Memes and World Peace

World peace is the concept of a world free of violence. Peace among humans is the key to a prosperous world full of happiness, progress, and resourcefulness. Humans and human societies require peace as a basic need. Several efforts have been made in the past for world peace, and several organizations have been formed to that end. Every year on September 21, the world observes the International Day of Peace. Furthermore, the UN declared a day dedicated to strengthening the ideals of peace by observing 24 h of nonviolence and a cease-fire. However, we are still a long way from having a peaceful society, and there is always the risk of war, whether it is minor aggression between societies or war against countries [35]. In recent events, the Russia-Ukraine war is an armed conflict with numerous consequences. As a result, thousands of lives have been lost, and millions of people's livelihoods have been disrupted due to displacement, homelessness, and loss of income. But, in the midst of all of this, it was noticed that there was a deluge of memes on the İnternet or on social media, and the issue was the Russia-Ukraine War. This suggests that using memes as social humor could be a new trend even in such a stressful environment. At the same time, it remains to be seen how true they prove to be in the peace lane.

Initially, memes used funny pictures as a meme element, which were taken from someone's photo and added interesting captions to it. Later, İnternet memes are used to express thoughts in a satirical manner about various phenomena that are currently happening [22]. Satire helps us to understand the unpleasant reality. In addition, Internet memes are a new face of freedom that enhances people's emotions and also represents flaws and increases the strength of society [7]. Through the copy or share feature, the meme format makes them popular and quickly spread on the İnternet or on social media. That is, the memes' messages are quickly and easily accepted by a large group of people. The greater the meme's spread, the more powerful the meme's message becomes [36].

In its development, Internet memes have also become a medium to convey peace messages in the form of satire; some users have also expressed their views in a funny manner regarding peace, which is often called "peace memes." In addition, the meme is an İnternet poster that is meaningful and inspiring in the İnternet society. Peace memes might incorporate words and even images from popular movie scenes, celebrity posters, TV shows, nature and animal pictures in the background, cartoon characters, video game scenes, and even the political world. The use of photos (JPEG), animated GIFs, or videos as a medium of communication and the dissemination of ideas in memes might be beneficial [7]. Figure 3 depicts a block diagram of the consequences of world peace memes, which are classified as direct and indirect. The direct method of communication is via peace messages, while the indirect method is via memes. Furthermore, memes generate humor and joy, both of which are associated with happiness, and happiness is associated with peace. Peace memes are used to promote World peace. By typing "peace memes" or other related keywords into a search engine or on social media platforms, you can find hundreds of peace memes.

2 Study 1: Observational Study on Existing Memes Related to Brand Communication and World Peace

The aim of the study is to identify the compositions (elements and layouts) of different memes associated with brand communication and world peace.

2.1 Method

2.1.1 Participant

For this study, five volunteer visual designers with more than ten years of industry experience and an average age of 40.5 years were chosen.

Fig. 3 Block diagram for consequences of world peace memes

2.1.2 Procedure

Initially, all five visual designers sat together and randomly searched the İnternet (Facebook, Twitter, Instagram, and so on) for memes related to brand communication and world peace. They collected 40 memes, 20 for brand communication and 20 for world peace, to identify the composition (elements and layouts) of memes. Furthermore, they conducted an observational study to examine the typical characteristics of identified elements.

2.1.3 Observations

Elements

The composition of different memes that are associated with brand communication and world peace involves various elements, such as

- **Photographs**—appropriated from famous movie scenes, TV shows, nature and animal pictures in the background, cartoon characters, video game scenes, celebrity posters, and even the political world.
- **Text**—differences in the typeface are observed in the text of memes.
- **Characters/Carricatchers**—it could be from animated pictures, a sticker, or something you made yourself.
- **Thought Bubble**—these are frequently used to create memes using comics (graphical stories).

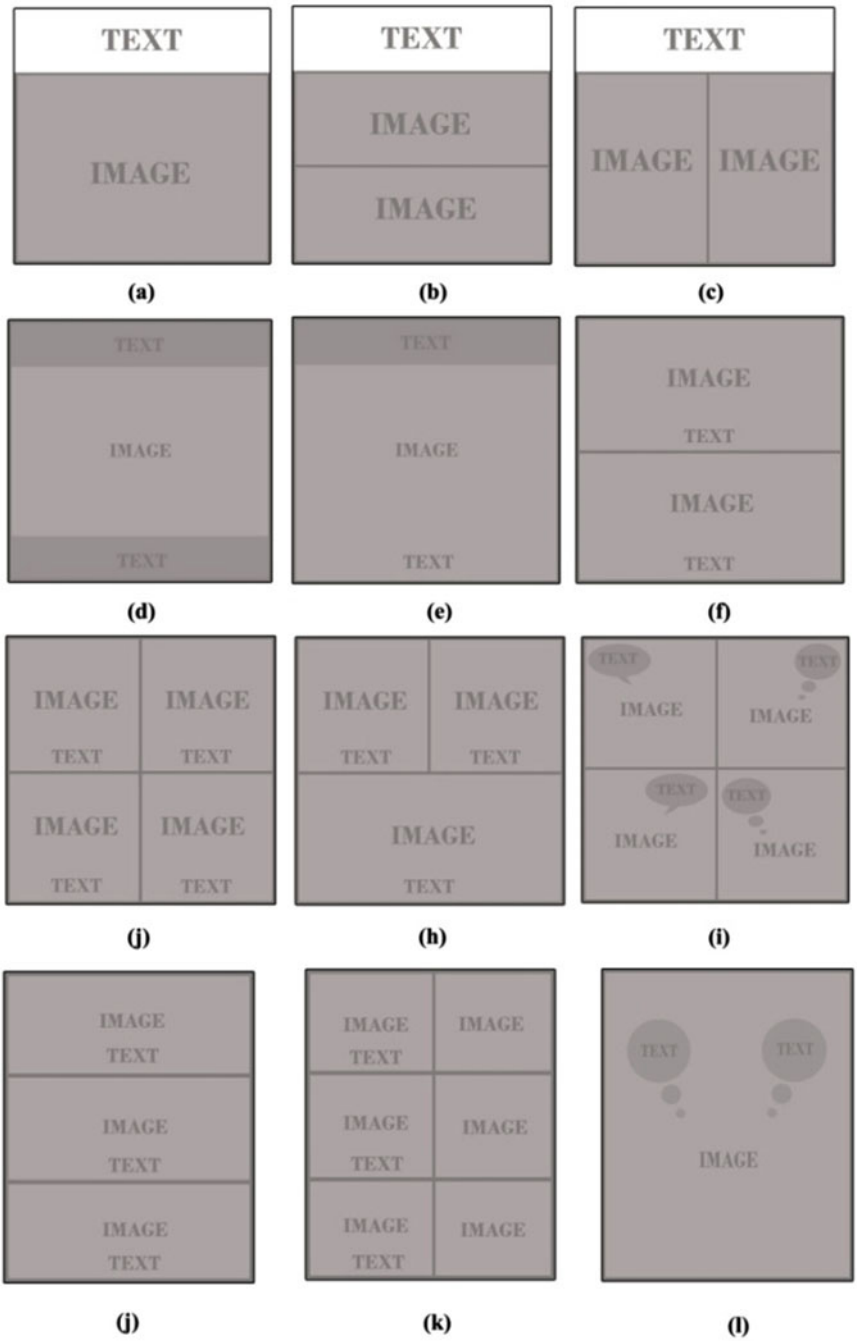

Fig. 4 Meme layouts with smaller size that are commonly seen on the Internet (from brand communication to world peace)

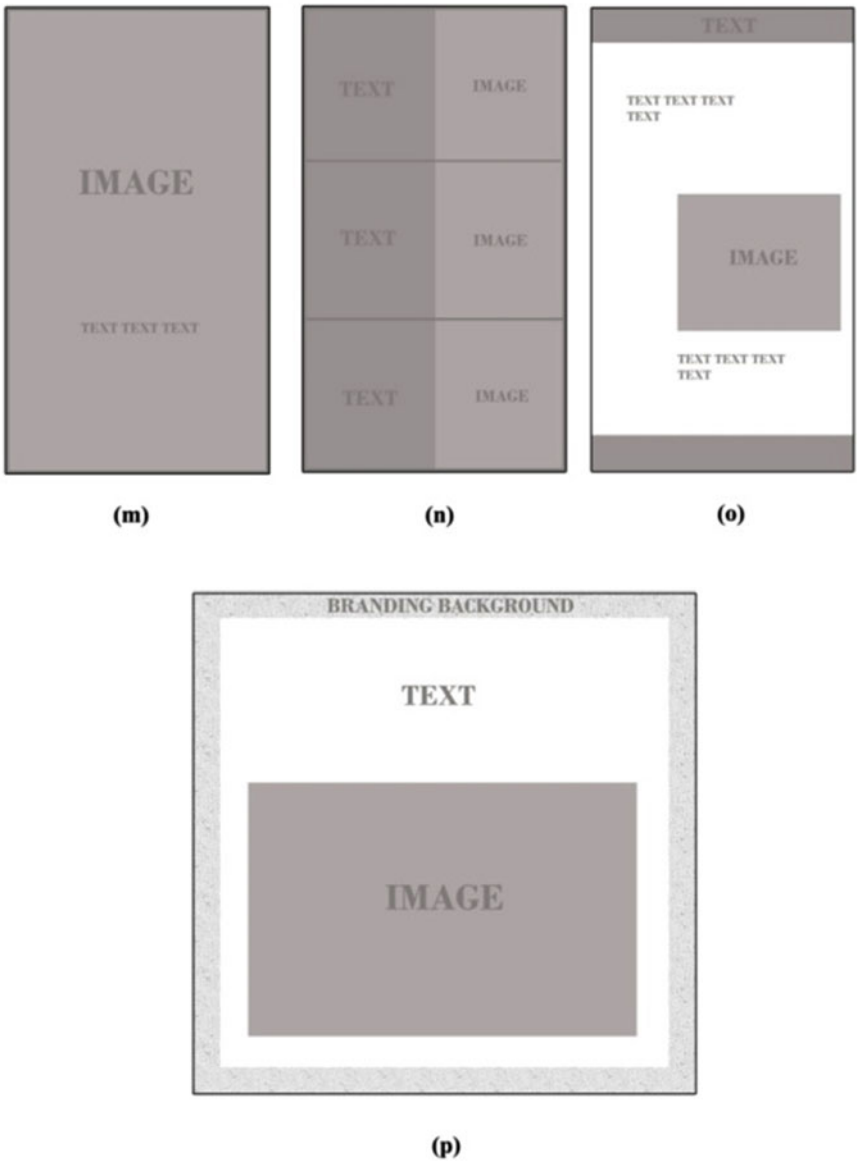

Fig. 5 Meme layouts with large size that are commonly seen on the Internet (from brand communication to world peace)

- **Emoji(s)**—these are frequently used in social media applications. However, current trends show that meme designers are also using emoji(s) or emoticons to compose memes.
- **Other graphic elements**—these include nature depiction, scenery, cute pets, and so on.

Although designers use a variety of elements in memes, the image, along with text (upper and lower), is the most common element in meme compositions and is known as a macro image template.

Layouts

The images chosen for this study have 16 different layouts, with an aspect ratio (size) ranging from 1:1 to 4:5 to 9:16.

Figure 4 'a' to 'i' is best suited with an aspect ratio (size) of 1:1
Figure 4 'j' to 'l' is best suited with an aspect ratio (size) of 4: 5
Figure 5 'm' to 'o' is suited either with an aspect ratio (size) of 9:16
Figure 5 'p' is a special layout only for brand communication in which the branding background of that specific branding theme is used and a whiteboarded meme with text and image is overlapped.

3 Study 2: Extensive Research and Study on Existing Memes to İdentify Current Genres or Styles of Memes Related to Brand Communication and World Peace and also Find the Most Liked or Viral Memes Associated with Brand Communication and World Peace

This study identified four common meme genres in which brand communication appears: Spoof/remix memes, Reaction memes, Video memes, Celebrity memes/new stock character memes, and three common meme genres in which world peace appears: Stock character memes with peace; Peace figure memes; and Reaction memes. Also, find the most liked or viral memes associated with brand communication and world peace.

3.1 Method

3.1.1 Participant

The participants are the same as in Study 1.

3.1.2 Procedure

From the analysis of the study 1 sample, several meme genres related to brand communication and world peace were identified. A large sample of memes was collected in order to further validate and test the representatives of these categories. The additional 40 memes related to brand communication and world peace were identified using the site search functions of imgflip.com and knowyourmeme.com. Knowyourmeme.com and imgflip.com are two websites dedicated to documenting İnternet phenomena such as viral memes and GIFs. This resulted in a total sample of 80 memes, from which the following study's findings were extrapolated. Applying Shifman's discussion of meme genres to our study 1 finding allowed us to clarify and parse out the dominant meme genres in the final sample, four for brand communication and three for world peace [36].

3.1.3 Observations

Genres

The genres or styles of different memes that are associated with brand communication are

- **Spoof/remix memes**—memes that are parodies or remixes of the original content may be characterized by exaggerated examples of defining characteristics or concepts, photoshopped images, or the absence of text [36, 37].
- **Reaction memes**—reaction memes are memes that reply to "recent" news items, events, or photos that are widely shared on social media.
- **Video memes**—video memes are popular nowadays and incorporate meme elements such as video.
- **Celebrity memes/new stock character memes**—make use of celebrity images and funny movie scenes while also conveying branding messages.

The genres or styles of different memes that are associated with brand communication are Spoof/remix memes, Reaction memes, Video memes, Celebrity memes/new stock character memes, and brands such as major food delivery apps and fashion e-commerce companies from India use these genres and styles in their social media pages for promotion.

The genres or styles of different memes that are associated with world peace are

- **Stock character memes with peace**—uses stock characters that are not related to peace, macro meme template.
- **Peace figure memes**—this could be a new stock character with peace figures, celebrity and nature images with peace massages, and a macro meme template.
- **Reaction memes**—Reaction memes are memes that reply to "recent" news items, events, or photos that are widely shared on social media.

Various social media pages used these genres and styles in memes to promote world peace.

3.2 The Most Liked or Viral Meme is Associated with Brand Communication

Memes are widely used in the promotion of major food delivery apps. They have a brand page on social media and use memes for brand communication, posting various meme genres on their page on a regular basis. We examined metadata to uncover the most liked or viral meme connected with Brand Communication and discovered that one of the meal delivery apps published a video meme that immediately went viral, getting 3,165,066 likes.

3.3 The Most Liked or Viral Meme is Associated with World Peace

Meme-based post was utilized on a government-run social media page of a country to advocate for global harmony. With 691011 likes, the meme post swiftly gained popularity, indicating widespread interest.

4 Result and Discussion

Literature surveys were conducted using Google Scholar and Science Direct, and research publications from the last 10 years were searched and analyzed. seven papers were shortlisted to assess the impact of memes on society; seven papers on memes as brand communication; however, there is less evidence on memes as world peace. However, there was enough visual research available to formulate an analysis based on the same. The analysis of seven papers on the impact of memes on society is mixed; memes can have both positive and negative effects on society. Furthermore, the vast majority of its societal consequences are in favor of society. Also, according to an analysis of seven papers on memes, which are related to brand communication, results show that memes help small businesses revive and can be

used to promote brands in such a way that memes are being used in more creative ways these days; they use popular topics and characters as a meme element. Creative memes capture the attention of customers. Simple, eye-catching, and creative memes designed for specific users are more effective. Memes are used as a marketing tool by a variety of businesses. For clarity and relevance, some brands use a logo at the bottom of the meme. A logo is also used to raise brand awareness. Furthermore, some brands employ additional feature layouts that make use of the branding background of that specific branding theme and overlap whiteboarded memes with text and images. To keep viewers' attention and engagement, some brands use cute images like babies and pets. Memes might be used to promote world peace with both direct and indirect consequences. The direct method of communication is via peace messages, while the indirect method is via memes. Furthermore, memes generate humor and joy, both of which are associated with happiness, and happiness is associated with peace. Peace memes are used to promote World peace. This study noted current genres of memes in which brand communication and world peace appear. These genres are classified as brand communication (spoof/remix memes, Reaction memes, Video memes, and Celebrity memes/new stock character memes) and world peace (stock character memes with peace, peace figure memes, and Reaction memes). We view genres as socially recognizable communicative categories that represent memes with similar structural and stylistic features, especially in the ways they draw brand communication and world peace into online discourse. Also, for desired affective responses, different elements and layouts of memes are studied. In addition, the most liked or viral memes in the context of brand communication and world peace were investigated.

5 Conclusion

In this study, the elements and layouts of popular memes were identified along with different genres. This study also tries to give an idea about peace memes and the use of memes for brand communication. Based on the current findings, designers can design and use various memes either for brand promotion or communication of messages related to world peace. It may be possible to design memes by designers and assess the impact of İnternet memes on society in the context of world peace message communication or brand promotion.

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Perceiving Museum as a Way to Living Culture: A Step Toward Cultural Sustainability

Pronita Mondal and Ritwij Bhowmik

Abstract In the twenty-first century, an essential discussion without any doubt will encompass the significance of sustainable practice to counter the devastating consequences of ecological changes and the loss of our culture and tradition. The Western idea of modernization has brought homogenization in every aspect of its system, and so in the representational practices of cultural narratives. Often indigenous cultures in the museum are represented through architecture and typical display design that customarily become a tool for creating ethnic diversity in a very stereotypical and homogeneous manner. Over the past decades, it is the radical reconfiguration of the meaning, scope, and functions of the museum that tries to appropriate cultural representation in a more sustainable way. With a focus on the curatorial project of Madhya Pradesh *Janjatiya Sangrahalaya*, a museum of living cultures in Bhopal, this paper will attempt to discuss how the architect Revathi S. Kamath and the artist and creative co-ordinator, Harchandan Singh Bhatty have put an active anthropological engagement to the community to develop a culturally appropriate and sustainable built environment. This paper will discuss the technicality, viewership, and museum's response to fit into its own rightful identity of a living culture. It will attempt to answer the central problem: How can a museum of living culture as a historical, cultural, and ecological continuum contribute to cultural sustainability?

Keywords Museum · Architecture · Community · Visual culture · Indigenous · Representation · Culture and sustainability

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1 Introduction

In the museums of India, tribal culture is displayed as a subject that will give a holistic sense of knowledge and belief of the aboriginal tribes that live in India and the world. Whereas museums generally emphasize categorization, a museum of tribal culture talks about the connection of cultural roots and aesthetics of one community with others who lives in a far land. The representation collectively shows the culture. In doing so, a homogenous identity is propagated through museum displays. Often, curators believed that inside a museum space, representing the variety of living of different communities is neither possible nor required. Instead, they often idealized these homogeneities as the unity in diversity. However, in reality, cultural diversity is required to be addressed to allow sustenance and coexistence.

The life and culture of tribal communities are generally considered ethnographic[1] subjects because of their relation to an aboriginal identity category. 'Ethnography' as a subject had immerged as the study of non-Western societies as the culturally and geographically 'other' by Western researchers. Its focus was on documentation entirely with the researcher's expression but not through the agency of the subject. Nevertheless, after the breakup of colonial powers, with many exchanges of arguments by critical theorists, Postcolonial critics, and cultural protests, the meaning, and scope of ethnography have changed a lot from the Eurocentric assumptions. The practice of stereotyping through representation in the museums, which is a colonial institute, and the practice of ethnographers, photographers, and artists by exoticizing and presenting their subjects in a pre-modern context has been accused. And today, it is no more associated with a particular subject category but with methods specific to this discipline, such as participation, collaboration, and observation at the location.[2]

This article discusses how ethnography has been practiced in a museum of a culture where architecture and display constitute cultural artifacts that embody local needs, values, and capabilities. This article will focus on analyzing and criticizing the architectural and curatorial project of the museum of tribal heritage, Bhopal, Madhya Pradesh, done by the eminent architect Revathi Kamath and notable sculptor, artist, and creative co-ordinator Harchandan Singh Bhatty (Fig. 1).

This discussion will lead to how buildings and the interior of the galleries are made, who are employed to build them, and the motivation and philosophy behind their construction. Through this museum project, this paper will focus on the concern of cultural sustainability that comes with other sustainable solutions to the existing problems of cultural identity, environment, economy, employment, and representation. In the age of mass-market production of homogeneous buildings and homogeneous display design, this project has given a different dimension to the typical twentieth-century museum practice.

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[1] Fetterman [1].

[2] Scholars like Akhil Gupta and James Ferguson have argued and defined contemporary ethnography as a research methodology based on participant observation on the location and collaboration. See Gupta and Ferguson [2]: To know the methods in detail see Fetterman [1].

Fig. 1 Madhya Pradesh Tribal Museum' at Bhopal

Architecture constitutes one of the most enduring cultural artifacts,[3] a distinct cultural category, and a major consumer of our energy and resources. The idea of collective Western society and modernization brings homogenization in every aspect of its system and so in the architecture domain. Today every mall, supermarket, corporate office, and even an entire city looks almost the same everywhere. It is because architecture is intensely involved in the processes of globalization. The collective Western notion has become a general global notion. Moreover, architecture is also involved in the process of localization by making it in an indigenous way. Therefore, by doing it, it is getting restricted to a particular place. It gives a local identity to a space.

Architecture is also a major contributor to current environmental, social, economic, and cultural problems like climate change, global warming, depletion of the ozone layer, and loss of our culture and tradition through changes in our way of living. Our traditional vernacular method, materials, skills, and values oriented with these are at a great loss in this fast-changing industrial and technological era. In response to counter these challenges, as Vellinga noted, there is a growing interest among architects, artists, and designers in developing an architecture that can address environmental, economic and, social, cultural problems in a sustainable and modern way[4] by making 'green buildings' with 'green technology'.[5] While many organizations all around the globe thought of these designs as an environmentally friendly attempt, which is made of low-cost, local, indigenous, and organic materials, while some regarded them as unsuccessful attempts because of the inability of the architect to design a building considering the user's individual cultural needs and expectations and because of their inability to understand the differences of technological intricacies among different cultures.[6] Their designs were mostly associated with a particular style of architecture which is mostly a traditional vernacular kind. In the

[3] An illustrated documentation through text and photographs of buildings, settlements and construction details taken by Yoshio Komatsu shows the diversity of vernacular traditions around the world. See Steen et al. [3].

[4] See Vellinga [4].

[5] Cole and Lorch [5].

[6] See Vellinga [4].

well-illustrated texts written by Steen et al. [3], the vernacular building practices have been idealized as 'sophisticated works of art' made by hands by the traditional communities and entirely associated with their physical environment and their natural resources. The emphasis is thus on buildings made of natural materials like mud, grass, wood, and bamboo and on buildings that are almost made without modern machinery but with simple tools, materials, and techniques.[7]

Nevertheless, even vernacular traditions have some adaptive nature. It grows in response to its surroundings and in a certain way of living. However, today a dominating stereotypical image of vernacular architecture has marginalized its adaptive nature and is considered no longer relevant to the future.[8] According to Oliver [6], the image of vernacular buildings is nothing more than thatched cottages and mud huts, which are only popularly considered for an exotic stay in the tourist destination. Though this type of building looks artistic and sensible, it leaves many questions unanswered about its construction methods, function, use, and meaning for the people who built or were employed to build them and who live in them now. So a building can be truly called vernacular for its relevant social and cultural identity where the mechanisms of practice continue to transmit and evolve with generations.

A sustainable modern approach to vernacular building, as Oliver [6] has called 'modern vernacular,' is a balanced approach to building making that uses the technical knowledge and wisdom of a particular tradition in a contemporary context. Revathi S. Kamath was an Indian architect who made the world aware of indigenous architecture's large diversity, durability, and beauty by experimenting with modern vernacular buildings. For her whole life, she has extensively worked with mud architecture in the era of technology and pioneered the practice. However, her practice is unique in a way that unlike the previously mentioned vernacular practices, she does not present 'a selective and idealized picture of vernacular traditions'[9] or does not present a particular tradition. Her practice is often much more varied, individual, and unique in design. Nevertheless, she improvises and fuses many modern elements. Among her projects of contemporary dwellings[10] all around India, 'The Madhya Pradesh Tribal art museum' at Bhopal is an important one (Fig. 2).

All the buildings of her design project were built to address the specific cultural and economic needs, skills, and aspirations of the community people who inhabit them or are closely associated with them. They are often hand-built, using renewable and sustainable materials and sometimes steel and iron as supporting materials. In case of the museum architecture in Bhopal, which is located in a land of ancient Iron Age and Bronze Age civilization, steel seemed to be a natural and choice as vernacular material. The structure of the building is supported by steel tubes and rods which are fabricated into intricate trusses.

[7] See Vellinga [4].

[8] Ibid.

[9] Ibid.

[10] See Kamath [7].

Fig. 2 Decorated iron armature and beam in Museum of tribal heritage in Bhopal

For any culture, a building is more than a structure.[11] And an anthropological approach to architecture goes beyond the mere appreciation of its 'organic' forms.[12] A respectful understanding of this approach leads a designer to look at the dynamic processes of living and using a place. It leads to a better understanding of the culture of people.

This article intends to show how for a museum of living culture, an ethnographic approach to museum architecture, design, and representation has an important curatorial role in addressing a community's cultural identities and economic needs. Besides building a zero carbon-producing building, the whole system generated by Revathi Kamath's design process is very labor-intensive, which this economy needs. In an interview she mentioned, that to keep a huge number of people employed, 90% of the expenses for building are on the labor. Likewise, only 10% is on the materials. She incorporates the extensive craft skills of Indian craftsmen into the architectural expression of her buildings.[13] For her, a building is both a process and an artifact.[14] She intentionally keeps her work labor-intensive and dynamic as a process. In the case of the Museum of Tribal Art and Heritage, this approach is more relevant as it acts as a patron and addresses the sustainability of cultural identity and practice by providing a platform for the practice of their art and craft to represent themselves as a living and the evolving subject of the display inside a museum.

1.1 Methodology

The researcher is interested in the representational narrative through display design in a museum. This is an independent investigation after completing the particular

[11] Oliver [6].

[12] See Vellinga [4].

[13] Urban Hustle 2.0 [8].

[14] Vellinga [4].

museum building project. For that reason, she has relied on the viewership of the curated design, her participation in the museum experience, and most importantly, on interaction and interviews related to the process and decisions on the final shape of the design. This is a qualitative research. So Primary data for the current research are the ethnographic data collected while participating in museum visits and another visitor, Mr. Malay Mondal, a visual artist. Photographs of the display and monographs of experience and viewership of the museum display by the researcher's team are important data. Conversation with other five visitors, three working artists who belong to the tribal community and who collaborated with the museum for display, and conversation with five craftsmen in the workshops at the museum premise and in the gallery under construction and interview with the creative co-ordinator Harchandan Singh Bhatty are another set of important data. All the interviews were semi-structured and open-ended discussions. Secondary data are the catalog, magazine, and publications by the Tribal heritage museum of Madhya Pradesh and *Madhya Pradesh Sanskriti Parishad* of Bhopal, published news articles, interviews, and blogs of the curators, officials, and most importantly, interviews of the architect and designer Kamath and published article regarding her practices and this project in particular. Last but not least, the literature review, narrative, and formal analysis have helped the researcher to bring the discussion about the alternative and unique approach of a museum to address cultural sustainability.

2 *Madhya Pradesh Janjatiya Sangrahalaya* and the Step Toward Cultural Sustainability

Madhya Pradesh Janjatiya Sangrahalaya is the museum of tribal heritage in Bhopal, dedicated to the original inhabitant of India living in Madhya Pradesh and Chhattisgarh, who were labeled 'tribal' by colonial settlers. Over thousands of years, these communities have evolved a way of life from a belief in the oneness of the land and the direct experience of the real living world. That gives rise to a collective consciousness that is manifest in their daily rituals, social customs, and material culture with objects and patterns that we today call 'tribal art.' However, 'tribal art' objects are not created in isolation or by an individual, but it is a collective process. John Burger, in his 'ways of seeing, described that such specific object that evolves within a context are lost by distortion of context. It often happens when only a few sensory objects are kept as relics in museums. The museum building and the display space dominate the objects displayed. Thus the culture is alienated, eroticized, and objectified through its representation in fragments. This is a challenge any museum dedicated to anthropological studies should require to engage with. As museum architecture is a container of the museum display, it is also a challenge for the architectural design. Beyond the usual disciplinary curatorial approach, the new museum building dedicated to living heritage in Bhopal, Madhya Pradesh, seeks to engage with this challenge. The Madhya Pradesh tribal museum was inaugurated in 2013. Harchandan Singh Bhatty,

the creative co-ordinator of the museum, an artist and sculptor, directed and designed the display along with people from the community whose culture is the subject of display. Among them, Arjun Singh Durve is from the Baiga community, Dhanesh Paraste is from the Gond community, and Bhuri Bai is a Bhil. They were also the representative members of the core committee and curatorial team for setting up the museum of living culture. Moreover, Kamath is the architect and designer of the experimental space. The curatorial practice of these two eminent personalities has provided insights into the alternative representation of a culture and ethnography in a museum. So under their direction in the construction process, they utilize the skills of the local people, whose culture is the objective and theme of the display. Many famous artists like Durgabai Vyam, Subash Vyam, Bauribai, Shanta Bhooriya, Geeta Bariya, and many community people have collaborated with the museum. Instead of showing old traditional objects and individual artworks as distinct masterpieces, they choose to display the ways of life practiced by the seven major tribes in the Madhya Pradesh and Chhattisgarh state—the Gond, Bhil, Korku, Baiga, Sahariya, Kol, and Bhariya—through their crafts that is exclusively designed, crafted and displayed for the museum[15] in collectives. The mural on the outside wall of the main entrance to the museum was first made on a paper roll by Durga Bai Vyam, which narrates a story popular in their community about the origin of the river Narmada from Amarkantak. The drawing was then enlarged in perfect proportion to mount on the wood.[16] In tribal life, there is no different concept for Art. Because it is part of a ritual to decorate the space and objects around them with metaphorical images, one can find an innate artistic sense in those crafted images. Any important event in tribal life like birth, marriage, death, or festivals is indifferent to Art. Therefore, in the museum display. There is no requirement to represent or talk about Art very differently. For example, in the tribal Art Gallery, paintings and crafts by some prominent native artists on display as contemporary Art look more isolated in the space than the overall display of their galleries.

There are often no contemporary elements in tribal representation. Whereas Tribal cultures are displayed in museums as historical subjects like most other subjects in a museum like relics, Madhya Pradesh tribal museum contradicts this practice and sets a new kind of representation of contemporary living culture by incorporating many contemporary modern elements in the display. Natives from the tribal community have been called to participate and contribute their knowledge and sensibilities in designing and constructing the whole space with the architect and the curatorial team. Moreover, unlike the lifeless white cube of museum galleries, the architect and curators develop innovative, engaging, and artistic ideas of architecture and display.

The Museum looks messy, very living, and delightful, and through its ever-transformative nature, it can be seen as an ideal representative of living heritage (Fig. 3).

About the nature of display in the Museum, Bhatty mentioned:

[15] See Tribal Aesthetic, Madhya Pradesh Tribal Museum Catalogue [9].

[16] Ibid.

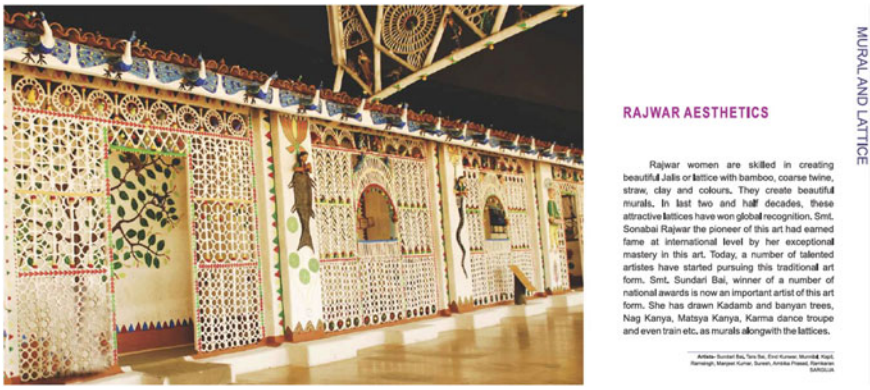

Fig. 3 Aesthetic of Rajwar community, Madhya Pradesh Tribal museum Catalog

> We have not finished our display yet. We haven't displayed it in a manner that it will be finished at some point and stay in a stagnant state for a long time as a final display. But we have wanted the people who have made their museums, their display, would get a job here, help in extending some other part of the building, and maintain and redisplay the ephemeral materials used in the display. It has become a necessity of this place to have those artists around because we think their presence will make the environment and the maintenance and display better and their work and the environment will improve. They are solely responsible for its restoration, conservation as well as extension. Because most of the tribal material cultures are ephemeral, they are ritualistic as well as temporary material. They get ruined with time. The very next year the display may look different. The display will keep changing.[17]

His statement shows the concern for sustainability in terms of employment and skill sharing. According to some visitors, unlike other typical museums where objects of importance are displayed with very little contextual information, this museum is much more delightful and engaging to experience.

So compared to other usual museums, fatigue comes after a longer viewing duration. It expresses an emotion about the tribal lifestyle, folklore, social rituals, and customs of the seven major tribes living in Madhya Pradesh and Chhattisgarh.

There is much dominance of warm and glowing colors (Fig. 4) in the galleries like yellow, orange, blue, red, etc. Everything on display in the space contributes to the holistic grandeur of the spatial narrative.

Traditional mud and brick houses of the tribes are displayed as artifacts and a small exhibit area where the audience can enter the architectural space inside these houses and look into the interior. The architectural spaces' interior has been recreated as a real functional space to reference their living culture. It is quite obvious that the construction of the building, making of the mud-plastered wall and the floor has been created not by any outsider skilled craftsperson but by participants of the culture and the profession. The recreated household space holds identical care and emotion to a real household. Unlike the other museums, the native sensibility has generated

[17] As stated in a personal interview taken by the researcher on 24th May 2019.

Fig. 4 Vibrant warm colors, contrast of light and shades in the gallery space

AWAKENING OF EARTH

The key role of music and dance in the life of tribal communities can be gauged by a Bhil myth narrated by Khuman Singh. According to the myth, Veelu Bai created the Earth, the Moon, the Sun, Mahadev, all the flora-fauna and human beings. The earth became green but was still a desolate place with no sound on it. Mahadev realized that it will not come alive without the beats of drums and other instruments, so he went to a carpenter who lived in Shajapuri and assigned him the job of creating drums. Carpenter went to the jungle fully prepared where he sought the permission of the teak tree whose branches were swaying up in the heaven. He then cut down the tree that felled in north-south direction. Hurriedly he tied a turban on the topmost branch of the tree, thereby preventing the sound to escape from the tree. 'Naad' or the sound was there on the earth since the beginning ,only the instruments were to be made to get that sound. Carpenter then made drums like Dhol, Mandar, Dholki, Sania Baja, Kundi & Dhaak . From the top-most branch he created the measuring jar and from the twisted roots of teak he created the instrument known as trumpet of modern times. He presented all these instruments to lord Mahadev. The later, in turn distributed them to the people of different tribes and castes. Gradually the sounds by instruments and dancing of people on the beats of the drums began to come from remote corners of the earth. Mahadev said now"My sister Earth is waking up".

Fig. 5 Catalog mentions the name of the native artisan involved in making a display piece

such a real association of their identity in these galleries. The natives on the job do conservation, restoration, and maintenance. So the whole space is entirely dedicated to the subject themselves.

The museum's catalog mentions the artisan name who made the significant grand pieces. To represent the importance of music and dance in festivals and events of the tribal community, myths from the Bhil community about making musical instruments and Gond myths about their ancestors have been symbolically addressed with the large structure of the tree of instruments named as '*Saja tree*' in the catalog and the display at the gallery of 'Tribal aesthetic'.[18] This big sculpture and installation have been set by Khuman Singh, Fudla, Anjora, Bepari, and Baljiya from Alirajpur (Fig. 5).

[18] See Tribal Aesthetic, Madhya Pradesh Tribal Museum Catalogue [9].

In the tribal life gallery, different types of dwellings unit of different communities, mainly a selected five among seven communities around an open courtyard, symbolize their neighborhood and coexistence with similarities and differences. Because there are space limitations, sometimes the houses are representative replicas of the real. Moreover, sometimes only a significant part of architecture represents the whole. Nonetheless, the architectural skills, method, materials, and aesthetic approach to house building have been displayed purposefully. Sometime around the space, the landscape has been recreated. Beside them, the fortresses of Gond King have been recreated. The crowded display and the void space inside the gallery symbolize the meaning of the space to the subject themselves.

Interestingly, the authenticity of the museum collection remains in question. The focus is not on any single object but the human association and myths about similar kinds of objects. They are considered historical as well as living subjects. So they have not displayed the objects as dead relics, but every object is the outcome of serious anthropological engagement of the community and the artisans through their craft. Their experiences are powerfully expressed in symbols of their surroundings, living traditions, and geographical environment. Most of the objects are constructed inside the museum premises in the workshop. While visiting the area, visitors can witness the community people engaged with their craft.

There are many sub-tribes among a major identity category. The Gond tribe has more than fifty such subcategories. There is some difference between them. Regardless, while representing, a dominant general idea of an identity category is given priority in any form of representation. Thus, it has also happened here. Still, the degree of homogenizing the culture is much less compared to the ethnography galleries of other museums, like the North-East Gallery of the National Museum of Art, Archaeology, and Anthropology in India. Constructing the museum and its surrounding space took quite a long time. From 2004 to 2013, the space was under frequent workshops with craftsmen and different kinds of craftsmanship, workshops with many anthropologists, ethnographers, artists, and designers. Moreover, in 2013, the museum was ready to open to the public. Revathi Kamath believed that a building needs to be participatory. It adds value to the work. Here the design got infiltrated by the consciousness of all the participants in the process. In this architecture, the participants' engagement and life experiences have been transmitted through the design. The thatched roof, hut-like structure, and some basic forms seem typical architectural forms though she has explored much and experimented with a modern design with the play of their proportion, area, and spaces and integrated other forms. The building is made in such a manner, on a huge area, and in an adaptive environment that can accommodate and facilitate various changes within the space. In that manner, one can consider the museum building a work in progress.

One of the primary purposes of the museum is to provide a workplace and employ the community people in their self-inhabited and self-represented space. Hence, the architectural and display design for the museum project is less about building but what it enables and represents in the difficult Indian context of the building, architecture, art, museum, society, and definitely of the representation of culture. This project has celebrated the spirit of its purpose.

3 Conclusion

Unlike the conventional display of indigenous cultures, current museum galleries and the integrated space explain how the community perceives art and aesthetics in everyday life. It has been evolving as a workshop for the living artist community. Kamath's designs show that buildings can be culturally responsive and environmentally sustainable if creative use of resources is made and vernacular methods are used in combination with modern technologies in an innovative way. Architecture and a designer have much to contribute to the current architectural and cultural sustainability discourse. An understanding and awareness of existing architectural and visual practices, their local economics, cultural values and practices, and the effect these have on the issues like cultural representation, native technology, and building standards helps to generate a different cultural embodiment of the architecture for society. Incorporating Kamath's and Bhatty's idea into the museum architecture and display is a milestone in the representational practice of living culture in the museum.

Besides being a major tourist attraction, there is a growing debate regarding the museum's representation and authenticity of its collection display. Some critics believe the ever-growing number of artifacts and displays causes a great degree of ornamentation and visual cacophony in this museum today. Again, the question arises: is the museum becoming a cultural Disneyland with this practice? It can probably happen that the interaction and engagement with the community have been reduced to a mere representation of their skills and the production of beautiful objects.

4 Future Scope of Research

The current research will give a direction for future research to engage and understand more profoundly the success or failure of the unique curatorial process of collaboration of the tribal community with the museum authority and the outcome of the display and functionality of the museum space. Years of engagement with the collaborators, changes in requirements and relationships, and experimentation with craft, space, and display will leave the scopes of research on how the issue of cultural sustainability will still be relevant in the context of representational practices in this museum or in the context of a museum in general.

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Innovation for Effective Low-Cost Processing of Assam Lemon

Prakash Kumar

Abstract North East is known for its rich biodiversity with a large variety of fruits, vegetables, spices, and herbs like pineapple, tea, peach, plum, strawberries, ginger, Cinnamon, bay leaf, *Bhoot Jolokia*, wild apples, lemon, beetle nut, Elephant apple, etc. being grown in the regions. Most of these items are perishable and require to be processed and preserved within a short span after harvest during the seasons. Many small processing units process this harvest locally. The best part of these units is that they operate with a very small capital and in a very small space but provide employment to the local population. However, these small units have significant scope for improvement as the processing activities are labor-intensive and most of the processes used in the units are the traditional methods. One such fruit is the Assam lemon which has a lot of nutritional value and medicinal properties and an interesting fact is that even the cover of the lemon is useful as it contains the natural pectin used in different kinds of preparations. However, due to its unique shape, the processing is difficult and the probability of contamination of the juice is high which reduces its shelf life. Also crushing or cutting the lemon seeds makes the juice bitter. So, there is a need for an effective solution that helps proper extraction of the lemon juice without bitterness and contamination risk. The paper highlights the development of a solution that addresses the issue related to the Assam lemon processing. It describes the issues related to lemon processing and then explains the development of equipment that addresses those issues. The paper concludes by reporting the evaluation of the proof of concept and the future directions for further testing and refining of the solution.

Keywords Assam lemon · Juice extraction · Seeds arrangement · Bitter taste · Solution · Device

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1 Introduction

North East is known for its rich biodiversity having a large variety of fruits, vegetables, spices, and herbs like pineapple, tea, peach, plum, strawberries, ginger, Cinnamon, bay leaf, *Bhoot Jolokia*, wild apples, lemon, beetle nut, Elephant apple, etc. being grown abundantly in the regions [1, 2]. Many of these products are perishable and require to be processed and preserved within a short span of their harvest [3]. Though there are many small processing units preserving and adding value addition to the harvest locally, the task becomes very challenging, especially, during the peak season. However, these small processing units are vital to the local ecosystem as they employ the local population of semi-skilled and unskilled laborers. The best part of these units is that they operate with a small capital and in a small space but generate ample employment opportunities [4]. However, these small units have significant scope for improvement as the processing activities are labor-intensive and most of the processes used in the units are the traditional methods [5–13]. Every horticulture item varies in shape, size, and physical and chemical properties, and cannot be processed with the same efficiency using the traditional tools. Also, the lack of a proper processing method increases the risk of contamination which drastically reduces the shelf life of the processed products. Hence, there is a need for designing solutions that fulfill the specific processing requirements of each product. Assam Lemon is one such local produce that lacks a proper processing solution due to its unique shape, size, and physical properties. Though it is rich in vitamins and minerals, it has high commercial value as its juice has many medicinal values and even its cover is used for extracting pectin [14]. The peel of Assam lemon is also used for preparing pickles which have good demand. However, due to its long oval shape and thick peel, it is difficult to be processed as compared to the normal round lemon. Hence an effort was made to design an effective solution for processing the Assam Lemon. The design methodology was used to innovate and develop the solution for effective juice extraction.

2 Method

The design method is a systematic and holistic approach used for solving complex multi-dimensional problems effectively [15, 16]. Similarly, for developing a suitable juice extraction solution for the Assam lemon, a systematic step-by-step process was followed which included problem identification, study phase, concept generation, screening, detailing and realization, testing, and refinement (Fig. 1).

Different steps taken during the design process in the context of the present problem have been discussed in detail below.

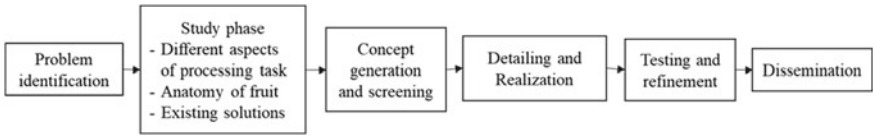


Fig. 1 Design method adopted for innovating solution for the processing of the Assam lemon

2.1 Problem Identification

The problem identification is the first step of the design methodology. In the present context, the problem was identified while interacting with different entrepreneurs and workers during another research related to the pineapple processing task. During my study, I visited a number of small fruit units in Assam that not only processed the pineapples but also processed other seasonal fruit produce in small quantities which included Assam Lemons and *Bhoot Jolokia.* And in the general discussion on the problems faced during different processing tasks, several units mentioned their limitations related to the processing of Assam lemons. This was initial input from the field that motivated me to study the different aspects of the issues in-depth.

2.2 Study Phase

During the study phase, different aspects related to the problems, the users, the fruit, and direct or indirect related technology, and practices were holistically studied to get an overall understanding of the problem.

A. *Anatomy of the fruit*

Assam Lemon is similar to any other lemon as far as anatomy is concerned (Fig. 2). The color of the fruit is either green or greenish yellow. The hybrid variety of fruit has less seed or no seed whereas the other variety has a significant number of seeds. However, it has an elongated oval shape which gives it a unique shape and every lemon varies from the other in dimensions. Therefore, a detailed study was conducted with 35 Assam lemons to determine the mean values of the different dimensions related to the fruit (Fig. 3). The diameter was found to vary between 4.7 and 6.0 cm, and the average value was calculated to be 5.6 cm. The length along the major axis of the fruit varies between 6 and 12 cm. The thickness of the peel including *Exocarp* and *Mesocarp* had an average value of 8 mm and it varied between 7.5 and 11.0 mm. The seeds are arranged around the placenta which is along the larger axis of the fruit. The seeds are arranged around the placenta covering a diameter that varies between 12 and 20 mm with an average value of 16 mm. The extreme ends of the fruit are somewhat pointed with a pedicle or flower stalk on the one side and remain of style on the other. The peel is thicker toward the point which has the stalk remain. The thickness is varying between 10 and 12 mm. Due to its peculiar elongated shape and structure,

it is difficult to completely extract the juice from the fruit using the existing juice extracting devices as they mostly extract juice by dividing the lemons into two halves. The seed arranged along the elongated axis is difficult to be removed completely as compared to the round-shaped lemon in which seeds are arranged radially around the core. Any seed left inside would be crushed by the existing devices and make the juice bitter.

B. *Study of workers at the task of Lemon Juice extraction*

During the study, different local techniques used by the workers for extracting lemon juice were observed and the different pros and cons were analyzed. It was found that generally two techniques were used by the workers.

(a) Cutting the lemon in two halves along the circular cross section

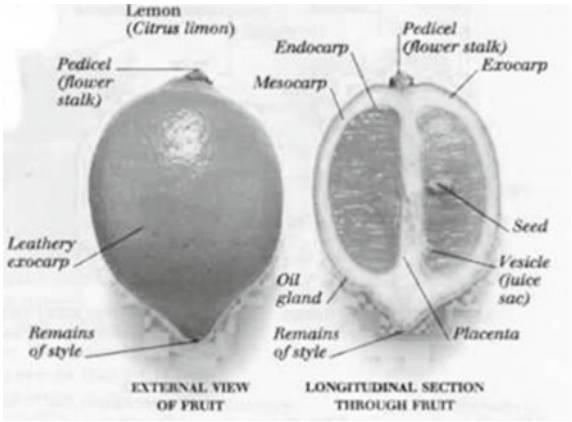


Fig. 2 Anatomy of the lemon fruit. *Source* Springer link

Fig. 3 Study of the different dimensions related to Assam lemon ($n = 35$)

Fig. 4 Lemon Juice extracted using first technique

In this technique, the juice can be extracted by holding the outer cover of the lemon. Hence the chances of contamination due to hand touch are reduced. However, it is difficult to extract the juice using this method effectively as a lot of force is required to squeeze or press the thick lemon cover. If some external aid is used to puncture the juice sacs, it may also crush the seeds and make the juice bitter (Fig. 4).

The advantage of this method of juice extraction is that the seed is easy to see and remove. However, it takes a long time to squeeze the juice and extraction is only partial in spite of taking good time and effort. The risk of contamination is higher as the lemon is continuously in contact with the hand.

(b) Cutting the lemon into slices along the longitudinal cross section

In this technique, the seeds are easy to remove and one can easily extract juice by pressing each slice by hand and also checking if the juice sacs are properly punctured. However, this technique is very time taking and the chances of juice contamination are very high as the juice sacs are in direct contact with hands (Fig. 5). So there is a need for a juice extraction method that makes the task easy and fast, does not crush the seeds, and reduces the chances of contamination due to direct hand contact during the task.

C. *Study of existing solutions for Lemon processing*

An extensive study was carried out to analyze different technologies, tools, and equipment used for the extraction of lemon juice. Different solutions used for the purpose have some pros and cons which gave insights regarding what problems the new solution should address to be more acceptable (Table 1). It was found that all the lemon juice extractors available in the market are made keeping in mind the round shape of the lemon and not the oval-shaped lemon. If these tools and equipment are used to extract juice from the Assam lemon, they won't be very effective. Either the juice yield will be less or the time taken will be more. In some of the methods, the chance of contamination will be higher. There is also a risk that the seeds will be crushed turning the juice bitter. Even the bigger equipment used for extracting lemon juice in large quantities is meant for the round lemons. For this equipment, the round lemons are fed one by one to the press with slicing blades and corer. After the feed, the central placenta, to which the seeds are attached, is removed first. In the case of

Fig. 5 Lemon juice extracted using the second technique

a round shape of lemon even if the placenta is not aligned with the corer, some seeds are removed by it and the chances of getting bitter are reduced. The mechanism is not effective for an elongated shape, leaving behind some seeds inside thereby increasing the probability of juice getting bitter due to seed crushing. Hence, there was a need for a specific solution for effective juice extraction.

2.3 Conceptualization

Based on the findings of the study phase, a brief was finalized to design a solution for effective juice extraction from Assam lemon. It has to be low-cost so that even a small processing unit can afford to buy it and get benefitted from it. Also, the solution has to be simple and made using the local materials to ensure that it can be troubleshooted at the local level. The first concept was ideated considering that juice can be extracted from one lemon in a single stroke. For this, the lemon has to be held vertically along its elongated axis. A circular fluted cutter first removes the placenta along with the seeds and then it takes an inflated shape like an inflated balloon to press the juice sacs to release the juice. The second concept was ideated considering that the fruit is cut in two halves along its circular cross-section. At first, a circular corer removes the placenta and seeds, and then the remaining part is pressed against the parabolic flute structure to extract the juice (Fig. 6). Both the above concept has certain pros and cons. The concept is perceived to be fast but has a complex mechanism, i.e., it is supposed to be fabricated from some special silicon or material that needs to be inflated by compressed air. The concept is also very expensive. It may not be a very suitable option for small units. The second concept is more practically possible. It can be manufactured using local materials but the juice extraction process is time-consuming (Fig. 7). Hence, another concept was generated combining good features of both the above concept. For this concept. The fruit has to be divided into

Table 1 Comparative analysis of some existing solutions

Sr.no	Existing solution	Pros	Cons
1		• Does not require any power • No Seed crushing	• Time required is high • Significant effort is required • Juice extraction is not effective • Not suitable for mass processing
2		• Does not require any power • No seed crushing • Lesser time required as compared to hand pressing	• Time required is still high • Significant effort is required • Higher probability of Juice contamination • Not suitable for mass processing
3		• Does not require any power • No seed crushing • Suitable for small time application	• Time required is still high • Significant effort is required • Not suitable for mass processing • Higher probability of Juice contamination
4		• Does not require any power • Suitable for small time application • Less time required • Lower probability of Juice contamination	• Significant effort is required • Not suitable for mass processing • High probability of seed crushing
5		• Does not require any power • No seed crushing • Suitable for small time application • Portable	• Time required is still high • Significant effort is required • Not suitable for mass processing

(continued)

Table 1 (continued)

Sr.no	Existing solution	Pros	Cons
6		• Does not require any power • No seed crushing • Suitable for small time application • Portable	• Time required is still high • Significant effort is required • Not suitable for mass processing • Higher probability of juice contamination
7		• Does not require any power • No seed crushing • Portable • Less time-consuming	• Significant effort is required • Not suitable for mass processing • Higher probability of juice contamination • High probability of seed crushing
8		• Fast operation • Less chance of contamination • Very less human intervention and effort are required • Suitable for mass production	• Requires power for operation • Fixed and Running cost is higher • More space is required • Not suitable for small entrepreneurs • Not suitable for processing the Assam Lemon

two halves. Both the pointed ends have to be cut too. Now each of the halves is to be inserted into the rotation tool head. This tool head is a combination of a round cutter and a fluted conic structure. at first, the round cutter removes the placenta and seeds and then, the fruit gets pressed on the conic structure and the juice is collected below it. The improved concept was then detailed to be fabricated and tested for its efficacy (Fig. 8).

2.4 Detailing and Visualization of the Product Working

Based on the ease of use, simplicity of mechanism, and fast operation, concept 3 was found to be most suitable. The selected concept was further detailed to establish

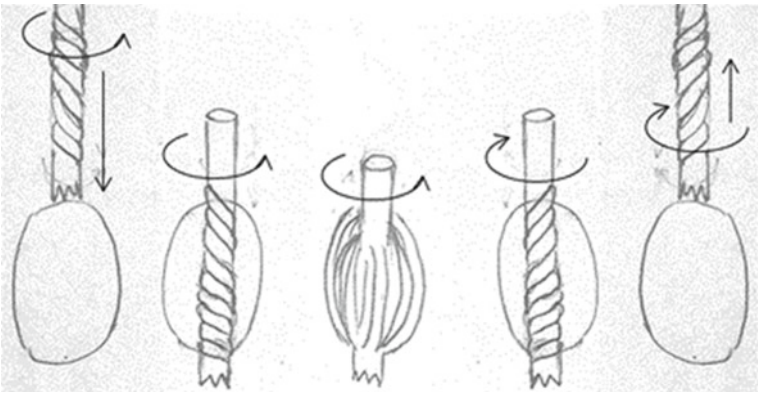
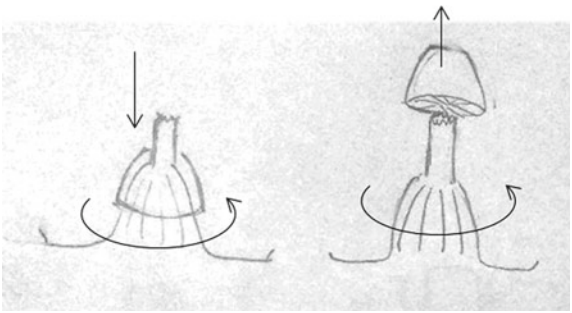


Fig. 6 Steps for juice extraction using solution concept 1

Fig. 7 Steps for juice extraction using solution concept 2

Fig. 8 Steps for juice extraction using concept solution 3



how various functions are to be packaged and arranged to achieve as the concept is transformed into a product. At first, the cutter with a conic structure was attached to a hollow pipe which is centrally mounted on the bearing and free to rotate. Above this pipe surface somewhere in the mid of its vertical height, a pulley is fixed which is attached to a motor pulley with a belt. Just below the fluted conic surface, a container

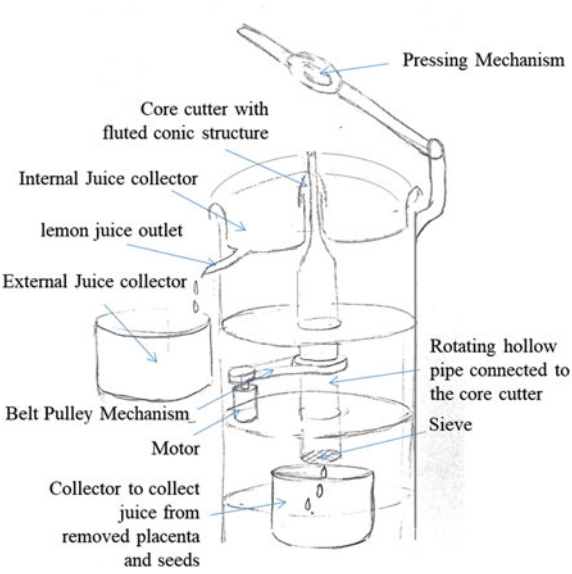


Fig. 9 Representational visualization of the new juice extractor's working

is fixed in such a way that it collects all the lemon juice. This container also has an outlet through which all the juice is connected to the external collector.

Just below the hollow pipe, a sieve is attached. The placenta and seed removed by the cutter move down through the hollow pipe and get collected over the sieve. Some amount of juice that is removed along with the placenta gets collected in the collecting container at the bottom (Fig. 9). Instead of the actual device, only a representational drawing has been demonstrated in the paper as the device is under the process of patent filing.

2.5 Initial Testing Procedure for the Performance

Before going for the complete fabrication of the solution, it was important to establish whether the proposed tool head would be able to remove the seeds and the placenta and extract the juice effectively. Hence, a small experimentation was done to check whether the concept would work if realized. For this, 3 batches of 4 fruits each were taken, and their juice was extracted using the traditional method, i.e., the lemon was halved along the elongated axis, seeds were removed manually with a knife and then lemon halves were pressed and scooped over the rim of any bowl-like container. The process was repeated several times with slightly rotating the lemon halves. For the new process, both the ends of the lemon were chopped by 8–10 mm and then the lemon was divided into two halves. These two halves were then pressed over the rotating head cum cutter mechanism and removed. The time required for juice extraction, the quantity and taste of juice obtained for each batch were recorded. The

process did not take into account the time spent on halving the lemons in both the processes.

3 Results

3.1 Findings of the Study Phase

After the study of existing solutions and study of the task being performed by workers, several findings were reported. It was found that the majority of the workers involved in processing tasks were women. Despite lacking a high literacy level, they were very skilled in their task. The tool generally used for extracting juice was the traditional knife. The low speed of work made them sit for a prolonged period which increased the ergonomic risk related to the work. Also, it was found that there was a lack of high-end equipment for extracting juice from the Assam lemon. It was also inferred talking to the small entrepreneur that even if there was a high-end solution they won't buy it due to the high cost involved. The apprehension related to the breakdown scenario was another reason for their reluctance. They were aspiring for a solution that could be made locally to avoid any troubleshooting-related delays.

3.2 Results of the Testing of the Head Cum Cutter Against the Traditional Juice Extractor

The results of the initial testing were encouraging as the results clearly showed that the new tool was not only able to remove the placenta and seeds but also extracted a large quantity of juice as compared to the traditional method. Due to the proper removal of seeds, the probability of juice getting bitter is drastically reduced. A few parts of the top cover of some seeds were also observed in the juice but they did not affect the taste of the juice. It was also observed that in the case of the traditional method, the force required to press the lemon was pretty high however, the seed removal was found to be efficient and the tool does not depend on any power source for operation other than human effort. On the contrary, the new device requires very less human effort as the lemon halves are to be just gently pressed over the new device head, and seed removal and juice extraction are done automatically. The residual parts are pulled out effortlessly. The time of operation is also very less. The mean time required by the new solution for extracting juice was only 16 s as compared to the 50 s required in extracting juice using the traditional method. The amount of juice extracted by the new method was also found to be more (25 ml) as compared to the traditional method which was 23.5 ml per lemon on average (Table 2).

The new mechanism was able to remove the placenta part containing the seeds almost effortlessly and without any time. The larger portion of the juice sacs ends

Table 2 Results obtained using the tradition method and new method of extraction

Methods of extraction	Mean time (in seconds)	Mean amount of juice (in ml)
Method-1 traditional technique using Knife and straight rim of a steel container	50	23.5
Method-2 new technique	16	25

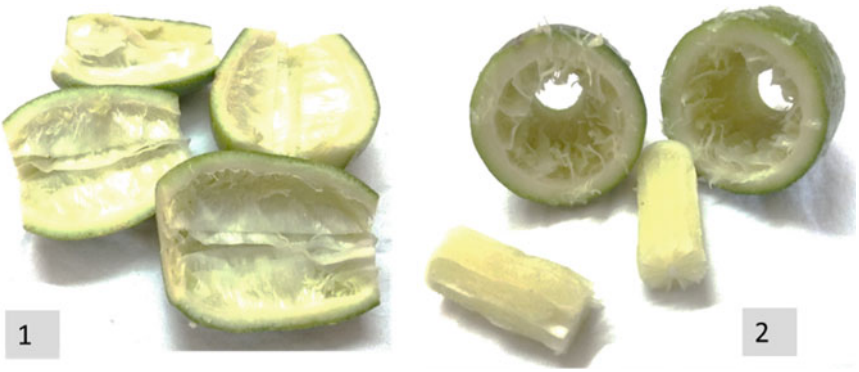


Fig. 10 Residual left after juice extraction using method-1 and method-2

were also cut with a placenta cutter. When this lemon half was further lowered, the juice was completely removed within few rotation of the fluted head leaving behind a dry residual peel (Fig. 10).

The amount of juice extracted during the process is also more compared to the traditional method. Since the yield difference is calculated only for a small sample; the actual difference would be quite significant in a factory setup where hundreds of lemons are processed in a batch.

4 Conclusion

4.1 Visualization of the System Using the New Device

The initial testing of the solution indicates the efficacy of the new solution. However, to have the full operational efficiency, the product also requires a system to operate so as to reduce the overall task timing. In this system, the first step would be to chop both ends of the lemon and divide it into two parts. Then these cut lemon halves are to be put in a container and shifted to the tables where the new device is placed. The person at the machine would pick the lemons halved one by one and place them on the new device, remove them from the device, and put the residual peel in a

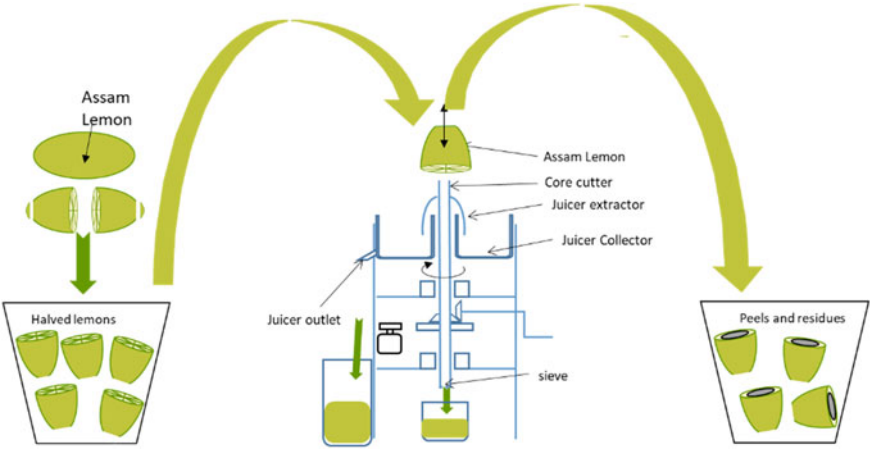


Fig. 11 System for effective juice extraction using new solution

separate container while the juice gets collected in a juice container. Some of the juice dripping from the placenta is also collected separately. The system would also prevent the risk of contamination as the period is significantly reduced (Fig. 11).

4.2 Future Scope of Work

Transforming the proof of concept into a full-fledged product would require further discussion with stakeholders and consequent refinement of the idea. For instance, some of the stakeholders suggested a dual mode of operation so that it could be operated with power as well as without power. These changes would require time and resources for incorporation. This research finding also encourages research in the field of processing of other horticulture items of the North East which has good potential and commercial value if processed and preserved with the help of effective tools and equipment.

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Design Issues and Their Associated Health Hazards from Metal Fumes During the Welding Process

Harsh Mohan Shrivastava and G. Srinivasan

Abstract This paper presents the various design issues and health hazards associated with the welding process. A detailed human-machine environment (HME) block diagram was constructed to analyze the welding process. Based on the HME diagram, field visit and literature review, a detailed set of questions was framed. The design issues and health hazards were compiled from a broad group of welders around Tezpur, India. The questionnaire consisted of parameters like length of welding exposure, welding duration, welding flashes, dust and fumes in welding, ventilation available, usage of protective equipment, and various symptoms and issues faced by welders. Based on the response received, the following was observed. In most cases, the welders used welding goggles and shields to protect them from welding sparks, debris, and ultraviolet rays. It was observed that the welders were unaware of the health hazards caused by metal fumes generated during the welding process and its impact on the welder's health. No protective equipment was used by welders to prevent metal fume inhalation. Thus, welders require an immediate occupational safety guideline to be implemented in the workspace to prevent metal fume inhalation. The concepts were developed by integrating the TRIZ principles and morphological charts. Based on the above factors, the authors have presented various product concept design alternatives to prevent metal fume inhalation among welders.

Keywords HME interaction · Welding · Need analysis · TRIZ principles · Metal fumes · Health hazards

1 Introduction

Welding is a manufacturing process carried out across the globe for joining various metals. The application of the welding process is widespread across multiple industries and sectors. It is estimated that 11 million people work as professional welders, and around 110 million people are associated with welding-related tasks and their

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exposure [1, 2]. Among the various welding types available, welders predominantly use the arc welding method. In India, it is observed that the arc welding process constitutes 80% of the joining process. Further, it was reported that the welding economy constitutes 18 billion dollars, and arc welding has a significant share of 13 billion dollars in it. The metals are melted, condensed, and vaporized into fumes during the welding process [3]. It is observed that welders are continuously exposed to welding fumes (NO, CO, etc.) that are toxic.

A study was carried out to determine respiratory and lung infections and their symptoms prevailing among welders and non-welders [4]. It was observed that bronchitis, a form of respiratory illness, was more common in welders (17%) than in non-welders (2.5%). The results depicted a strong relationship between welding practice and its associated health hazards for welders. In the case of mild steel welding, it was observed that welders have a higher chance of getting infected with lung cancer [5]. It is observed that based on the metal that is welded, various infections and diseases are reported in welders. For example, manganese welding causes neurological disorders, and chromium and nickel-based welding results in carcinogenic effects among welders [6]. A detailed analysis of 128 welders in a factory found that welders had ocular symptoms and eye safety issues. The signs were correlated to the length of welding time, workload, and dust and fumes observed in welding practice [7].

The literature review shows that current welding practices carried out by welders have potential health hazards [4–7]. Thus, protecting the welder from metal fumes during the welding process is essential. This can be achieved by redesigning the welding equipment and providing appropriate guidelines. From the literature review, it was observed that there are few profound research articles on the redesign of welding equipment considering the effect of welding metal fumes inhalation by welders. Proper guidelines for welders were not available with respect to welding fumes and their associated health hazards caused by welding fumes.

This paper presents the various design issues and health hazards associated with the welding process. Based on the HME diagram, field visit and the literature review, a detailed set of questions was framed. The design issues and health hazards were compiled from multiple welders through questionnaires. The following was observed based on the response received from a board sample size of welders. It was seen that the welders were primarily unaware of the health hazards and working environment. It was found that the welders require an immediate occupational safety guideline to be implemented in the workspace. Based on the above factors, the authors have proposed redesigning the welding helmet, which requires a change in design, technology, and management to design the volume of human-machine components and their comfort level in the welding process. The new concepts were generated by integrating TRIZ principles with the morphological chart. Three different concepts were generated and compared with the existing shield. The proposed design will incorporate necessary changes to avoid the inhalation of metal fumes during the welding process. Further, detailed guidelines will be outlined during the welding process.

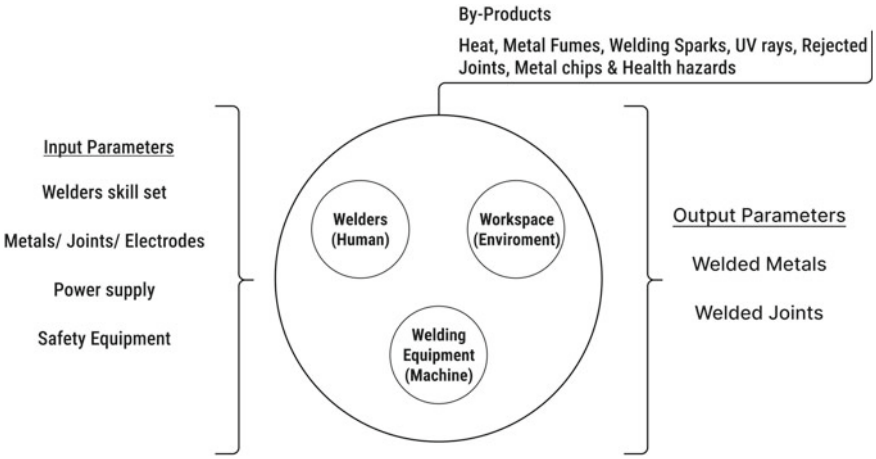


Fig. 1 A human-machine environmental model—welding process

2 Human Machine Environment (HME) Model—Welding Process

A detailed study of the human, machine, and environment was conducted to understand the welding process. The HME model helps us understand the overall attributes of three central subsystems like human, machine, and environment. The inputs for HME are listed as the skill set of welders, electrodes, electricity, and metal. The welders (human), welding equipment (machine), and workspace (environment) are the subsystems in HME. The byproducts observed from the HME model are heat, metal fillings, metal fumes, dust, health hazards, and sparks. The output of the HME is welded joints, metals or finished products. A detailed HME model is shown below in Fig. 1.

3 Development of Questionnaire and User Data Collection

A detailed set of questionnaires was prepared based on the HME model and its interactions with the environment. The following procedure was adopted to get feedback from the welders.

1. The questionnaire consisted of the following parameters

- Lighting/visibility
- Ventilation
- Posture
- PPE kit implemented
- Awareness of welding hazards
- Frequency of illness

- Skillset
- Knowledge of equipment
- Implementation of safety equipment

2. The questionnaire also included age, years of experience, feedback from welders, and the frequent health issues welders face.
3. The welders were requested to rate the questionnaire on a scale from 1 to 5.

   1—Worse 2—Bad 3—Neutral 4—Good 5—Very Good

4. The user analysis was conducted on six different welding shops and industries across Tezpur. The total number of welders interviewed was 25. Many welders and their colleagues shared similar experiences. Thus, the analysis neglected identical evaluations obtained from welders or colleagues from similar industries. The analysis was considered for 15 welders. The various welders and their associated working space in the existing welding shops and industries along with the safety equipments are shown in Fig. 2.

4 Analysis of User Data Collected and Its Outcomes Using Pareto Chart

The collected data were used to plot a Pareto chart to identify the critical parameters that are the primary concern for the welders. The questions rated as 1 (worse) and 2 (bad) were considered for the process improvement. This helps separate the critical parameters that affect the welders on a large scale from the primitive ones. The questions are arranged in descending order, emphasizing the horizontal axis's critical factors. The frequency of response from the welders is shown in the primary vertical axis. The cumulative percentage of response in percentage is shown in the secondary vertical axis. A graphical representation of the factors and their associated frequency is shown below in Fig. 3 to understand the rating of the welders. The red bar diagram implicates scores/ratings 1 and 2. In contrast, the blue bar diagram depicts the scores/ratings 3, 4, and 5. A detailed set of questionnaires was prepared based on the HME model and its interactions with the environment.

Based on the above graph, significant parameters which the welders suggested to improve were (i) PPE equipment to prevent metal fume inhalation, (ii) frequency of illness reported (fever and frequent water seeping from nose and eyes), and (iii) implementation of single safety equipment to cover metal fumes, UV rays and sparks. The parameters mentioned above were interlinked with the inhalation of metal fumes. The welders inhale the metal fumes that originate during the welding, and in most cases, no safety or protection equipment is worn by the welders against fumes. It was observed that welders used regular spectacles and shields more frequently, which protected them from sparks, UV rays and eye-related illnesses. However, no safety

Fig. 2 Welders and their safety equipment—existing in welding shops and industries around Tezpur

equipment was used for metal fumes, and the welders were not knowledgeable about the effects of metal fumes; and their associated illness.

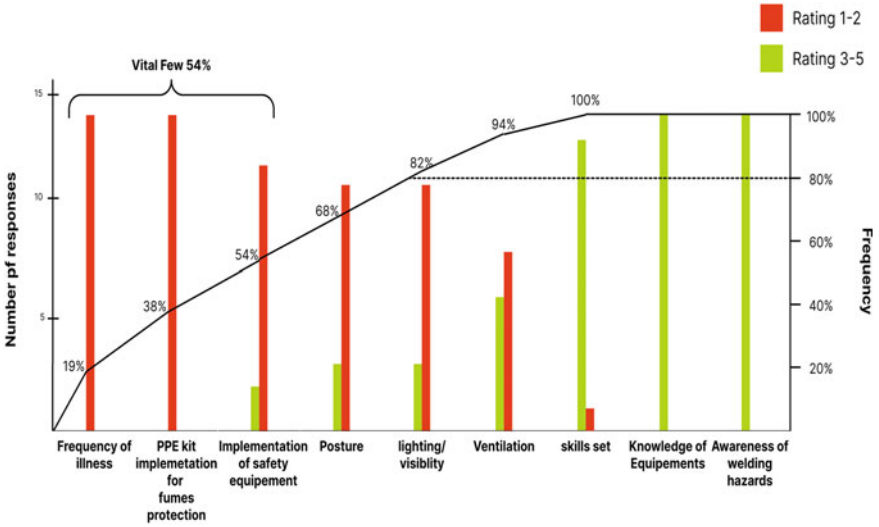


Fig. 3 Pareto analysis of critical parameters-welding process

5 Concept Generation—Integration of TRIZ and Morphological Chart

In this paper, the welding helmet design was designed based on the integration of morphological and TRIZ principles. The above methods were used to develop suitable design solutions in the concept generation stage. The TRIZ principles were used to solve the design issues identified through literature reviews and field visits. The morphological chart was mapped based on the user need analysis and TRIZ principles. Universality and Spheroidicity were the TRIZ principles used to build the concepts in the morphological chart. The design features used in the morphological chart were the mounting feature, glass design, helmet shape, and protection from metal fumes. Various concepts were generated based on TRIZ principles and morphological design features. Three major design solutions were obtained and refined to fit users' needs. Figure 4 shows the integration of the morphological chart and TRIZ principles used to develop the design concepts.

6 Development of Concepts from the Integration of TRIZ and Morphological Charts

Based on the literature review, HME model, and questionnaire, the primary focus was to design safety equipment to prevent the inhalation of metal fumes. Concept generation started based on the amalgamation of customer needs, and its associated

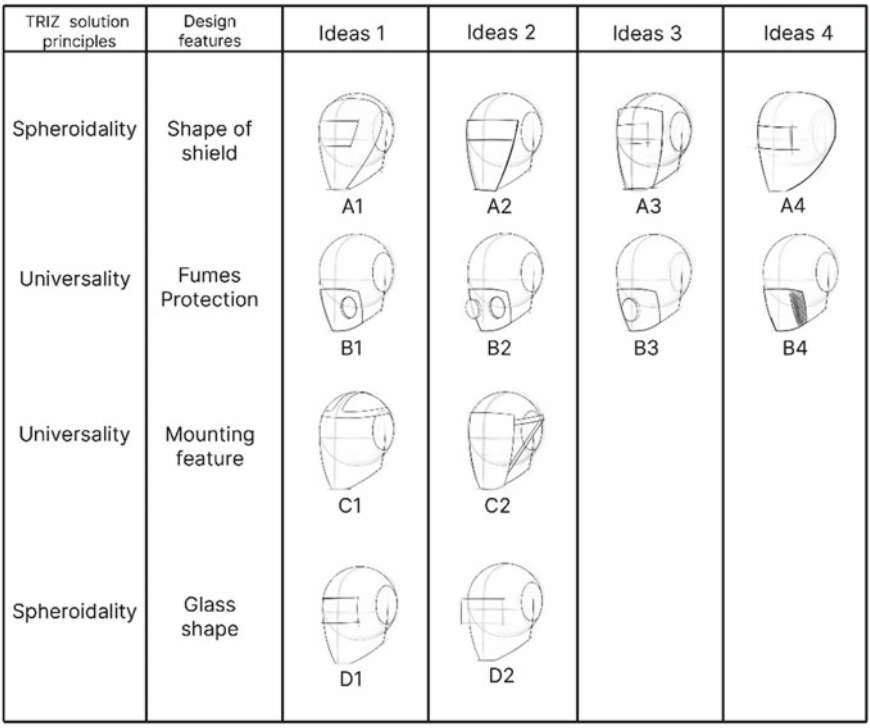


Fig. 4 Integration of TRIZ and Morphological chart—Concept generations stage

target (prevent metal fumes) was considered. Thus, various design solutions and ideas were generated to target the customer's needs. Various concepts were generated by integrating the TRIZ principles and morphological chart, as shown in Fig. 5. Three designs were selected from the various combinations as shown in Fig. 6a–c.

7 Evaluation of the Proposed Design Concepts

The developed design concepts were evaluated based on the design selection attributes. The current design available in the market is compared with the developed concepts based on welding fumes protection, attachment to head, weight, cost, ease of manufacturing and design stability. Based on the design goals, the developed concepts were evaluated as shown in Table 1. The design selection attributes of each concept were mapped with respective design interventions and the score was evaluated. Based on the score, ranking of the concepts was set. It was observed that concept 3 had a better ranking when compared to other design concepts and existing products.

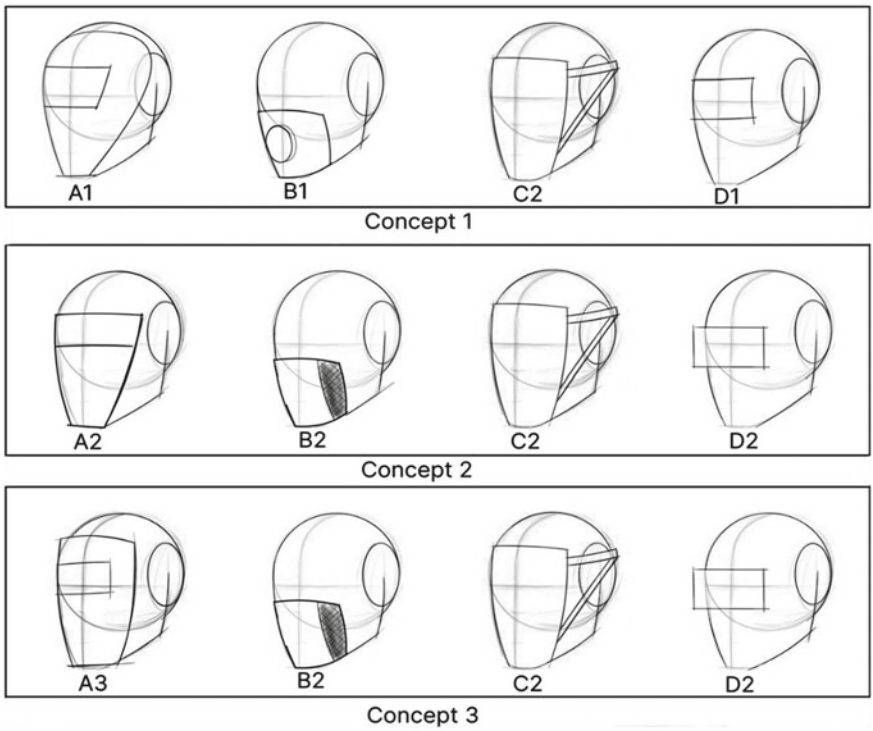
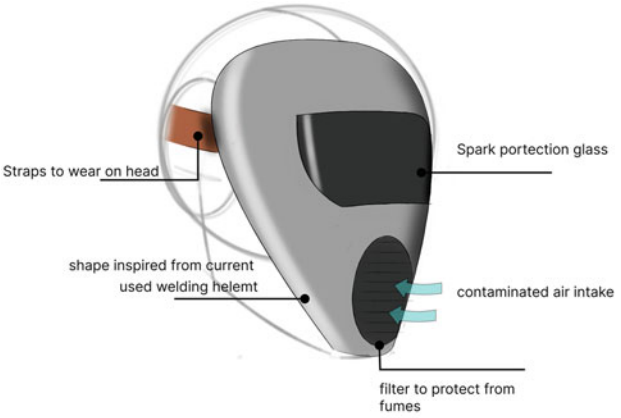


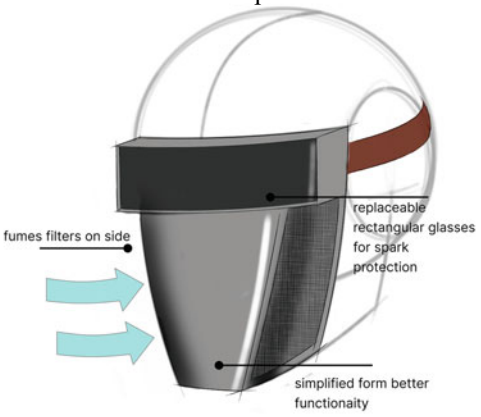
Fig. 5 Various concepts generated from the morphological charts

8 Final Design Selection

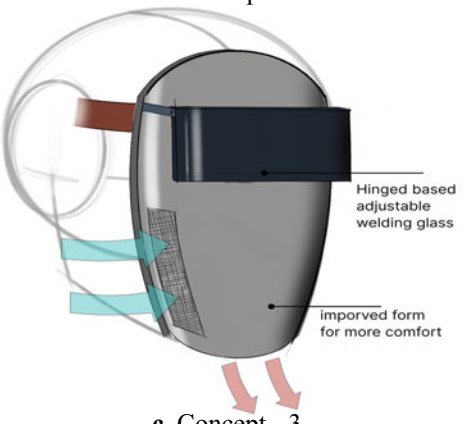
The various design concepts generated from the TRIZ principles and morphological charts were evaluated. Based on the final score and ranking, concept 3 was finalised as it outperformed the other two concepts. The sketches are primarily designed such that the welder requires a single piece of equipment to protect from sparks, UV rays, and fumes. The final design sketches are shown in Fig. 7a. The exploded view of the final design is shown in Fig. 7b. Further, comfort and simplified design solutions are provided with proper filters and air vents for inhaling and exhaling air. The filters are designed to avoid metal fumes, and the whole equipment can be used as integrated safety equipment. Adjustable welding glass is provided such that it comes in a modular design arrangement with straps to hold it correctly.



a. Concept - 1



b. Concept - 2



c. Concept - 3

Fig. 6 **a.** Concept-1. **b.** Concept-2. **c.** Concept-3. **a, b and c** Concept generation—Different sketches—welding equipment

Table 1 Evaluation of datum and developed concepts based on design attributes

Design selection attributes	Datum	Concept 1	Concept 2	Concept 3
Protection from metal fumes	–	+	+	+
Attachment to head	–	+	+	+
Weight	–	–	–	+
Cost	0	–	–	–
Ease of manufacturing	+	–	–	–
Design stability	+	+	+	+
Total score	−2	0	0	2
Ranking				
Evaluation (+ = 2; − = −2; 0 = 0)				

9 Conclusions

The design issues and associated health hazards from metal fumes during the welding process were comprehensively studied. The following observations were made.

- The questionnaires were framed based on the HME model and interacted with various welders across Tezpur, India.
- The rating of the various questionnaires by the welder was carried out, and Pareto Charts were implemented to analyze the collected user data.
- The following critical parameters were observed from the user data and need analysis (i) PPE equipment to prevent metal fume inhalation, (ii) frequency of illness reported (fever and frequent water seeping from nose and eyes), and (iii) implementation of safety equipment.
- Based on the observations, it was seen that the welders predominately ignored health hazards from metal fumes. Hence, this work provides design solutions through concept generations and sketches developed by integrating TRIZ principles and morphological charts.
- The evaluation of various concept generations was compared with the existing helmet. The proposed design concepts are found to be performing better than existing products. Based on the final score and ranking concept 3 was finalized.
- The proposed helmet considers the following issues (i) Integrated safety equipment to consider sparks, UV rays, and metal fumes. (ii) The design accommodates filter units for metal fumes and vent units for proper inhaling and exhaling of air while breathing (iii) Adjustable welding glass and straps are provided for comfortable wearing during the welding process.
- The welders must be sensitized to the health hazards caused by welding fumes. Thus, welders require an immediate occupational safety guideline to be implemented in the workspace to prevent metal fume inhalation.

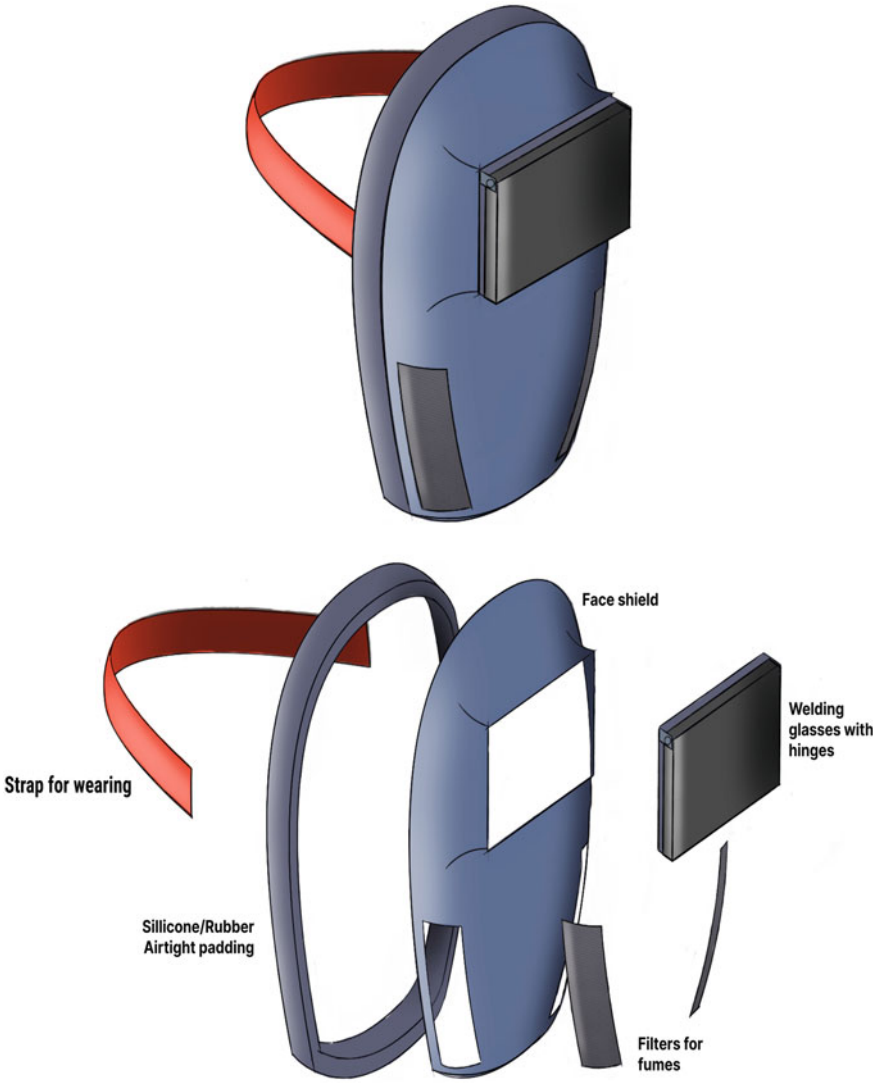


Fig. 7 **a** Selected concept based on ranking. **b** Exploded view of the selected concept

10 Future Challenges

- A prototype of the proposed design will be developed and tested.
- Feedback on the proposed design will be collected from the welders.
- Based on the feedback from the welders, necessary changes will be made in the final design.
- The final developed equipment will be tested in real-time scenarios.

- Selection of filter material to be integrated with the welding helmet to prevent the metal fumes will be carried out in the future.

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Reducing the Pollution of Mithi River: A Waste Disposal Intervention

Tanya Swaminathan and Arundhati Guha Thakurta

Abstract Water may be a very important part of our lives: whether or not we're cooking, cleaning, washing or drinking, we tend to acquire contact with water in many forms of ways, every day. We assume it to be clean and safe, but even drinking-water can be contaminated by harmful bacteria. These harmful bacteria breed and multiply in our water systems. One of the main causes for this is stagnation–water remaining stationary for an extended period of time. Standing water, before stagnating, acts as a breeding ground for harmful bacteria and becomes stagnant. This paper focuses on slum dwellers living along the Mithi River and directly using the river for their garbage and subsequently, causing small pockets of water to be obstructed and stagnated. It also aims to understand the behavior of the people in the community with respect to garbage disposal and allow the residents of the area to live hygienically without the presence of unpleasant smell and sight. Using different design research tools, 60 participants were involved in generating insights through research like surveys, interviews & camera study to tackle the problem at hand. It discusses on designing a solution that will help understand and provide a system to encourage the proper usage of waste disposal elements. We believe that this system will certainly help people gradually increase their usage of garbage bins and indulge in a healthier community mindset.

Keywords Water stagnation · Waste disposal · Domestic waste · Urban slums · Water borne diseases · Mithi River

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1 Introduction

Water stagnation is considered as a major health hazard because it provides a better incubator for several disease-carrying bacteria and parasites. One of the most popular and notorious being, Malaria, spread by infected mosquitoes. Mosquitoes are a biting annoyance and have significant economic and health implications, particularly for residents of tropical nations like India. It is necessary to create natural preventative measures for the management of mosquitoes and mosquito-borne diseases due to the environmental problems and health risks associated with synthetic insecticides.

1.1 Global Scenario

Together with six other diseases, malaria accounts for 85% of the socioeconomic burden of infectious diseases worldwide. There are over 2020 million people who could develop malaria. Of the 1.4 billion people living in 11 countries in the WHO's Southeastern Asia region, 1.2 billion are at risk of contracting malaria, with the majority of them residing in India. But just 2.5 million of the world's malaria infections originated in Southeast Asia. Of these, India alone was responsible for 76% of all instances [1]. With the help of epidemiological models, geographic information, and demographic data, it has been determined that Plasmodium falciparum outside of Africa, particularly in Southeast Asia, measures 200% higher than what was reported by the World Health Organization. This calculation takes into account clinical episodes. Additionally, 71–80 million cases of P. vivax malaria have been reported globally, with Southeast Asia and the Western Pacific region accounting for roughly 60% of those occurrences [1].

1.2 Indian Scenario

The World Health Organization (WHO) and the Ministry of Health & Family Welfare (MoHFW), Government of India, hosted a two-day meeting in 2016 to discuss strategy, innovation, and research, strengthen the health system, and exchange experiences for the elimination of malaria in India. The new framework would incentivize all Indian states with varying rates of malaria transmission to step up their efforts to eradicate the disease and set forth clear benchmarks and objectives to do so. Innovative approaches and unwavering will are necessary to eradicate malaria. The framework must have the cooperation of all stakeholders in the health sector and be fully implemented in order to reach its milestones and improve the health and welfare of millions of people throughout the nation. The WHO South-East Asia Region's Regional Director, Dr. Poonam Khetrapal Singh, stated that this is a chance

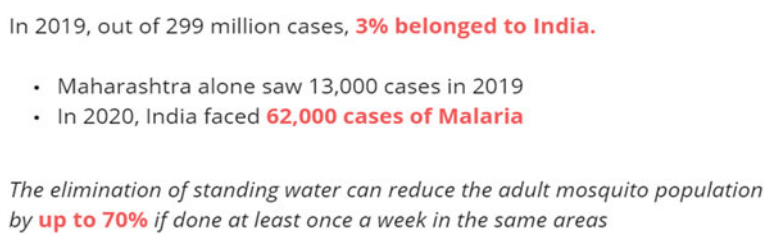

Fig. 1 Statistics of Malaria in India and Maharashtra. *Source* Information

to bring about long-lasting, noticeable change and calls for firm and unshakable determination [2] (Fig. 1).

It is a huge step forward because of the Government's commitment to eliminate malaria by endorsing the Global Malaria Technical Strategy 2016–2030 and setting a national malaria elimination target of 2030 that will have a major regional and global impact according to Dr. Henk Bekedam, WHO Representative to India. The objectives of the National Framework for Malaria are comparable to the WHO Global Technical Strategy (GTS) for Malaria 2016–2030 and Asia Pacific Leaders Malaria Alliance (APLMA), Malaria Elimination Roadmap for the Asia Pacific [2].

2 Literature Review

2.1 Various Interventions to Reduce River Pollution and Mosquito-Borne Diseases

Insecticides have been a major component of vector and larval control efforts against the vectors of many tropical diseases, including malaria, dengue, zika, and many more. Numerous pesticides used in fumigation, bed net impregnation, indoor residual spraying, and the treatment of larval breeding grounds have already lost their efficacy or are in danger of doing so. The ability to deploy aquatic predators to target vector larvae in their breeding environments has not yet been given high priority in control initiatives. Aquatic predators' resources include aquatic forms of numerous land- or aerial species as well as animals that live in water [3]. Numerous species of those animals have evolved to either feed on mosquito larvae or to prey on them. The current investigation's findings indicate that it is now necessary to install sufficient effluent water treatment systems and for the regulatory authorities to enforce pollution control laws to prevent the irresponsible discharge of industrial as well as domestic wastewater into water bodies [4].

A fog-cloud based cyber-physical system that enables the association of devices in the physical space, such as smart wearables, IoT sensors, and smart cameras with cyber space to obtain the desired information After then, it makes use of the internet to collect, examine, and distribute medical data among consumers and

healthcare providers. To distinguish, categorise, and keep track of MBD-infected people, a wholly original system supported by IoT sensors, cloud computing, and fog computing is presented [5].

In a study, a method for making silver nanohybrids that can be used to kill mosquito larvae while still being environmentally benign, simple, and green is shown. It has excellent performance at low concentrations and is resistant to a wide range of environmental factors, including temperature and other compounds that might interfere. Thus, it may be possible to control mosquito breeding using environmentally friendly materials. This study can be expanded while keeping track of the materials' efficiency in stopping mosquito breeding in stagnant water, sewage water, and other areas [6].

Beginning in 2015, Tamil Nadu adopted a state-funded solid waste management programme. The SWM program's primary goal was to maintain the villages' general cleanliness. Villages' solid waste should be disposed of safely. The plan offered a comprehensive SWM solution that included trash collection, transportation, segregation, safe storage, and disposal of the collected waste. SWM activities involved 66,310 "Thooimai Kaavalars." Due to the lack of a treatment mechanism, open drains, streets, vacant land, or aquatic bodies were frequently used as dumping grounds for the gray water produced by rural households. Land contamination, aggravated waterborne diseases, and surface water contamination were the outcomes. The biggest difficulty in coming up with a global strategy for controlling the gray water was the lack of appropriate technology choices, especially for rural areas. Detailed Guidelines with Type Designs for the Construction of Individual and Community Soak Pits were given by the Government of Tamil Nadu MGNREGS during 2017–2018 in order to take up Gray Water Management in a Big Way [7].

The estimation of malaria's genuine burden and control are crucial to tackling these problems with the ultimate goal of lifting the human resource beyond the poverty line because malaria is well known for its crippling, demoralizing, and impoverishing repercussions. As treating the disease is financially ruinous for the populations living on the edge, the impoverished may find it difficult to deal with the recurrent malaria problem. A compelling argument is made for sufficient investment in malaria prevention in India by the predicted 20-fold returns on investment. In India's current era of economic liberalization, a wise investment in malaria control makes sense from both a public health and financial standpoint. Effective malaria control is crucial for human resource development, which is crucial for fair and long-term economic growth [8].

2.2 Slum Settlements and Waste Disposals-A Misalliance

Only two-thirds of homes in Mumbai, a megacity with more than 2000 slum settlements, have access to upgraded toilet facilities and have inadequate water access. Mumbai's problems with water and sanitation need to be resolved in order to change the city's environment. Creating a baseline for the existing conditions in a few Mumbai slums can be the kickstart of eradicating the misalliance [9]. It will assist in

creating useful social interventions and should be applied to all Mumbai slum areas. Addressing issues including efficient garbage disposal systems, along with other issues like ample water supply, and women's safety in restrooms has now become a need [10, 11].

These compelled us to provide a human-centered intervention that will aid in bringing about long-lasting changes in neighborhood communities by community interventions for clean-up activities and waste disposal habit loop.

2.3 Mithi River

Mumbai has utilized Mithi as a sizable sewer over the years. For low-lying coastal towns like Mumbai, this very polluted river is actually a blessing. If Mithi were to perform as intended, flooding in the city would be avoided [12, 13, 14]. Mithi serves as a natural storm drainage system. Around a thousand city inhabitants perished in the 2005 deluge, which was brought on by inefficient drainage during periods of heavy rain and high tide. Both the pattern of the rivers and the degree of invasion change over time. In order to plan out the new initiatives, the out-of-date information on the Mithi is of little help, hence a new research will need to be conducted to assess the Mithi's current condition [15, 16, 14].

3 Methodology

This section includes all the tools and methods that helped to carry out the study in the right manner. All the measures that were taken to carry out the research process seamlessly have been discussed (Fig. 2).

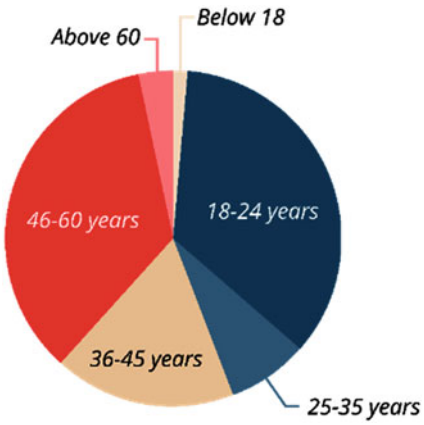

Fig. 2 Demographics of the participants

3.1 Participants

The study included 60 participants from Mahim Causeway as well as 63 participants from Mumbai, who were a part of an online survey. The study also included other stakeholders such as B.M.C. Officials, Pest Control Office staff and N.G.O.s. Participants were interviewed and data was collected. The current study includes the target demographic of 18–40 year-old householders. The following are the processes and tools used to conduct the research. They are divided into three phases and have their own requirements and expectations.

3.2 Materials

Phase I: This phase of the research included data collection through empathy interviews by using various tools and to understand the stakeholder's emotions, thoughts, feelings and motivations during a task related to the research area. Mind mapping were used to express and generate ideas and thoughts was used to help build content and narrow down on specific problem area. It also helped identify the primary stakeholders for the selected domain. Then through online survey was sent out to all the targeted groups with questions that focused on broad aspects of the topic "Water stagnation" and "Mosquito severity". It helped guide the study in a certain and specific direction (Fig. 3).

A camera study was done to observe the location, community, and actions of the user group when they were present in their respective homes. It was done for 2 h at Mahim Causeway in Mumbai. Empathy interviews were conducted to understand the user group's emotions, thoughts and feelings that they have while doing their

Fig. 3 Area along the Mithi River bank in Mahim Causeway

daily task(s). These were very vital as they give genuine information about the user and insights were very easy to draw from these.

Phase II: This phase of the research focused on synthesizing the data collected from the previous phase and using it to come up with problems and solutions. Learning how to come up with creative solutions was a crucial part. Empathy maps were created by breaking down the information of the empathy interviews and separating it into six different groups, 'Think & feel', 'Say & do', 'Hear', 'See', 'Pain' and 'Gain'. They help in digging deeper into the interviews and finding real reasons for the user's problems. Then saturated wall technique involved combining the above six groups into one to convert thoughts as well as ideas into tangible, visual pieces of information that helped inform and inspire the research. These were grouped to find insights, themes and patterns that may emerge, and strive to move toward identifying meaningful needs of people and insights that informed the design solutions. The Point of View (POV) was a structure that gave forward direction to the study. It helped narrow down problems and focus on a few for better results.

The initial conceptualization through the how & why laddering was done by using the POV formed, splitting it into smaller parts, asking questions 'How' & 'Why' to gain depth in the topic and then using those questions, brainstorming was done by thinking about ideas and thoughts for each of the questions. Finally, concepts were created by combining two or more randomly picked ideas and then connected in a manner where it would solve the problem of the user group.

Phase III: This phase being the last one required to re-visit the initial concepts and refine them accordingly. The final concept was built on the previous ones and required a Product Vision too.

The previous Point of View was reiterated to suit the status of the project. It was done by going back to the insights gained from the grouped wall and adding layers to the POV. Using the POV, a product vision was formed to give a base to the solutions and concepts that would be formed later. It conveyed the intent of the project and helped users connect better with specific problem scenarios. Minimum Viable Product (MVP) was formed as a version of the final concept that was made with less features but enough to collect feedback with. Value hypothesis was formed based on what value the concept would give to the users. It was done by thinking on the lines of the product Vision and defined problem statement. Another hypothesis but based on how it would grow in the market and in the near future. Risk analysis was done by mapping an uncertainty v/s impact map for the concept features that were decided upon. SWOT analysis: This analysis was done to find the strengths, weaknesses, opportunities and threats to the final concept.

Low-fidelity prototypes were made to test the working and functionality of the product. This was done to gather feedback from the users as to how they feel about it. Using this feedback, high-fidelity prototypes were made which test the look and feel as well as the working and functionality of the product.

The user testing was done where actual participants from the target audience interacted and used the design, for the authors to understand how the user responds and interacts with it. Before the final test took place, a pilot test was conducted as a practice to keep in mind what all could or might go wrong during the actual testing.

Fig. 4. 7 of 10 people of the community, throw garbage into the river, directly

To conduct the user test in the right manner and to combat any last-minute mishaps, it was ensured that everything was in the right place. The users were informed in advance about their timings and a confirmation was taken from their side as well. Parts of the session were recorded on camera by taking the user's consent on a written document that states the same. The user testing was done for half an hour and included various tests and processes like expectancy test that included questions to the users, such as, "What would you expect to happen once you use this product?" etc. This test helped to analyze whether the user's mental model matches with that of the designed mental model. Some scenario-based tasks were given to the users which had to be carried out in the application. Every scenario gave the user a perspective to think from and further helped to understand the user's decisions and emotions and finally a post evaluation questionnaire was done on a 5-point scale where users were asked how they found the overall experience and features of the design. Debriefing was done to understand the reasons why the users did what they did. The users were made to think-out-loud during the entire user testing and were questioned at each point where they take different decisions (Fig. 4).

The last phase ended with user testing and feedback of the design solution made. This feedback would further help in the improvement of the design. The user testing also helped in learning how to handle difficult situations with real participants. During this entire process of using different tools for the study was not linear. A lot of steps had to be repeated and done again as the results acquired in the first time were not right or sufficient. In addition to that, all the steps did not take the same amount of time and number of people.

4 Results and Discussions

This paper aims to understand the behavior of the people of the community with respect to garbage disposal and what encourages the residents to continue such a lifestyle. After choosing 'Stagnation due to garbage' as the topic, Primary as well

as Secondary research was conducted. Few of the insights found from the empathy interviews are as follows,

- Domestic waste is disposed of in the river because there is no trash pick-up for the community to turn to.
- Band-aid solutions without planning is not a holistic approach to stop the disposal of waste in the river.
- Governmental plans have no mention of pollution control, slum rehabilitation, or the construction of a riverfront to make the project self-sustainable.

To give the research a direction, a Point of View was formed, i.e., 'Slum dwellers need to feel as a part of the society and contribute to it while doing so with a sustainable lifestyle to improve their living conditions.' (Fig. 5).

After forming multiple solutions through Why-How laddering and Brainstorming for our problem and getting feedback from peers and mentors, a final solution was designed. It consists of a solar-plant pot that will be a part of a bigger recreational environment along the river bank. This plant works by tracking the amount of garbage being collected in the community bins and along with smart technology it translates this information to the solar pot in order to start or stop its functioning. The solar pot would only be triggered to function if the threshold of garbage collecting in the bin has crossed a certain limit, this plant would store the solar power throughout the day and later be used to light up the streets of the slums. Safety being another common issue amongst this community, it was thought beneficial to incorporate the benefit of having street lights after evening. The solar-plant will open and close its panels; hence, this will reset it every day when the garbage bins are emptied out by the B.M.C. truck. It will serve as a daily goal for the user and the community.

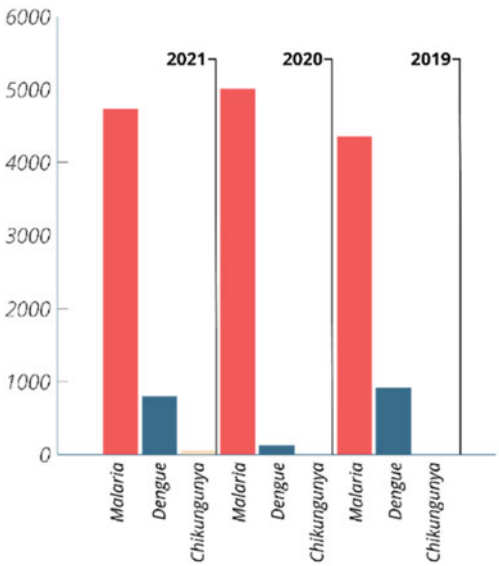

Fig. 5 Statistics of Diseases in Mumbai for 3 consecutive years. *Source* Information

While detailing out the solar-plant, aspects such as dimensions, technology, working, cost structure as well as maintenance and safety were kept in mind. This is required as the product is going to be present in a recreational environment that will be open to all age groups as well as all demographics. The system of the solar pot uses a set of technologies. Firstly, a Force sensor, that will be used to measure as well as track the amount of garbage being collected in the bin. Second, the most important element would be a Bluetooth model and simple motor. The Bluetooth model will ensure communication between the pot and the bin and help maintain a log of each change in amount. The motor will be triggered to function only when the minimum threshold is crossed, causing the solar panels to be exposed to sunlight and hidden away from the light (Fig. 6a, b).

The recreational space that will hold together all the elements of this project consists of Anamorphic art and design installation that will help in converting the unpleasant river bank into a scenic spot This will bring the attention of the public towards the river by engaging social media campaigns and/or advertisements as well. This space will use the advantages of art to move people and encourage the discussion of sustainable solutions to help communities that live in the lower strata of our society (Fig. 7).

To understand how effective, the designed solution would be, a user testing was conducted with three real participants. Tests like expectancy tests and task/ scenario-based questions helped understand the user's perspective and thought process even

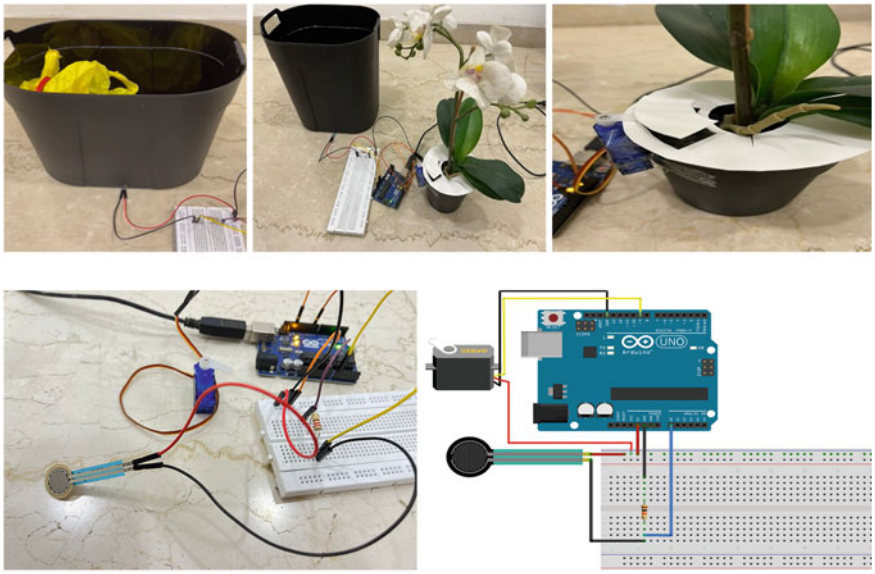

Fig. 6 **a** Functional prototype of the solar-plant. **b** Inter connectivity of the functional model of the solar-plant

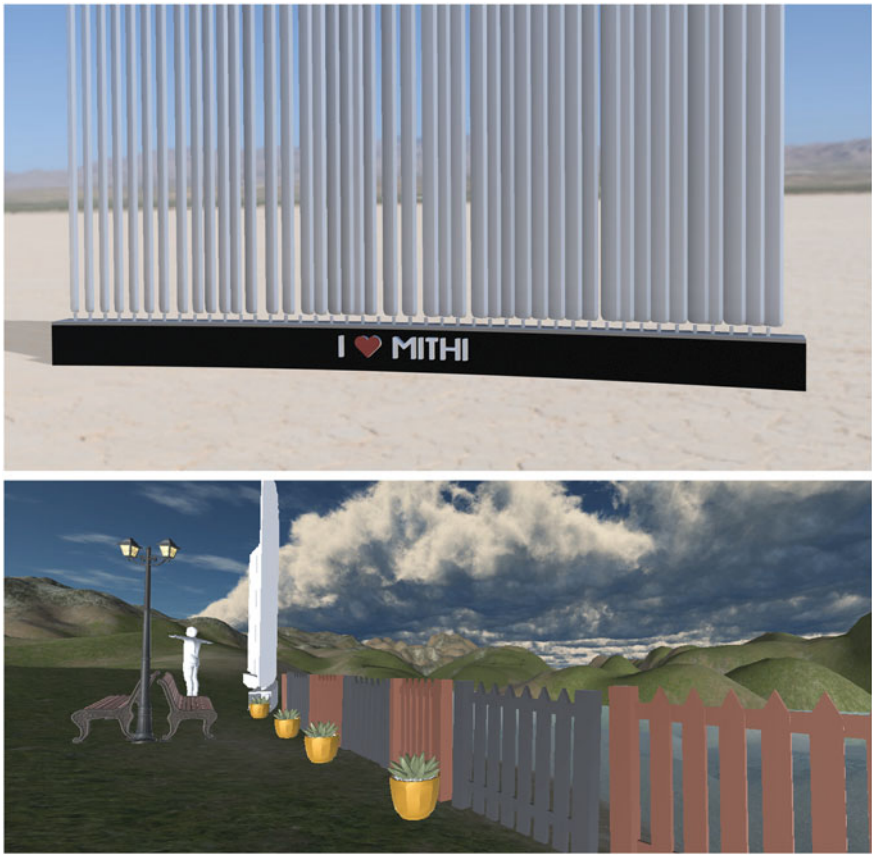

Fig. 7 Proposed recreational space

better. The participants were asked to complete a few tasks that were given in particular scenarios. They were also asked to think aloud while completing the tasks as well as reviewing and commenting on the design concepts (Fig. 8). All of the above discussions suggest that the space and product design made through the study makes the users accomplish the work by themselves, without having to stir away from their routine. The space, however, does have its limitations. The community will not benefit from recreation if health guides are not put properly in place. There is also a restriction of time as the community consists of people mostly employed in the labour sector. However, these limitations are less likely to occur as the wristband is very friendly in look and feel and does not have a harsh effect on the user while alerting them about their actions.

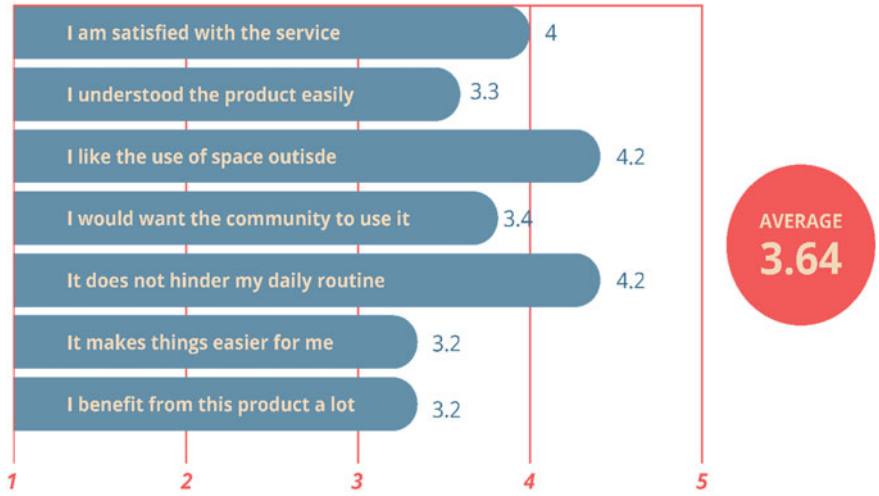

Fig. 8 Post evaluation user's feedback

5 Conclusion

It is important to understand space and foresee its benefits by unlocking its full potential. Some of the major pros of this are that it eliminates inconsistencies, it will speed up the process and make the life of the customer easier and simpler by providing a lot of resources. In conclusion, this system will help induce mindful disposal of domestic garbage amongst the slum dwellers and reduce the chances of water stagnation happening in the river. They will develop healthy community habits in the long run. This system will grow in the future by incorporating various activities such as cultural events, health drives, word of mouth, social media, tourism as well as celebrity endorsement promoting the wellness of the city. It can be promoted in schools and colleges for teenagers during orientation lectures to make them more sensitive towards the pollution of natural resources. The objective of this paper was to spread awareness about the water stagnation in Mithi River and its disastrous impact on the city's habitants as well as the quality of life and health [17]. We look forward to more people getting aware about various ways in which we need to take precautions towards keeping our water resources safe and flourishing for our own benefit.

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Bamboo as the Sole and Soul of Hangers

Pravinsinh Solanki

Abstract India is a country of diverse cultures and skills. The people of North-East India are skilled in the bamboo craft which is deeply rooted in their culture and traditions. Despite the rich craft tradition prevalent in the region, the bamboo sector is unorganized. It lacks design thinking, therefore, the impact on the Indian and global markets is less. Many lifestyle products are "single-use" products and made from plastic which is a threat to the world. Cloth hangers are the second largest contributors of waste material. Sustainable alternative to plastic is the global need to take steps against environmental exploitation. Cloth hangers are lifestyle accessories that seem small, but in reality, it significantly generate plastic waste. This paper enquires into hanger designs which are functional, aesthetically sound, easy to produce, and durable. These hangers are fashioned out of bamboo and are very easy to produce in a cooperative manner. This impacts the world in terms of environmental betterment, export increment, and the North-East region, in terms of global exposure for the artisans by enhancing their standard of living. The bamboo hangers are "designed in India" but are "made for the world".

Keywords Bamboo · Hanger · Sustainable material · Craft · North-East · Innovation · Design · Fashion lifestyle product

1 Introduction

India is the second largest producer of bamboo and has nearly 200 species of solid and hollow bamboo [1]. It is difficult to utilize both of these types of bamboo. The bamboo found in North-East India is hollow.

Bamboo has the ability to grow fast and can survive in various climatic and edaphic conditions. It can grow under any extreme soil conditions, varying from organically poor to mineral rich soil. It can be regenerated without replanting if harvested and managed properly.

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Bamboo also plays an important role in carbon sequestration and biodiversity conservation. Bamboo's diversity in terms of its size, being light but sturdy, hard and straight, fast growing, and found in abundance makes bamboo amenable to the versatility of use which is often species specific. It is an important non-wood forest product which is used in furniture, construction, shoots as food, pulp, and paper industry, handicrafts, and even in channeling water as a substitute for pipes.

Due to all these uses, it is considered a common man's timber. It is also capable of providing ecological, economic, and livelihood security to the people. It is durable, available in abundance and sustainable compared to other materials used in making furniture. A bamboo clump can be harvested after 4–5 years of cultivation whereas wood takes many more years. Generally, bamboo parts such as the branches and the knots of the bamboo are discarded and just used for burning when cooking. However, these parts too can be identified as a potential component for making a product.

2 Bamboo in India

In North-East India, bamboo plays a huge role in people's lives. From building houses and irrigation channels to making handicrafts and even as food, bamboos are used. The tender bamboo shoots are cooked as delicacies and eaten; they cook the food in hollow raw bamboos and use the dry bamboo as fire. Skilled artisans make bottles, tiffin boxes, and various other essential products with bamboo. These products made with bamboo are of high quality.

India is moving towards increasing exports of bamboo products and is being supported by the National Bamboo Mission to help local artisans.

Using Bamboo to make products that are part of our day-to-day life has a social impact. It allows for intercultural interaction when people work together. Economy-wise, increased domestic usage of bamboo can directly increase the exports which will help grow the economy in the country and globally as well. Simultaneously, it will also help the local people for their livelihood. Encouraging designers to work with bamboo can widen the scope to create new innovations in this field.

India has no shortage of skilled craftsmen and has ample resources in the field of working with bamboo. It can be massively utilized to serve the global demand of sustainable products.

3 Hangers

3.1 Design Opportunity

The designer designed the hangers keeping in mind that they are used by everyone globally. They are made out of bamboo and have been experimented with several designs and each hanger serves a particular purpose. He fashioned out multiple designs for the hangers, many of which he believes are the most efficient in using bamboo which requires minimal labor and tools. The hangers are designed to be durable, cost-effective, portable, easy to assemble, and functional. The designs are such that a novice too can work with bamboo and can make the hangers and need no special set of skills or tools.

In India, there is a growing number of retail outlets. Regardless of whether it is a regular or premium clothing store, clothes are displayed on hangers. They are usually made out of plastic, metal wire or wood. The designer's perspective is that bamboo is the perfect substitute to other materials for designing and manufacturing hangers which are durable, aesthetically pleasant, and suitable for mass production. It is also beneficial to the country and the artisans who are involved in the production. Few of the hangers are designed in a way that no one will be able to steal them, such as the "Pacman" (Fig. 11), which can be used in boutiques, hotels, etc.

3.2 Design Intervention

People in India use bamboo to make furniture and objects like caps and baskets. Products like caps require the skill of deriving slivers from the bamboo and weaving it in a particular manner. The existing products made from bamboo are very heavy, thick to hold, lack aesthetic sense, look bulky and are difficult to transport as they result in large packages. The designer pondered that if the raw materials are ample and the local people are skilled, then why there is a lack of remarkable development in the field of bamboo products? The designer realized that the existing artisans and weavers did not have a standard yardstick, for instance, if any artisan makes a cap out of bamboo, it would be different in size than the other so it might not fit an individual in the same manner. The products lacked uniformity and mass production techniques.

The element missing in this field is a design intervention, an idea of making a unique product using the same material but with a functional design, aesthetic value, and an easy production process. When it comes to a designer, commonplace materials also form a unique, functional, and aesthetically sound product that no one could have expected.

3.3 Bamboo as Sole and Soul of Hangers

The designer had an innovative approach to contemporize bamboo products. It follows a component model. The design of each hanger can be broken down into few numbers of simple components that are easy to make and assemble.

The typically discarded parts of the bamboo such as the knots and branches are used, making them highly purposeful. They provide strength and dimensions required for the hangers. It is also cost-effective as they are cheaper than the internodes and the main bamboo.

Based on the type of species available in the region, any of the hanger designs can be adapted for production. The components for these hangers can be made by anyone with a little training and requires no special tools or facility to produce.

3.4 What Goes in Making

The material that is used for the hanger takes every part of a bamboo clump. The goal was to create a process that required no specific type of bamboo species. It was also ideated such that it could be made from any location with basic tools and skills. The material used for the hangers are the bamboo branches and the bamboo knots which are generally discarded to be used as firewood for cooking. This is to optimize the use of material in the design.

The tools required for making the hangers are very common. They are made from easily available hand tools and require no heavy machinery. Even during the absence of electricity, one can still make the product using the "Daau" or hacksaw. The "Daau", a long knife used in probably every North Eastern household is used commonly as a handy piece to cut bamboo. However, in order to increase efficiency, reduce manual labor and allow for mass production, power tools like a radial miter saw or band saw can be used. The other tool needed is a drill. The hand drill, power drill or pillar drill can be used for drilling holes in the junction that attach the shoulder stems. Here it requires no special skill.

The cutting and drilling process is made uniform across all the pieces by using a jig. It helps in achieving the dimension and maintaining the required angle for drilling the holes. These jigs assure the self-quality checks by the workers and good quality of the product. Once the bamboo components are cut and drilled, they are treated to preserve them.

As a finishing touch, the hangers are polished with a belt sander or by hands using sandpaper. The last piece attached to the hanger is the hook. The hooks are made out of a durable material such as galvanized wire (GI) or brass. These wires are easily available everywhere. The wire can be bent in a particular shape using another jig to make the hook. After the shoulder stem and the knot are assembled, only the hook has to be attached to the knot. The hanger assembly is complete. The whole process of making these hangers has been simplified into components which can be

made individually by even unskilled labor from the comfort of their own homes. These components can be assembled at a designated place and transported for retail as a finished product. Alternatively, it can be transported as components itself and assembled after. Branding can incorporated on the piece with branding iron or laser engraving. Holistically, a sustainable packaging would not only keep the product safe but also echo the values of the product.

4 Conclusion

People in India believe that bamboo furniture or accessories cannot be as durable as wood. The objective was to take an unexplored field of bamboo and take it to the mainstream industries. Every part of bamboo is put into use in making these products making it truly sustainable. Be it hollow or solid bamboo of any diameter, the designs can be achieved. Breaking down the product into simple components ensures efficient mass production and better quality control. Making these components needs little to no training for the locals. It does not require any special facility for the production of these hangers. It gives an opportunity for the locals to live at their own place, work as per their comfort and earn as per their capacity. Every member of the family can contribute to it. The marketing of the finished product can then be undertaken by the government or private sector. Apart from domestic usage, Tourism and fashion being a large market globally, these hangers can be targeted towards these sectors. From a broader perspective, the designer aims to rethink the existing hangers in the market. To envision it as a product that is not only sustainable but also has a contemporary spin to it, in terms of both the design and how the bamboo is used. The components of the hangers can be easily flat packed or made into DIY kits.

Globally and nationally, there have been some efforts made towards using bamboo effectively for making bamboo products. Few examples of products that use mass manufacturing processes are bamboo chairs, shelves, etc. For the Kaltlamara project [2], Bamboo bikes were made in Africa which used certain mass production processes and these bikes were made from bamboo species locally available in Africa [3].

For the designer, it was a challenge to work with limited resources in a demanding manner and to make the designs not only functional but also producible through an efficient system. The designer has done vast research and has worked extensively on bamboo products like toy cars, furniture, and accessories. This gave him the direction for efficient mass production by arriving at the component model. The component model empowers every stakeholder at each stage of the process from ideation to manufacturing to marketing and finally reaching the end users. The designer has truly imagined bamboo as the sole and soul of the hangers.

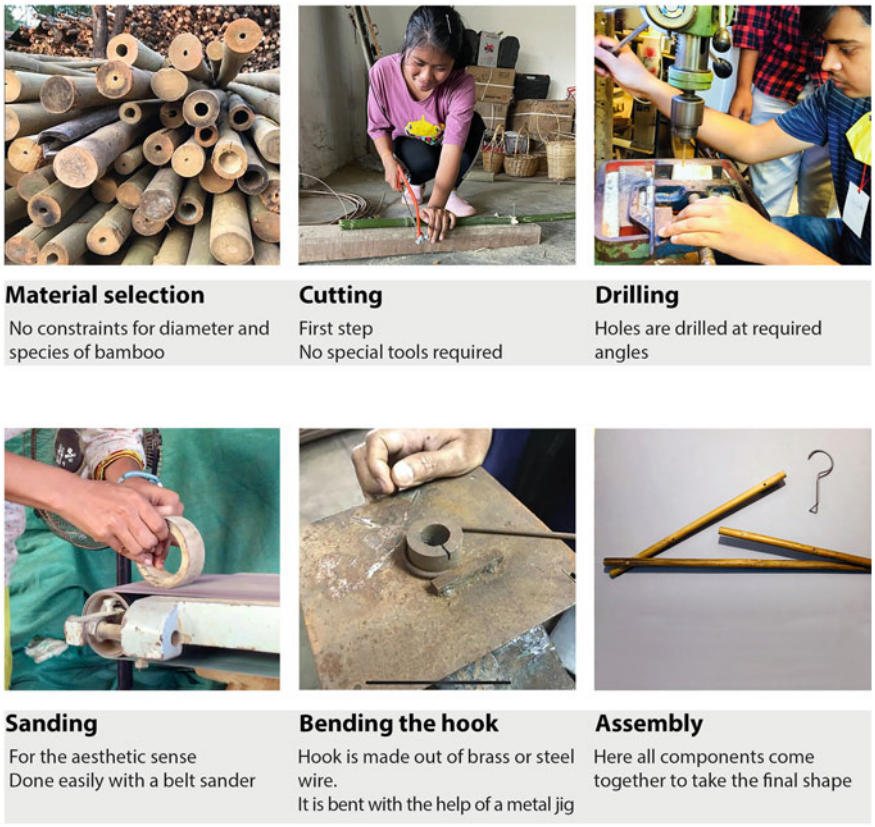

Fig. 1 Production process

5 Illustrations

See Figs. 1 and 2.

6 Outcomes

See Figs. 3, 4, 5, 6, 7, 8, 9, 10 and 11.

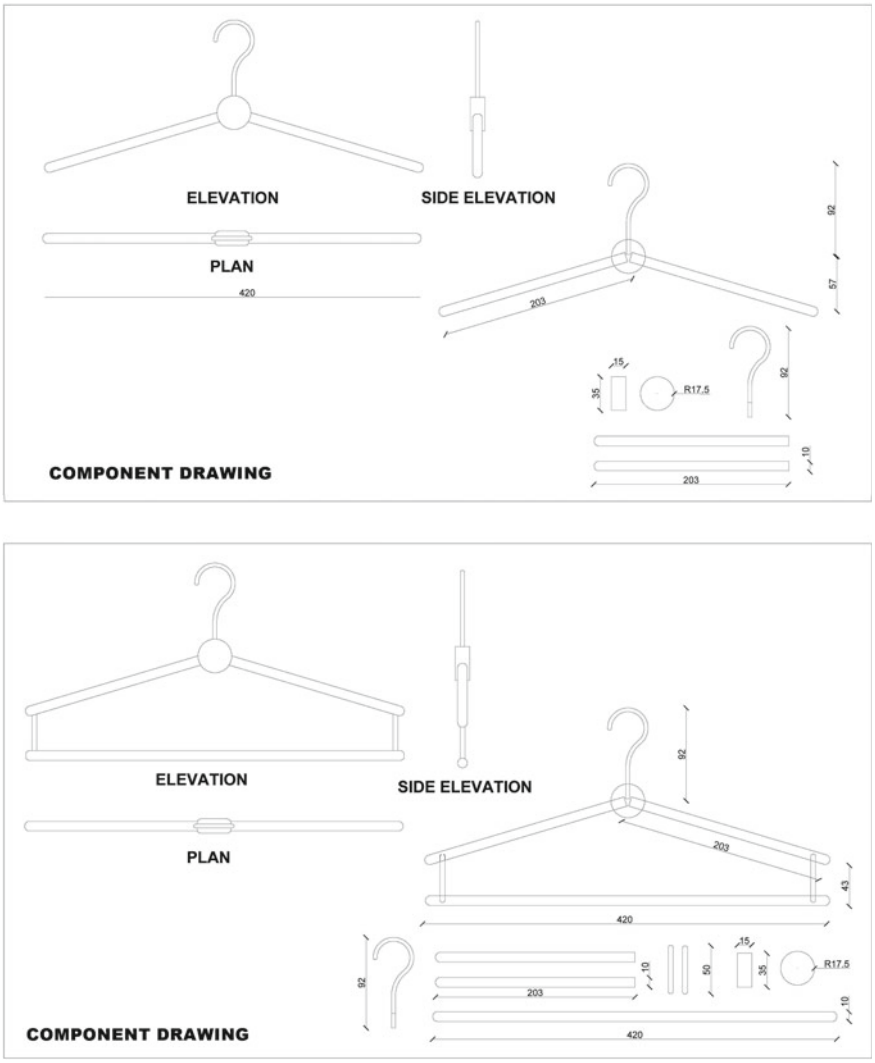

Fig. 2 **a.** Component drawing for antene. **b.** Elevation sketch for Cassa

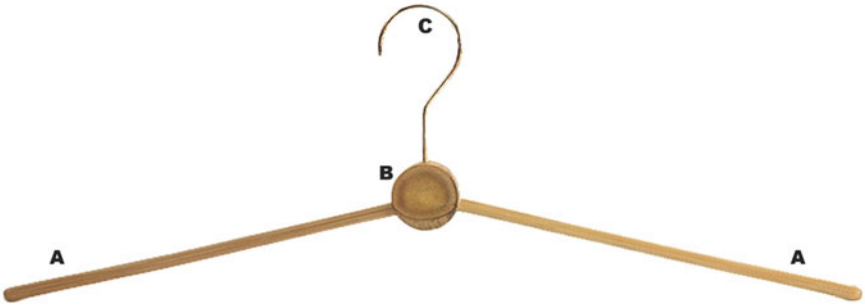

Fig. 3 **Antene**: Solid bamboo knot is used as the junction in this design. The two shoulder stem and the hook is attached to the junction. This is specifically made for shirts and t-shirts

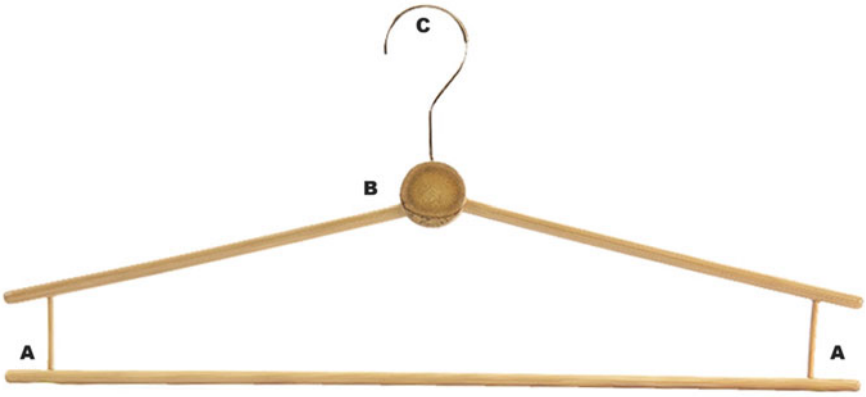

Fig. 4 **Cassa**: Additional support has been given to hang pants, shawl or sarees

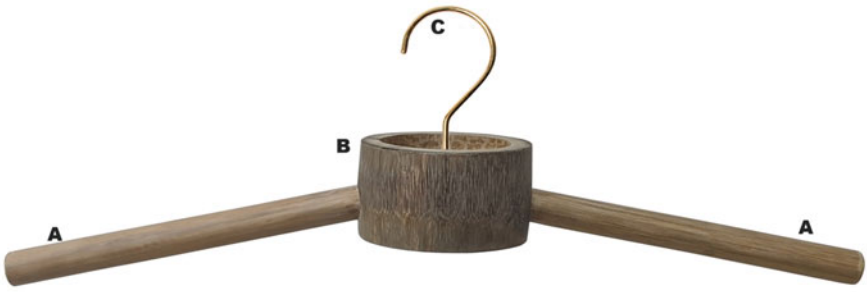

Fig. 5 **Collo**: The hollow bamboo knot has been used as a junction. It is positioned sideways to support the shoulder stems on either sides. This is specifically made for shirts, t-shirts and heavy garments

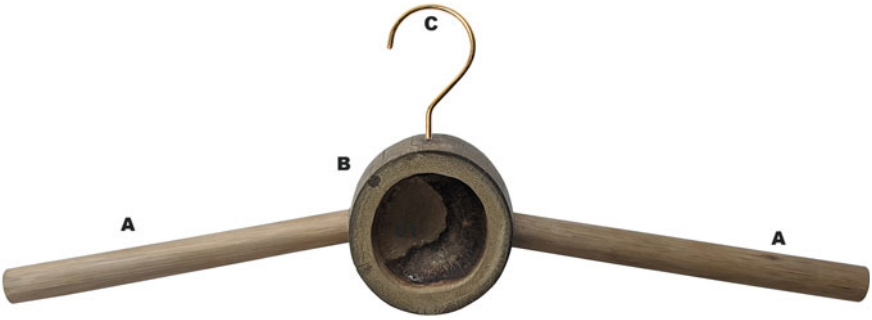

Fig. 6 **Moto**: In this variation the knot of the hollow bamboo is placed upright as the junction. This is specifically made for shirts and t-shirts and heavy garments

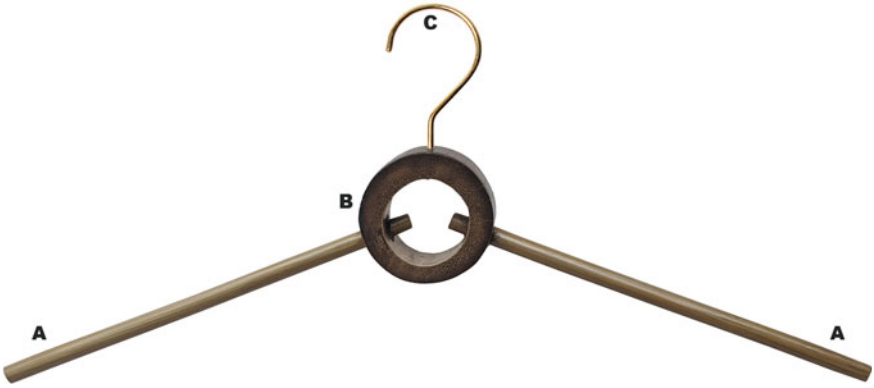

Fig. 7 **Time**: The thickness of the shoulder stems and the section wall are thinner in this variation. The cut section of bamboo is used as a junction. The shoulder stems are partially pierced through this section. This is specifically made for shirts and t-shirts

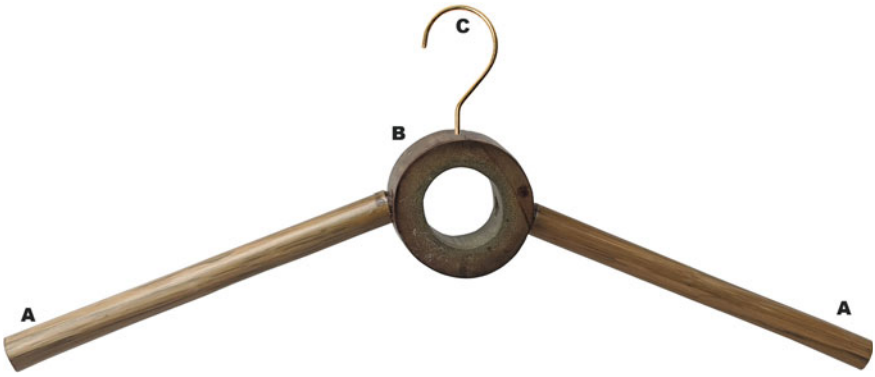

Fig. 8 **Cavo**: Thicker shoulder stems and section walls are used in this variation. The section is used as the junction. It is designed to hold heavier garments

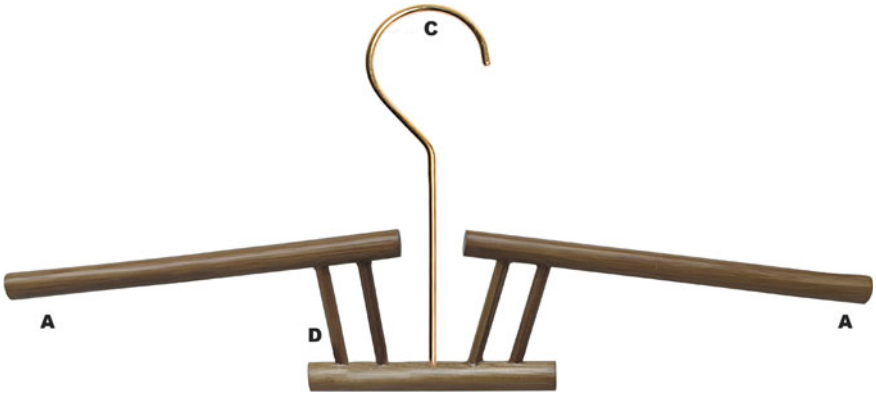

Fig. 9 Spalla: Bamboo sticks are used as shoulder stems and for the junction. They are both connected by the bamboo pins. This is specifically made for shirts and t-shirts

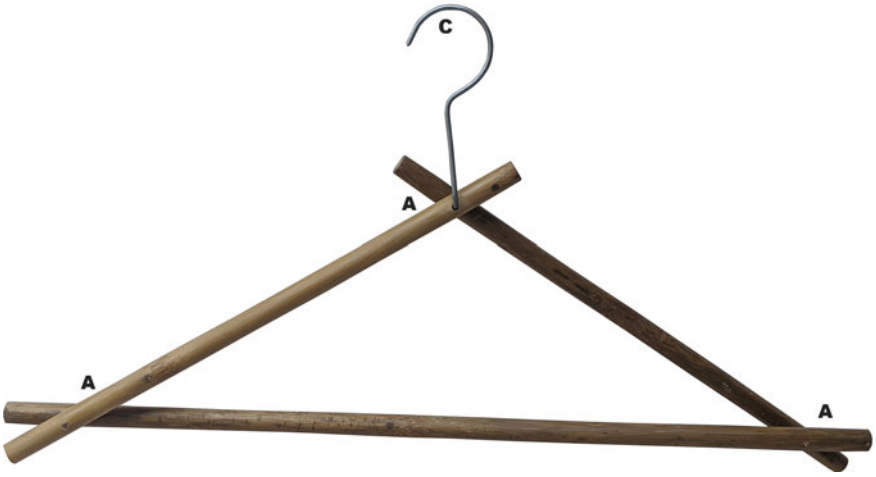

Fig. 10 Ghost: In this variation, the hanger is made collapsible. The hanger consists of three bamboo members and a hook. The corner junctions are riveted. The central junction is held together by the hook itself. It can accommodate all types of garments

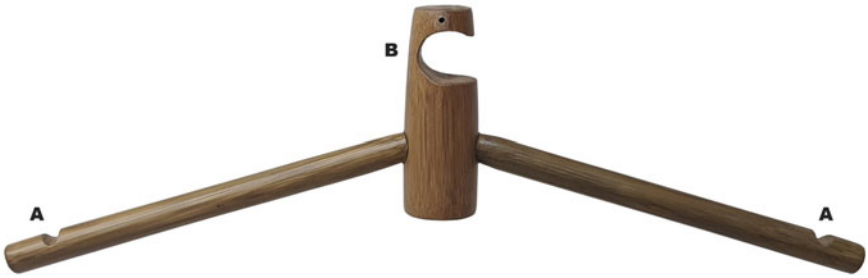

Fig. 11 Pacman: This variation is designed to be anti-theft. The central junction is made of solid bamboo which holds the shoulder stem on either side. The top of the junction has a unique profile cut. The hangers have to slide into the rod during the time of installation and cannot be removed by anyone. This is specifically designed for hotels. It can hold coats, shirts and t-shirts

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Water Carriage by Women in Hilly Areas of North-East India: Challenges and Future Research Direction

Bhupen Chandra Barman, Vikramjit Kakati, and Sougata Karmakar

Abstract Statistics show that in India, 20% of the rural areas are still devoid of essential quantity and quality of water. Daily water carriage by women folk for drinking and household activities is common in rural India. Traditional methods of carrying water on the head, shoulder, and waist or by hand are tiring and impacted by numerous factors like weather conditions, distance, walking path, etc. Such activities lead to adverse health consequences like musculoskeletal disorders (MSDs) in the long run. Water carriage by women in hilly areas of North-East India is challenging from multiple perspectives. The prevailing practice of on-head carrying of water is a risky and time-consuming task. The risk and drudgery are enhanced due to slippery, uneven, hilly terrain, no support structure/mechanism for climbing up-down, bad weather conditions, and long-distance travel. The people, especially the women in hilly rural areas, face tremendous hardship to carry water, but there is a lack of reported research and thereby, appropriate intervention to resolve the issue. Following the literature review, it is evident that various attempts have been made to supply drinking water in hilly areas. However, many of these interventions are not feasible/influential due to prevailing climate conditions. There is a need to strengthen such traditional practices through appropriate context-specific design interventions. Hence, it aims to document the current scenario and various challenges faced by the women of North-Eastern hilly areas to develop a proposal for the most feasible interventions.

Keywords Ergonomics · Anthropometry · Backpack · Mode of water carriage · Problems of carrying water · Water problems in NE Region · Women carrying water

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1 Introduction

In rural areas of most developing countries, the sole responsibility of collecting water for their family falls under women, girls, and children. Women also spend more time gathering water than men. It is also common in developing countries for women to face health problems while collecting water [1].

In the existing scenario, carriage of water by people is done in various ways. Water-filled containers are carried on the head, shoulder, waist, or by hand by the women folk for drinking and household activities is the most common practice (Fig. 1). However, carriage of water with wheelbarrows, animal-drawn carts, or rolling water-filled containers are prevailing practices in rural areas. In some hilly areas, a water supply system is done using a pressure control tank. Water is carried through the supply pipe according to the difference in latitude from a water storage structure into a pressure control tank and stored temporarily. Water supply is done by discharging downward [2]. As per data, 150 Million Woman Days and INR10 Billion are lost every year in fetching water globally [3]. Report by The United Nations indicates that more than 2 billion people around the globe lack safe and clean water. In another study among 25 countries in sub-Saharan Africa, United Nations Children Fund revealed that about 16 million hours are spent by women fetching water every day [4]. A study in Kenya shows that an average of 4.5 h per week is spent collecting water for a home. This activity brings 77% worry about their safety and 24% from looking after their children. As per the report, in Asia and Africa, the average distance traveled for collecting water by women is 3.7 miles (6 km) every day [5]. Carriage of such loads on foot over the uneven, slippery road and steep terrain can bring about health issues such as strained backs, necks, heads, shoulders, and other injuries [6].

Data shows that in India, 20% of the rural population still lacks the necessary quality and quantity of water for their homes [7] and it is also projected India will face severe climate-induced stress due to water. In the hilly areas, the habits, and lifestyles of people are closely associated with nature. It influences to a large extent the development of the human being. Although scientific knowledge related to climate change and water-the most essential commodity is growing at both global and national levels, necessary knowledge on the human dimensions of the same at local levels is weak [8].

In a World Water Development Report, India ranks 120 out of 122 countries and ranks 133 out in a list of 180 countries for quality of water. Whereas other countries nearer to India like Bangladesh, Sri Lanka, Nepal, and Pakistan have a better position than India having 40th, 64th, 78th, and 80th positions respectively [9].

Let us have a glance at the census report of India, 2011. Report shows that NE region has a total population of 455,87,982 numbers. It reflects that the Region has 4% of the total population and 8% of total landmass of India [10].

From the data mentioned below, we can have an idea about the sources of drinking water available in NE India (Tables 1 and 2).

Fig. 1 Different modes of carrying water by women in hilly rural areas

Table 1 States of North-East India with the population (*Source* [10])

Name of state	Area (SqKM)	Population as per census (2011)	Population density (/sqm) (2011)	Rural house hold (%)	Urban house hold (%)
Assam	78,438.00	3,11,69,272	397	84.80%	15.60%
Arunachal Pradesh	83,743.00	13,82,611	17	74.80%	25.20%
Tripura	10,491.00	36,71,032	350	72.10%	27.90%
Manipur	22,347.00	27,21,756	122	66.20%	23.80%
Mizoram	21,081.00	10,91,041	52	47.40%	52.60%
Meghalaya	22,429.00	29,64,007	132	78.40%	21.60%
Sikkim	7,096.00	6,07,688	86	72.10%	27.90%
Nagaland	16,579.00	19,80,602	119	71.20%	28.80%

Table 2 Data obtained in Dima Hasau district, Assam and Khowai district, Tripura

Sl. no	Parameters	Range	Data obtained (nos.)	Data obtained (%)
1	Age (years)	Upto 20	23	18
		21–30	14	11
		31–40	53	42
		41–50	23	18
		Above 51	13	10
2	Height (cm)	Upto 140	5	4
		141–150	83	66
		151–160	38	30
		161–170	0	0
3	Weight (kg)	Upto 40	23	18
		41–50	78	62
		Above 50	25	20
4	Mode of carriage	Backpack	4	3.2
		Hand carriage	63	50
		Head	119	94
		Other	0	0
5	Type of carriage container	Plastic container	89	71
		Drum/Tin	30	24
		Bottle	119	94
		Other	52	41
6	Cost of existing container (INR)	Upto 100	1	0.8
		101–500	89	71
		501–1000	35	28
		No comm value	1	0.8
7	Carriage done by people	Male	0	0
		Female	126	100
		Child	0	0
8	Source of water	River	0	0
		Lake/ditch	23	18
		Foothills	75	60
		Deep well	28	22
9	Distance to be traveled (km)	0–1	77	61
		2–3	48	38
		>3	0	0
10	Road condition	Katcha	126	100
		Pucca	0	0

(continued)

Table 2 (continued)

Sl. no	Parameters	Range	Data obtained (nos.)	Data obtained (%)
		Sand gravel	0	0
11	Qty of water carried (L)	1–10	12	10
		11–20	114	90
		>20	0	0
12	Family members (nos.)	1–4	19	15
		5–7	95	75
		>8	12	9.5
13	Av. Requirement of water (L)	1–20	0	0
		21–50	0	0
		51–100	52	41
		>100	74	59
14	Av. Climatic condition	Hot	0	0
		Cold	126	100
		Moderate	0	0
		Others	0	0
15	Water to be carried (month/year)	1–3	0	0
		4–6	0	0
		7–9	46	37
		10–12	69	55
16	Source of income	Cultivation	113	90
		Service	0	0
		Business	23	18
		Others/laborer	25	20
17	Av. Income/month/family (× 1000) (INR)	1–5	30	24
		6–10	85	67
		11–20	11	8.7
		21–30	0	0
		20	0	0
18	Max. cost they can bear (INR)	Nil	10	7.9
		1–500	74	59
		501–1000	42	33
		1001–2000	0	0
		>2000	0	0
19	Troubleshooting	Head, neck pain	124	98.4
		Back pain	107	85
		Body pain	108	86

(continued)

Table 2 (continued)

Sl. no	Parameters	Range	Data obtained (nos.)	Data obtained (%)
		Others	27	21
20	Quality of water (visual)	Clean	93	74
		Dirty	12	9.5
		Contaminated	93	74
		Others	0	0
21	Purification measures taken, if any	Filter	12	9.5
		Boiling	0	0
		Others	0	0
		No measure	114	90
22	Expectation	Alt. measure helpful	56	44
		Needed FoC through Govt	50	39.68
		No comment	29	23

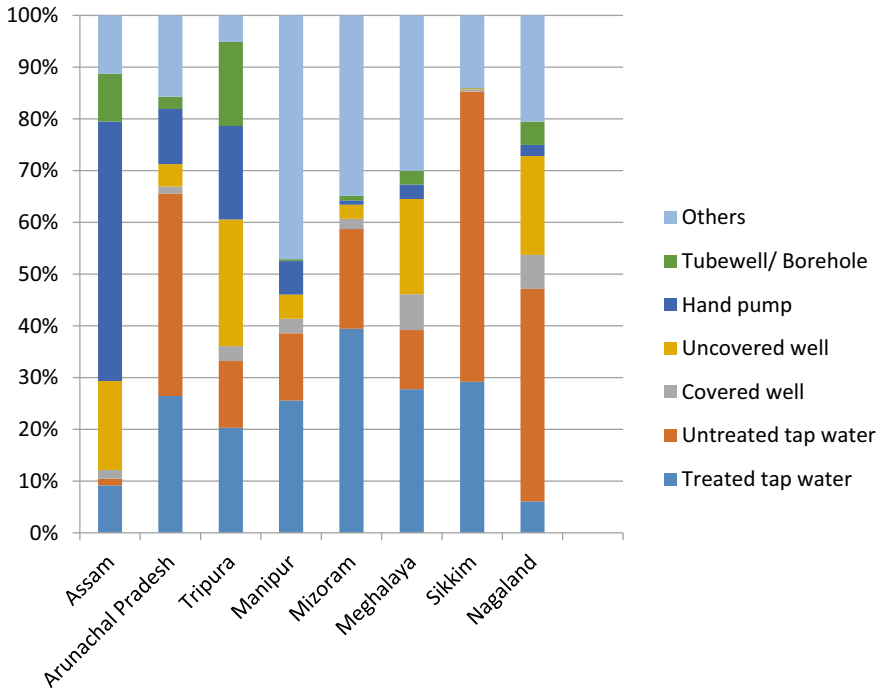

Fig. 2 Distribution of drink water sources in states of NE India (*Source* [10])

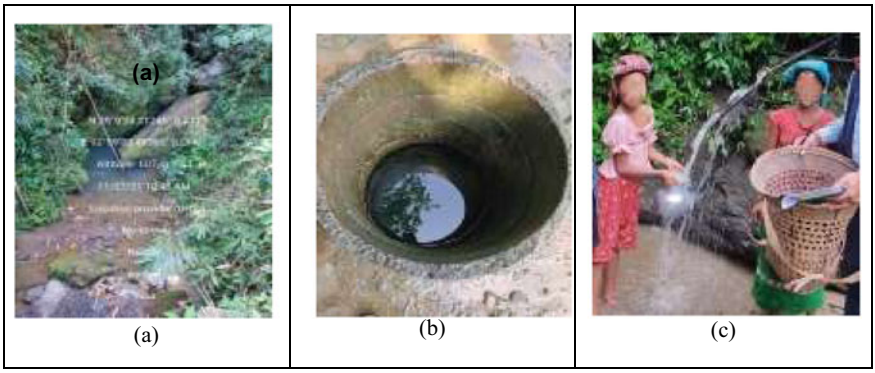

Fig. 3 Some of the existing sources of water in hilly rural areas of the NE Region

In our country, only 4% of households use other sources of water like lakes/ponds, springs, rivers/canals, etc. than water from the tap, well, and tube well/ borehole. 15% of people in the region use the same water.

Figure 2 shows different sources of water available in their locality.

It is clear from the figure above that the majority of people in Arunachal Pradesh, Nagaland, and Sikkim use tubewell or boreholes as sources of water, while in Assam majority of people use tape water followed by uncovered wells, other sources, and hand pumps. In Manipur, Mizoram, Tripura, and Meghalaya majority of people use other sources, tape water uncovered wells, and tap water respectively (Fig. 3).

The most risky factor for the people in developing countries is the lack of safe water. It has been extensively reviewed to enhance access to safe water and reduce the impact on health. At the same time, the focus on acute infectious illness related to water is also reviewed for evaluation of the outcome.

1.1 Problem Statement

Traditional methods of carrying water bring health issues to the carrier. It shows that regular carriage of loads of water results in adverse physical stress for women. Such a load without physical ergonomics is harmful to the carrier's health. It may lead to musculoskeletal, spinal, or other joint-related disorders. Carrying water physically by such means as on the head, shoulder, or hand with various types of porters results in various types of health injuries related to catastrophic, spinal problems Et cetera. It may lead to even the end of life too. It results in dysfunction in the neck, in particular, occurs in women with chronic pain [11].

Carrying loads of water is an enormous physical hardship for the children. Their learning in school is also severely affected by this kind of regular activity. If water is scarce, usage of water for preparing food, drinking, Et cetera is always given priority. Other tasks at home are assumed to be of second priority. Rural women

are capable of undertaking household laundry at some intervals. Bathing for them at home may also be done at some intervals. Limitations of this kind hamper the good health of the people since it may lead to skin-related problems, which is typical for them. Soon after the dry season, the availability of water in the distinct sources gradually vanishes. During that time, women and children had to face a tough time collecting water. They have to travel further in search of other sources of water at long distances. This kind of tough job of carrying water physically is a risky factor. Even if water is collected by some means, water quality becomes a secondary factor and a notable concern [12]. The quality and quantity of both surface and groundwater are constantly changing due to environmental degradation and anthropogenic activities. These changes in the properties of water contribute to water pollution. Water quality depends upon the physical–chemical and biological characteristics of its surrounding environment. Contamination in drinking water may give rise to serious health hazards. It may also result in various water borne diseases like typhoid, cholera, jaundice, dengue, scabies, botulism etcetera [13].

The people, especially the women in hilly rural areas, face tremendous hardship in carrying water [14], but there is a lack of reported research and thereby, appropriate intervention to resolve the issue. Following the literature review, it is evident that various attempts have been made to supply drinking water in hilly areas. However, many of these interventions are not feasible/influential due to prevailing climate conditions and frequent land-slides [15]. Such a type of practice of carrying water is a time-consuming task and a risky factor for the carrier. On the other hand, precious time for women is lost to a large extent. It stands as an obstacle to the growth of the economy of the family too.

1.2 Aim

Water carriage by women in hilly areas of the North-East India: Challenges and future research direction and how to address the challenges.

2 Methodology

This correlational study included a total of 126 nos. of females and girls who carried water in some parts of hilly areas of the North-East Region. Each respondent voluntarily signed an informed consent form after the overview of the research was thoroughly explained to them.

2.1 Survey Planning

Following the literature review, the questionnaire was designed. Based on the designed questionnaire, primary data were obtained one by one by direct interaction with the people carrying water living in those hilly areas of NER. Sources of water, prevailing means/ways of carrying water, condition of the roads carrying water, weather conditions, and distance to be traveled from the source of water to their respective destinations/homes were physically observed. Physical data such as gender, age, height, weight, height from waist to shoulder, etc. of the interacted people were recorded. Photographic and video graphic evidence of the activities were also taken.

2.1.1 Location

The study was carried out for 61 nos. of people at Langting, Durringpunchi C.D., and Hafflong under Dima Hasaou district, Assam. The same study was also carried out for 65 nos. of people at Nonachora, Hajpara, and Waisokpara under the Khowai district of Tripura.

2.1.2 Targetted Users and Respondents

People carrying water for drinking and household use in hilly areas of the North-East Region were targeted. The study was carried out on a total of 126 nos. of people. Out of those people, 100% people were found to be female (108 nos. of women and 18 nos. of girls).

2.1.3 Questionnaire Development

Following the literature review, a detailed questionnaire relevant to the process of water carriage, its difficulties, road conditions, physical parameters of people carrying water, environment conditions, distance to travel to carry water, socio-economic condition of people, impact on health on water carriage, etc. was prepared for obtaining data from the people carrying water in hilly areas of the North-East Region.

2.1.4 Data Collection

Field data were obtained from 61 nos. of people at Langting, Durringpunchi C.D., and Hafflong under Dima Hasaou district, Assam. The same was also obtained for 65 nos. of people at Nonachora, Hajpara, and Waisokpara under the Khowai district

of Tripura. Primary/open-ended data were obtained based on the prepared questionnaire by direct interaction with the people carrying water in those places. Details of prevailing practices of carrying water right from the collection of water at the source to the storage of water were observed. During the process of carrying water, they were stopped and interaction was done one by one. Physical measurement of people such as age, height, weight, etc., gender of people carrying water, environment condition, distance to travel to carry water, socio-economic condition of people, impact on health on water carriage, etc., Sources of water, prevailing practices of carrying water, amount of load carried by them, condition of the road, mode of carriage, distance to travel, etc. were recorded. Pictorial evidence & videography of the activities were also taken.

3 Results and Observation

Prevailing traditional methods of carrying water by the women were observed. The main issues, challenges, and various problems faced by them were discussed thoroughly. So many people responded well, and expressed their will & woes, expectations, and the issues which may be summarized as follows:

(a) The responsibility of managing water for their household use comes under the women.
(b) Women belonging to the places like Langting, Pitilikei, Durringpunchi, etc. under the Dima Hasao district of Assam use *Longkhai*- a locally bamboo-made pan wherein they put containers, plastic bottles, etc. filled with water and carry it on their heads. The main sources of water are deep well, foothills and streams. People (mainly women) from Nonachora, Hajpara, and Waisokpara under the Khowai district of Agartala use *Langa*- a locally bamboo-made container wherein they put the water-filled plastic, and silver containers and carry water on their heads (Fig. 4).
(c) People living in those areas are very poor. Most of the habitats are cultivators (90%) by profession.

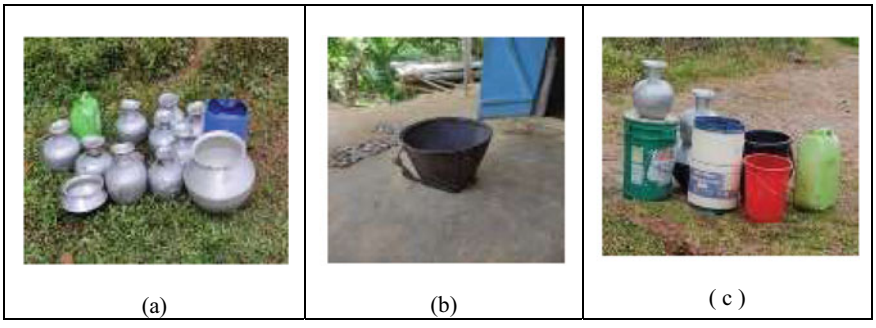

Fig. 4 Figures showing some containers used to carry water in hilly areas of NE Region

(d) There is always a scarcity of necessary water for their use. Public water supply facility in those areas is still not done.
(e) Road communication from the sources of water to their home is hilly and uneven, and Katcha road. They carry water on their heads with high risk. Roads become slippery during rain and become very dangerous to walk on.
(f) Most people need to carry water throughout the year.
(g) Physical stress due to the carriage of load leads to pain in the head, neck, waist, and even the whole body of the carrier. As a result of pain, they suffer from fever also.
(h) Some of them have to travel up to 2 km also to carry water. Continuous carriage of load for so long distances gives rise to pain in the leg too.
(i) Lots of valuable time is wasted in carrying water. Mothers can't look after their children well due to business in carrying water for all the members of their family.

Data obtained from the survey of 126 nos. of respondents may be tabulated as follows:

From the above data, the following observations can be made:

(a) It was observed that out of the 126 people carrying water, 100% were female (Women-108 nos., girls-18 Nos.).
(b) The socio-economic condition of the people is very poor. Most of the habitats are dependent upon cultivation only (90%).
(c) Family size of most households (75%) is 5–7 members.
(d) Monthly income of most families (67%) falls in the range of 5–10 thousand rupees only.
(e) The majority of females carrying water were in the age group of 30–40 years (Fig. 5).
(f) Max. nos. of females (66%) carrying water fell under the height range of 140–150 cm (Fig. 6).
(g) Weight of max. no. of females (62%)came in the range of 40–50 kg.
(h) 94% of females carried water on their heads and 54% of females carried water on their hand only. 44% of females carried both hand load & head load.
(i) The main source of water was foothills (66%) and a little deep well (22%).
(j) The majority of females carried water from the 10–20 L range excluding the weight of the container.
(k) 55% of people have to carry for 10–12 months/year and 37% of people have to carry water for drinking & household use for 7–9 months/year.
(l) 98.4% of people stated that their health is affected by head and neck pain, and 85% and 86% of people stated that carriage of water resulted in back and body pain respectively.
(m) Water available in the sources was clean and contaminated (74%).
(n) Almost no purification measure is taken by the people (90%).
(o) 44% of people stated that the invention/ introduction of an alternate measure of carrying water would be helpful for them and around 40% of people stated that Government's initiation was needed for a better mode of carriage/supply of water.

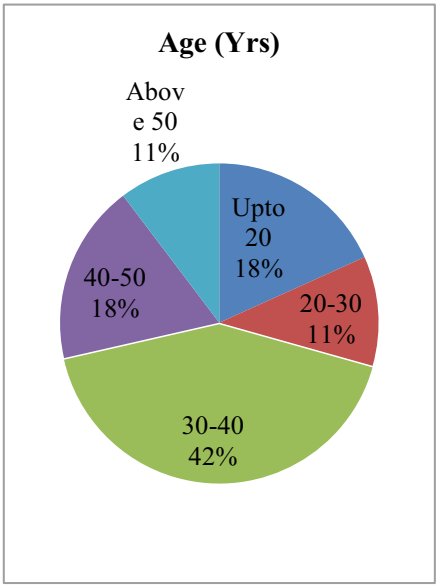

Fig. 5 Age-wise % of people carrying water

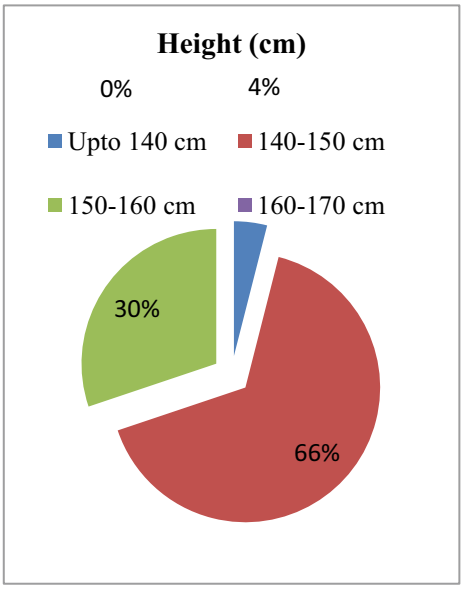

Fig. 6 Height-wise % of people carrying water

(p) 59% of people stated that they could bear expenses for the container to carry water up to 500 rupees and 33% of people stated they could bear 500–1000 rupees for the same.

(q) 75% of the family have family members of 5–7 nos. Accordingly, the daily requirement of water for most of the families (59%) is more than 100 L.

4 Discussion

To understand the current scenario of the people living in hilly rural areas of the NE Region, the study was conducted. During the study, basic demographic information, socioeconomic conditions, etc. were also collected. These data are very much relevant to understanding their present difficulties and at the same time planning for future research direction or to address the existing problems faced by them.

The result of the current study shows that the prevailing practice of on-head carrying of water in hilly rural areas is a risky and time-consuming task. The risk and drudgery of this task are enhanced due to slippery, uneven, hilly terrain, no support structure/mechanism for climbing up/down, prevailing bad weather conditions (rain, fog, low light, etc.), and traveling a long distance. Moreover, the loss of adequate time for their personal/household work is also a significant concern. Thus water carriage by women in hilly areas of North-East India is challenging from multiple perspectives [16].

Traditional methods of carrying water [17] on the head, shoulder, and waist or by hand are tiring and impacted by numerous factors like weather conditions, distance, walking path, etc. Such activities lead to adverse health consequences like musculoskeletal disorders (MSDs) in the long run [18]. Personal safety and comfort are always important during the execution of any work in any environment [19].

The present study also shows that road communication from the sources of water to their home is hilly, uneven, and Katcha road. They carry water on heads with high risk. Roads become slippery during rain and become very dangerous to walk on. Thus weather, topography, the poor economic condition of people, etc. are the key factors to face the challenges to carrying water by people in hilly rural areas of the North-East Region.

One of the major findings of the study is that carriage of water for long-distance in hilly terrain brings about health issues to the women carrying water. Due to prolonged carriage of heavy load on the head, they suffer from pain in the head, neck, back, and whole-body and which leads to fever in the carrier. Since women have other domestic responsibilities also, their families are badly affected. This is a very big challenge for the people carrying water in hilly areas by traditional prevailing methods.

Another important factor of the study is that although 90% of water is contaminated, the majority of people don't undergo any purification measures which is a health hazard for the people.

Finally, it can be conferred that despite so many challenges faced by the women carrying water in hilly rural areas of the NE Region, the initiative by the Government to improve the facility is not up to the mark.

4.1 Limitations

The study was carried out in different hilly places in the NE Region. Primary data were obtained with direct interaction with the persons of those places. While undergoing the study, some of the limitations are stated below:

(a) The survey was carried out in some specific hilly locations in NE India. It is not possible to do this in all hilly places of the NER due to geographical remoteness, poor road communication, etc.
(b) Language is a major barrier to interacting with people of hilly rural areas of NER. They don't understand any other languages than their local language. In that case, assistance of mediators/translators was taken to obtain the data.
(c) Most of the women and girls of the hilly rural areas feel shy to interact with a male from outside areas.
(d) The knowledge & understanding levels of the women and girls living in those areas are very low. It is very difficult to get a reply directly to whatever is being asked for.
(e) The sample size was small. So far as data from 126 nos. of people was obtained.
(f) Only a few communities were involved in the collection of data. That is the sample size is very small.
(g) Most of the people didn't want to speak anything of their will.
(h) Some people thought that those type of questionnaire was not helpful and relevant to them.
(i) Some of them did not want to comment anything directly on us.
(j) The women carried water on their heads and hands only in those places. Any other modes of carriage of water were not seen.
(k) Ages of the people carrying water were recorded on verbal information only.
(l) Contamination of water carried by them was not tested and recorded on visual inspection only.
(m) Distance from the water sources to their respective homes was recorded on verbal information only.
(n) Monsoon or summer season is not favorable to visit those places due to hilly terrain, and uneven and slippery roads for collection of data.

4.2 Future Scope

Looking at the problems, hardships, and challenges faced by the people, especially the women in hilly rural areas of the North-Eastern Region, it is perceptible that there is a scope of reported research and thereby, appropriate intervention to resolve the issue. Following the literature review, it is perceptible that various attempts have been made to supply drinking water in hilly areas. However, many of these interventions are not feasible/ influential due to prevailing climate conditions [20]. There is a need to strengthen such traditional practices through appropriate context-specific design

interventions. There is scope of developing some products which can reduce physical stress, and drudgery and thereby focus to improve the health condition of the women carrying water in hilly rural areas. Efficient modes of water carriage with adopted technologies will minimize the challenges faced them.

Improvement of road condition is also very important to minimize the existing problems faced by the women in hilly rural areas. Development of water supply facility, creation of water sources in nearest location of the habitats are also another focusing areas to reduce the current problems.

Hence, it aims to document the current scenario and various challenges faced by the women of the North-Eastern hilly areas to develop a proposal for the most feasible interventions.

5 Conclusion

Going through a participatory approach, a majority of people mentioned that they need better, safe, and convenient means of carrying water. Based on the proper document on the carriage of water in hilly areas of North-Eastern India there is the scope of inventing alternate modes of carriage considering the physical ergonomics of women living in those areas. Undergoing such activities, focusing on the women's good health shall be a significant factor.

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Handicraft Entrepreneurship: Advantage for Young Entrepreneur

Kiran Kumari Mahato and Pratul Chandra Kalita

Abstract Nowadays houses are being altered according to the culture and tradition. This trend of fashion is increasing rapidly. The antique characteristics of brass and the nature of being easily blended with any different types of crafts, increase the demand for brass decorative items. The study is on brass metal handicrafts and how they incorporate entrepreneurial factors. This study shows a theoretical and practical analysis of how handicraft entrepreneurship can play a crucial role for young entrepreneurs. It strengthens the growth of young entrepreneurs. It also reinforces the indigenous skills of handicraft entrepreneurship in front of the world by engaging new entrepreneurs and handicraftsmen. It concluded that handicraft entrepreneurship is a culture of creativity and flexibility, advancing their capacity for adaptability and creating new designs. Thus entrepreneurs get help in idea generation as per consumer requirements through handicraft entrepreneurship. Also, an abundance of cheap and skilled labor is available to help in the economical way of product change, evaluation, and screening of product ideas, etc. The new design strengthens the growth. Through entrepreneur engagement with handicrafts, it reinforced indigenous skills in front of the world.

Keywords Brass handicraft · Handicraft entrepreneurship · Indigenous technology · Design management · Young entrepreneur

1 Introduction

The manufacturing sector has played a crucial role in the economic growth and development of the country. It removes poverty through employment and economic growth. It significantly contributes to the GDP growth of the country. Today the

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Government aims to transform into a global manufacturing hub through innovation, skill development, and protection of intellectual properties under the Make in India Scheme. To achieve this aim, the Government promoted entrepreneurship and job creation at the grassroots level under the scheme of Stand Up India. This study shows a theoretical and practical analysis of how handicraft entrepreneurship can play a crucial role for young entrepreneurs. It strengthens the growth of the country through product innovation and job creation.

2 Methodology

This research encompasses both qualitative primary and secondary investigations. The study involved conducting a field survey to analyze the brass metal handicraft industry in Hajo, Assam. The primary objective was to examine the challenges associated with the current manufacturing process. Semi-structured, personal interviews were conducted with stakeholders to understand the problem.

3 Background of Handicraft Entrepreneurship

3.1 Entrepreneurship

Entrepreneurship is the engine for economic development and industrialization. It is a process of creating a value-added new product by expending time and effort. It has financial, psychological, and social risks and receives rewards from capital value, personal satisfaction, and independence of decision making. The concept of entrepreneurship defines the entrepreneur [1].

3.2 Handicraft Entrepreneurships

Industrialization is considered economic development through an increase in the production rate. According to R. Chattopadhyay's argument on industrialization, described employment also plays a crucial role in the nation's economic growth [2]. Handicraft plays a significant role in both economic development and employment. In this handicraft, entrepreneurship plays a crucial role [3–5]. To understand handicraft entrepreneurship, we must look at the traditional heritage handicraft production system. Product diversification, mixing with different materials, crafts, etc., are witnessed innovations and interventions over time to meet consumer requirements. Artisans always used simple tools considering the flexibility in production. Due to the technical excellence of artisans, creativity, and innovation, Indian handicraft

never lost their identity under the rule of different eras and rulers [6–9]. The handicraft sector's circular economy nature creates a feasible and environment-friendly business environment.

4 Significance of Handicraft Entrepreneurship for Young Entrepreneurs

Developing the vision and business Idea, raising capital for a start-up, assembling a business team, finding the right business location, finding good employees, finding good Customers, unforeseen business challenges and expenses, dealing with competition, keeping up with industry changes and trends are challenges faced by new entrepreneurs in building the entrepreneurship [10]. Design is currently considered a cross-functional and multidisciplinary innovation activity, capable of making sense of social challenges while devising strategic and holistic solutions to support competitiveness [11]. The Craft School of Finland and Iceland focused on developing the student's thinking skills, enabling them to work through various handicraft processes from initial ideas to the final products [12, 13]. There is a tremendous demand for handicraft products all over the world. In recent years, with the emergence of online retail and the proliferation of various e-commerce channels, the accessibility to handicrafts has become more convenient for consumers. Virtual entrepreneurship can reinforce indigenous skills in front of the world through mutual collaboration [14]. Handicraft entrepreneurship is a culture of creativity and flexibility, advancing their capacity for adaptability and creating new designs. Thus entrepreneurs get help in idea generation per consumer requirements through handicraft entrepreneurship. Also, abundant of cheap and skilled labor is available to help in the economical way of product change, evaluation, and screening of product ideas, etc.

5 Pilot Study of Brass Metal Handicraft Industry Hajo, Assam

The use of brass, bronze, and copper metals is centuries old in India. It is the largest brass-making country in the world. Antique characteristics and the mixing nature of brass metal with other craft products make it more demandable. Both utility utensils and decorative items are made of brass. Today Moradabad cluster is the chief supplier of brass handicrafts to the world. The traditional metal handicraft cottage industries of Assam are losing their shine due to competition from products of Moradabad and better quality products produced by competitor's countries.

The handicraft products are analyzed using the Lean tool to understand the product value chain. Also, to identify and improve the bottleneck process. A lean tool is a

value stream map that shows process activities, the flow of products and information, the relationship of suppliers to the value chain, and customer needs [15].

5.1 Issues and Concerns

- Traditional tools & equipment are used in the crafting process.
- Surface finishes and quality issues, for example, rack formation, lead to product rejection.
- Government designed interventions to improve the crafting operation, but some equipment is not in use. The main reason for this is the formation of wrinkles on its surface while making the craft. Thus it affects the product's quality and leads to product rejection.
- High cost of raw material.
- The Assam government set up a rolling mill to solve the problem of raw materials. But slow craft production rate and less demand for raw materials, causing an increase in the inventory cost and higher operating costs. Today this mill is closed.
- The artisans are paid wages based on total production. Artisans have to face problems for sustainable livelihood with low production.

The findings from the field survey reveal a noteworthy initiative by entrepreneur Bordoloi aimed at revitalizing a fading ancient craft. Collaborating with brass metal handicraft entrepreneurs in Assam, Bordoloi has innovatively designed the "Pitoloi chair" (as shown in Fig. 1). This endeavor showcases a proactive approach to preserving and rejuvenating traditional crafts through entrepreneurial vision and collaboration within the local artisan community.

In similar ways to the cultural heritage and creativity of handicrafts, with the help of artificial intelligence, an ontology has developed as the conceptual framework. It generated a bill of the material list for all parts and raw materials to make a unit of the product shown in Fig. 2 [16].

Fig. 1 Collection of pitoloi chairs

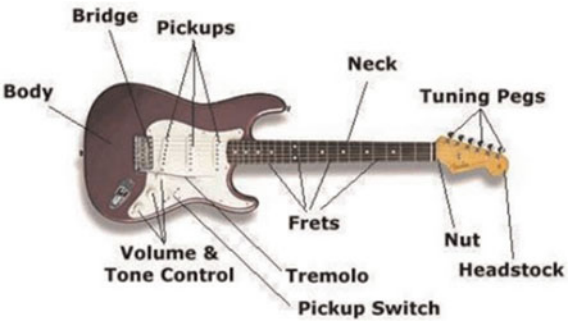

Fig. 2 Metal electric guitar with main components. *source* Bandini and Sartori [16]

Here contribution of our research work through tool design intervention to improve the production rate and quality of the craft's product.

5.2 Discussion

The introduction of product diversification has significantly contributed to enhancing the value within the handicraft sector. The feasibility and value added by handicraft skills and techniques are particularly advantageous for young entrepreneurs during the product development phase. However, it's noteworthy that both the quality and pricing dynamics impact both traditional handicraft artisans and emerging young entrepreneurs in this industry. In response to this, there is a pressing need for effective tools that can enhance both the quality and production efficiency. Crafting tools intervention proves to be pivotal in this scenario, bringing numerous benefits to artisans and entrepreneurs alike. These tools not only contribute to reducing material costs but also play a crucial role in minimizing overall production costs while simultaneously elevating the quality of the end product. The integration of efficient tools, therefore, emerges as a strategic solution, fostering a positive impact on both traditional handicraft artisans and the new generation of entrepreneurs involved in the craft.

6 Conclusion

Handicraft entrepreneurship can play a crucial role for young entrepreneurs. It strengthens the creative thinking skills of non-technical design persons through technical support and Strengthens the advanced technology knowledge through creativity. Also, abundant cheap and skilled labor is available to help in the economical way of product change, evaluation, and screening of product ideas, etc. The new design strengthens the growth. Entrepreneurial engagement with handicrafts reinforced indigenous skills in front of the world.

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Green Toys for Early Childhood Care & Education

Soumen Das and Pratul Chandra Kalita

Abstract Activity based teaching is a methodology which builds interest among the children by keeping them engaged and making them learn concepts while playing. In this study, the activities are developed using locally available material with a meaningful purpose and finally to come out with affordable solutions for the effective implementation of developmentally appropriate early childcare and education. These engaging products can help in reducing dropouts at early childhood and can be very useful in the effective implementation of new NEP (National Education Policy). The study uses a design and development research methodology. In the design phase, focus group discussions were held with educator to determine the objectives of the activity. In the development phase, prototypes developed were evaluated among children and educators. Each phase was reported and many design guidelines emerged. It also indicated the process of being self-reliant for the rural preschools rather than being dependent on a global supply chain. This can be a game changer for Anganwadi schools and for effective implementation of the new NEP.

Keywords Activity based teaching · National education policy · Early childhood education · Rural livelihood · Anganwadi schools

1 Introduction

This study is based on the fundamentals that there is a need of an ecosystem consisting of stakeholders like designers, psychologists, researchers, artisans, packager, marketer, etc. who together can design and manufacture toys from locally available materials which can be of tremendous usefulness in the preschools including the rural preschools. This will also open up market for the artisans and if branded

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properly then it can emerge into a new business for the artisan clusters present in the region. This is a multidisciplinary study which includes child development, child psychology, interaction with environment, product design, standards, ergonomics, aesthetics, safety, etc. In this study, some aspects of toys & activities, designer, toy design and guidelines, etc. have been provided.

1.1 Toys and Activities and Their Importance in Children Life

Toys and activities have been an integral part of children's life. For children play is the most important work. They learn while playing rather than reading and writing. All the children love to play and when they look for a playmate, toy is their first friend. Playing games and playing with toys help to develop their mental and physical health in addition to the occupation of just being engaged. Plays and toys also help to find out the disorders like autism at an early age. This also helps to get away from digital addictions [1]. The earliest toys were made of material found in nature such as rocks, stones, sticks and clays. The great toys are those which can imbibe discovery, enhance child-play environment, fun and educational learning and are age appropriate [2]. Children's brain grows fastest in the age of 0–5 years. The factors which need to be considered for designing of toys is very important so that the relevant toys can help to impact the behavior of child, develop their social skill and hand–eye coordination, be suitable for age group, and of course safety [3].

1.2 Designers

Designers are very important stakeholders for the designing of toys & activities. They are the ones who will understand the learning outcome and accordingly design the relevant product for different learning outcomes. The designer needs to keep in mind the sizes, and material to be used, and keeping in mind the cost and safety parameters [3]. Designers while designing such activities need to be very careful on the safety of children and attractiveness of the product for children [2]. The toy or activity designer needs to collaborate with various stakeholders like artisans who will produce, the educators who will facilitate, marketer who will market the product, researchers who are doing study with children and most importantly the children who utilize the products. The designers need to have proper knowledge of design parameters and design guidelines. Designers should understand children's psychological needs; the products should have good design orientation and can better meet the need of users, through the product children should better understand the object world and should help in the development of physical and mental health of children [4].

1.3 Artisans

North eastern states have some of the finest artisans in the country who have the skill of working with bamboo for various product developments. However, they face challenges in designing new products specifically children's toys as there is no connection between the artisans and market. The craft work at present is going on in a cottage industry scale and most artisans are unorganized. Government of India has taken multiple initiatives of forming clusters for organizing these artisans for product development on a large scale and also creating market linkages. However, there is still a gap for branding and proper packaging of the product which can make these products compete in the domestic and international markets. While interviewing with the department of design at IIT Guwahati and conducting focus group discussions with artisans it came to light that there are multiple design projects being done at IIT Guwahati which remain as research work and there are several instances when artisans required design support for product development and packaging but then they remained unaddressed as there is no connecting of such design schools with ground level artisans.

1.4 Toy Designing Guidelines

Fun, engagement, emotional stimuli, physical and mental challenges, socializing, and creativity are the main goals of toy design. The focus of toy development is that it should be interactive with a better user experience. The global toy industry is growing and is very dynamic. The Chinese toy industry has grown multiple times compared to Indian toy industry. This is quite visible from the export data i.e. our toy export to China is only 0.34% of the total toy export to the entire world and our import from China is 77.4% from China of the total import of toys [5]. The competitiveness of the Indian toy industry is declining compared to both the world and China which is a major concern for the Indian toy industry. The majority of toys available in the market are made of plastic and are not of a sustainable nature. Moreover, when there is a pandemic situation and disruption in the supply chain the schools and children in the rural area suffer. So, it is very important to come out with policies by the government to develop toys from locally available materials with a definite purpose. This will also open up opportunities for the artisan clusters and entrepreneurs to develop toys for both local and national markets. Some of the common hazards occurring from toy usages which need to be taken care of while designing the toys are [6].

- Ingestion of magnetic toys
- Choking or aspiration due to small parts of the toy
- Cuts by sharp parts of the toy
- Motor toy vehicle incidents
- Chemical substances in the material.

2 Methodology

The initial phase of the study was a focus group discussion with educators of various preschools in north east India mainly from the rural areas. This was particularly done to identify the problems regarding engaging activities in the schools and the discussion brought out some factors which are to be taken care of while designing the activities. Based on these factors some toy design guidelines were created and then prototypes were developed. These activities were then tested with a group of students facilitated by an educator in the school environment.

Factors which were noted during focus group discussions were that the toy should

- Provide excitement to children
- Develop hand–eye coordination
- Build up strength
- Create intellectual stimulation
- Develop knowledge and understanding
- Build social skills
- Age appropriate
- Parent friendly
- Attractive design aspects
- Safe
- Affordable.

Child development

Plays and toys have a very important role in the overall development of a child. Toy is the first playmate of a child. Activities and toys stimulate the intellectual mind of a child, fine motor skill develops through play, a child learns shapes, colors, geometry through toy and while playing in a group develops its social skill [1].

Age appropriate

Most of the children get hurt by the usage of a product when the product is not of their age. The toy makers need to follow the guidelines of age appropriateness of Consumer Product Safety Commission [7]. The guidelines consider size as one of the main criteria, the child must be able to physically manipulate and play with the toy and the child should understand how to use the play [8].

Parent friendly

Most of the time the child is at home and playing with siblings of parents/guardians. Nowadays due to nuclear families child stay only with their parents and siblings if any. At many homes, there is only single child and they look for playing with their parents. These days in many cases both the parents are working, as a result, parents get very less time to play with their children and sometimes when they have time, they feel like not to play as the toys and games and not designed considering the parent factor. They have a hard time to play with the toys & games with children.

Though the designers cannot change the social problem they can create guidelines for incorporating parent–child factors in the toys [9].

Design aspects

It is now well known fact that toy makers are segmenting toys according to gender. A study of US Disney store website shows that toys are segmented according to color and type of toys. The bold color toys like black, red, brown or gray toys and with action figures, weapons, vehicles and building toys are typically "boy's only". Pastel colored like pink or purple colored toys and those are dolls, kitchen sets, cosmetics, jewelry or domestic-oriented are "girl's only" [10].

Safety

Children are very delicate and they try to put anything in their mouth, so safety of toys is very important. Toys can cause severe injuries including death of a child. Toys sold in European Union and US have to be approved by various safety norms. There are several safety guidelines like Toy Safety Directives 2009/48/EC [11]. Most of the injuries are avoidable if the following things can be avoided while designing a toy:

- Toys with small removable parts.
- Toys with sharp objects.
- Toys which produce loud noises.
- Toys with strings or cords with more than 7inches.
- Toys painted with lead paint.

Affordability

The toys plays a vital role in the life of a child however adult pays the price of the toy and if it is affordable then it can serve the purpose to a large population. A child should get the opportunity to play with multiple toys so that various stimuli can be worked on. A toy should be usable by a variety of age groups and should be playable at multiple positions. A toy should have the purpose of developing certain specific skills and should be affordable to the mass population.

3 Results and Discussions

The use of locally available material for the development of activities can be well received by pre-schoolers at early childcare and educational institutions and at home. While playing they engaged themselves with friends, educators at school and parents and relatives at home. The children expressed their imagination, patience, independence, and developed their communication and sharing skills. The activities were designed with a purpose and children could achieve the goal of the designed activity while playing. The level of learning and achieving the goal for most of the children lay in building and compiling the puzzles and games. The motivation of this

Fig. 1 Mikado

study is the fact that there are only a few guidelines for activity based toy design using locally available material but most of these guidelines can be created from practical experience and empirical research. This study hence determines that the designer can learn more about children and toy design by interacting with educators, psychologists and researchers who are working with children related research. This paper can be very useful for toy designers and who are looking to start business in toy manufacturing. Few of the toys/activities which were designed and made with locally available material and which are tested among the children are.

3.1 Mikado

The inspiration of this Mikado is a pick-up stick game, played with a set of same-length bamboo sticks which can measure between 17 and 20 cm. Each stick has got a specific score (number). The sticks are bundled and taken in one hand that touches the table or ground. These sticks are then released which creates a circular jumble. Now the players take turns, in which one stick after another should be taken up without moving or touching others. The take-away could be by hand, possibly through pressing on a stick's tip or if one has already picked up a special stick (Mikado), it could be used as a helper, possibly to throw up another stick. On a fault, the turn ends (the last stick taken is not counted). The next player bundles and drops the sticks again. After several rounds, the one with the highest score—the total of the values/score of all the sticks that have been picked up—is the winner (Fig. 1).

3.2 Sorting Box

Sorting box is made of bamboo and the tiles are made of hard corrugated cards. This is a classification game for children of the age between 3 and 5 years. A child drops each tile into the box where it belongs according to the category marker placed

Fig. 2 Sorting box

on the top. On placing each tile into a different hole, the child builds vocabulary skills. Finally, the child opens the roof to retrieve the tiles which were put and an adult verifies that (Fig. 2).

3.3 Spindle Box

A box made of bamboo with ten compartments numbered 0–9 along the back and 45 bamboo sticks. The sum of the numbers 1–9 is 45, so there is exactly the right number of sticks for the exercise. If a mistake is made, the child will find that he has either too few or too many sticks when he comes to the last compartment. He can correct his work independently. This game helps the child to learn number, counting and helps the child to associate number with its real quantity. This game is suitable for 4 years and older children (Fig. 3).

Fig. 3 Sorting box

3.4 Phonetic Game

This game is made for 10+ years of age group of children. The parts of the game are made with chart paper and for standardization, a printer is used for taking print on card papers. On the back of each card, three to four clues are given and from each clue a word is obtained. In the next stage, these words are phonetically rearranged to create a new word which is displayed on the front side of the card. This game can be played between 2 and 3 players or more and also in teams where each team can consist of multiple persons.

The children when were administered with the above games, they enjoyed and they wanted to do repeat play. The adults who played with the children also didn't get bored or didn't find it difficult to play. They developed their social skill while playing with others, intellectual stimulation was created, hand–eye coordination was developed, developed knowledge and understanding and provided excitement. The toys were developed with locally available material so were not very expensive and affordable for rural preschools and also for parents.

Two schools were selected and from each school, a group of 15 students were taken and divided into three categories:

Group 1 (School 1 & 2): 5 students who were given activity based toys
Group 2 (School 1 & 2): 5 students who were given paper and pencil and some task to be done using paper & pencil in a traditional manner
Group 3 (School 1 & 2): 5 students who were not given any assignment.

It was found that activity based games are more effective than traditional learning methods. The effectiveness was measured with the following parameters. The quality of experience was measured and it was found that activity based games were more enjoyable as confirmed by educators. These games were described as 'fun' 'exciting' and 'fantastic'. More than 90% of students children found it interesting than the paper based exercises. 100% of students wished to play more the 'Mikado' game, 80% wished to play more the 'spindle box' game when the category marker placed on the top was modified, 70% wished to play more the 'spindle box' game when the game was made a bit more challenging i.e. when they were asked to finish in a shorter period of time. On the other hand, only 40% wished to solve additional paper based exercises. The group found it more motivating as the educators could often help them while playing the game compared to the paper based exercises.

As per the experts, all these games helped in developing hand–eye coordination. The spindle box game helped in developing the skill of estimation and counting. All these games hone fine motor skills. Since all these games are three-dimensional, this also helped in creating spatial awareness among the children.

4 Conclusions

Based on the theoretical aspects and also testing the developed toys & activities from locally available material, it is clear that a number of such activities can be designed from locally available material. These activities can be of tremendous value for the children for their multiple developments. Such activities can be very useful for effective implementation of the new NEP. The new NEP gives importance to play based, activity based and inquiry based curriculum. The new NEP supports physical and motor development, cognitive development, development of communication and early language, literacy and numeracy. So the discussed activity based toys in this paper and similar toys of this kind will support the new NEP. Further, a detailed research needs to be conducted and more such activities need to be designed which can be a good handbook for the rural preschools and specially the Anganwadi schools. Youths can venture into entrepreneurship and develop such toys and activities and can improve the design by collaborating with a design school and brand it properly and come out with a good brand with an exhaustive list of toys and activities.

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Exploring Bamboo Craft Works of North East Region for Developing Furniture & Equipment for School and Relationship to an Indian Design Institute for Being a Driver

Soumen Das and Pratu Chandra Kalita

Abstract Bamboo being a green material is evergreen and is becoming recognised as an alternative material for building various products worldwide. It is light in weight and flexible which is its most unique quality. It grows faster than trees and produces more oxygen and thus can be branded as a sustainable material. Indian preschool market is USD 735 million and there are varieties of requirements which include toys, furniture, equipment, etc. Bamboo can be a potential material for manufacturing a variety of these products. The preschool toy, furniture & equipment market is ever changing and growing over the decades and extensive use of plastic has become a concern for long term environmental impact. This research is performed to understand the acceptability of bamboo products among the children and educators of preschools. The research was conducted by collecting data, observing and analysing problem, product design and product testing. The prototype was created with the help of artisans of functional bamboo clusters of MSME (Ministry of micro, small and medium scale enterprises) present in north east India. The design innovation was explored in collaboration with an Indian design school. The result indicated that products required at Early Child Care & Education centres can be manufactured using locally available bamboo and can develop a model of self-reliant rural preschool. The research has identified the challenges in product design with bamboo as material. However, once products are developed, such products can make the bamboo clusters self-sustainable.

Keywords Rural Livelihood · Bamboo industries · Sustainable development · Preschool furniture · Green school

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1 Introduction

Indian preschool market is USD 735 million [1] and bamboo can be an important raw material for developing various products for preschool. Bamboo can also be a potential source of employment in rural areas by manufacturing different value added products for schools. Excessive use of plastic material in furniture and other products for school has become a cause of environmental concern. Climate change and energy problems are the major concern now for the world. Across the world, many initiatives are being taken where the major steps are for saving energy but the low carbon concept is very less popular. School as a special community where the future generation is growing can be a good platform for creating awareness of sustainable development and making the future generation well informed. In this regard, there are few green schools launched in China which are providing a platform for cultivating the concept of sustainable development [2]. In addition to the green practises, the products used in school can also be green products.

2 Methodology

Methodology was sub-divided into five sections: Study of literature on building sustainable bamboo products; study of the products displayed in exhibitions/trade fairs; exploring the products made by artisans at technology centres and artisans' own work-sheds; study of similar existing products at school/institutions; Focus group discussions with stakeholders for using bamboo as material for building sustainable products.

2.1 Desk Research

Extensive desk research was done to identify various sustainable products for schools which are made of bamboo as material. These researches were conducted for different geographical areas and on north east India perspective. The activity focussed on the identification of such products, challenges faced in manufacturing such products and the acceptability of these products among consumers.

2.2 Study the Products Displayed in Exhibitions/Trade Fairs

A number of exhibitions and trade fairs were visited and bamboo and green products displayed there were identified which are useful for schools. The product pictures

were then shown to the educators in the school and feedback on the products was taken from them.

2.3 Explore the Products Made by Artisans at Technology Centres and Their Own Work-Sheds

Cane & Bamboo Technology Centre at Byrnihat (Meghalaya) was visited and interacted with artisans from Tripura and Nagaland SFRUTI clusters. Products at these places were identified which can be useful for schools and institutions. Pictures of these products were then shown to the educators and their views were taken on the utility of such products.

2.4 Study the Similar Existing Products at Schools/ Institutions

Total of three schools from different location of north east was taken into consideration and the products placed there were compared with the green products identified at various locations. These products were then compared with the green products identified and a comparison table was created.

2.5 Focus Group Discussions with Stakeholders for Bamboo Substitute

A focus group discussion was done with artisans, educator, designer, entrepreneur and parents for identification of the challenges faced in designing green sustainable products, manufacturing them and studying the acceptability of such products among consumers.

3 Results and Discussions

Results indicate that there are some products already there in the market however commercial production of such products has not yet taken place. Government is already keen in developing clusters for such commercial production [3]. However, there are several challenges for commercial production which are discussed in detail. When we conducted the region specific secondary research, we could find that there are several products for schools which are being produced in very small quantities

in fragmented manner and there is further scope for the production of such products. A study done by IIT Guwahati for the state of Meghalaya indicates that multiple products for schools can be made from bamboo in north east [4]. Bamboo products for schools can contribute toward sustainable development, few of such products are:

Bookshelves

Bookshelves are the common products used in school which are mainly made up of wood and plastic. The portable bookshelves used in preschools are mainly made of plastic. There is not much research done in this regard for alternative bamboo as a material to be used for manufacturing of this product. Bamboo can be used to make such products which are not only strong but also aesthetically appealing. However, proper design needs to be developed for making portable and strong products (Fig. 1).

Tables-Chairs and Desks-Benches

Tables and chairs are the main products in a school. Tables and desks are utilised for multiple purposes like writing, computer work, self-study at home, etc. Majority of the preschools utilises plastic table and chairs. Using bamboo as material will not only make the products sustainable but also can create rural employments for artisans (Figs. 2, 3, 4, 5, 6 and 7).

Dustbins

Fig. 1 Bookshelves at rural school

Fig. 2 CBTC Byrnihat

Fig. 3 School in Dimapur

Fig. 4 School in Silchar

Fig. 5 IIT Guwahati

Fig. 6 IIT Guwahati

Fig. 7 Hunar Haat Guwahati

Fig. 8 CBTC Byrnihat

Dustbins are requirements of every school and household. Majority of them are made of plastics. These can also be replaced by bamboo dustbin. However, proper cost effective designs are yet to be created for different uses (Fig. 8).

Laptop/Study table for studying on bed/floor

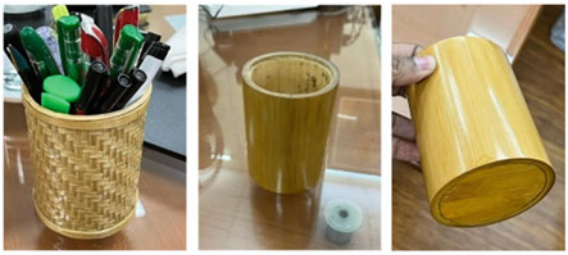
Laptop tables or portable small tables utilised by children when they study in bed are commonly found in market which are made of plastic. This can also be replaced with bamboo, however, extra care should be taken for a safety perspective as even a small bamboo fabric can pierce into a child's skin as they are very delicate and can cause injury. Further, a child friendly design needs to be created which will increase the sales of such products (Fig. 9).

Pen/Pencil Stands

Pen stands are commonly used at schools and also by children at home to store pencil, pen, toothbrush, toothpaste, etc. Children these days are fond of buying such products with cartoon characters. Most of these products again are made of plastic and the ones which are made of bamboo are not made child-oriented and do not attract children (Fig. 10).

Fig. 9 CBTC Byrnihat

Fig. 10 CBTC Byrnihat



Brooms

A very commonly used product in school cleaning is broom. Customised broom can be made for various purposes (cleaning different areas). This product is not only used in schools but used by most of the Indian households, offices and municipalities (Fig. 11).

Challenges

Bamboo was primarily used by paper and construction industries. However, the demand in the paper industry has gone down and many bamboo products are being substituted with other materials. New market needs to be created for bamboo products [5]. Industrialization in the bamboo sector is less as a result of the domestic market potential and the international market which is presently dominated by China is yet to be tapped [6]. Artisans working in the bamboo sector are not educated enough to know

Fig. 11 CBTC Byrnihat

the development happening across the globe and they are mostly acquainted with only local language, so they also have a language barrier to know about the developments happening in the outside world [7]. Most of the artisans are economically backward and as a result, they cannot manage the tools required and do the necessary marketing of the products. Cluster initiatives are being taken by the government for setting up common facility centres, raw material banks and training of the artisans on further skills [8]. However, presently the clusters or artisans are not connected with designers who can guide the rural community on product design and come out with innovative products which can have a good market potential.

4 Conclusions

This research attempted to explore and identify various products useful for preschools which are made of bamboo as material. This research can be very useful for making schools green and sustainable and can give a good source of income to the artisans who are making such products. It can be used as a material for a number of products which can be of use in schools across the globe. Further, sustainable development awareness can be created at school itself for the coming generation by bringing them nearer to sustainable products which can be developed with bamboo. However, it requires collaboration with an Indian Design school for developing such new & modified products with domestic and international market standards. This will also support the existing and upcoming bamboo clusters for marketing their products to domestic and international markets. The innovation in this study is to explore various products which are being created by artisans and which can be further modified by design schools for branding them at national and international platforms. The products displayed above are developed by artisans and kept as prototypes in some schools and technical centres and few were displayed in fairs. However, commercial production of such products is yet to take place. Further, detailed research needs to be done in this area to explore avenues of building such an ecosystem.

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Advance Methods of Ornamentation in Fabrics Woven Using Fly-Shuttle Semi-Automatic Handloom

Manohar Mahato and Amarendra Kumar Das

Abstract Many weavers live below the poverty line due to the weaving of plain fabrics only. Ornamentation of fabric through extra warp/weft can create more value in the woven fabrics and enhance their income. Ornamentation can be done during weaving itself by using extra weft with or without extra warp. This type of ornamentation does not affect the strength of the ground fabric; if the extra warp and extra weft are removed from the ornamented fabric, still resultant ground fabric will remain as plain usable fabric. There are many other ways to do ornamentation on ground fabric, like embroidery and painting. Embroidery reduces the strength of the ground fabric, and painting may not be as durable as intended. Ornamented fabric through extra warp/weft can enhance the earnings of the weavers in this digital marketing world. Government and many private organizations assist in marketing handloom products. There is an advanced way of doing ornamentation during weaving by lifting warp yarn with the help of different shed formations using tappet, dobby, or jacquard to insert extra weft manually or through an extra weft insertion machine named Chaneki. Extra warp can also be added by using an additional warp beam at the top or bottom of the back side of the loom, maintaining a gap between two warp sheets. This paper presents the advanced semi-automatic handloom named De sign loom for ornamentation during weaving using extra weft to produce high-value handloom products. Shedding and beating are the only manual motions in the loom to facilitate plain weaving with ornamentation.

Keywords Handloom · Ornamentation in weaving · Weaver

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1 Introduction

"There are 3144839 households involved in handloom work in India. Assam, West Bengal, Manipur, and Tamilnadu have two-thirds of handloom households in India. 3522512 handloom workers are working in this sector across India. 97.8% of handloom households earn less than 15000 rupees per month. Only 3590 handloom households, i.e., 0.12% of total handloom households, earn more than 50000 rupees per month. Handloom households in the top five states weaving sarees and dress materials are 15% of total handloom households involved in handloom activity. It highlights that most weavers are not focusing on weaving high-value products. Approximately 82% of sales have been done through the local market and master weavers with almost no sales data, whereas 9.8% of sales have been done through cooperative societies and organized fairs. Export is only 4% of total sales of handloom products. Only 50.34% of handloom machinery have dobby/Jacquard attachment to weave ornamented fabrics; the remaining handloom machinery is used to weave plain fabrics only" [4]. Most of these looms are made with wooden frames and are not in good condition for continuous weaving as part of commercial activity. Competing with power loom and automatic loom products in plain weaving is difficult. Therefore, the focus must be on weaving customized ornamented fabric through handloom to compete and sustain in the market. Earning of weavers can be directly improved by reducing the cost of input materials like yarn, and dye, improving the productivity of pre-weaving and weaving, reducing quality issues, and weaving majorly high-value customized products.

In this setup, how can we revive the handloom sector to improve the livelihood of more than 3.5 million handloom workers through weaving high-value customized products? Other factors are not considered in this study.

This study is carried out to understand the effective way to do ornamentation, shortcomings, and design intervention in handloom weaving to improve productivity.

1.1 Ornamentation During Weaving

It is an incremental, experimental, society-driven, applied, and curiosity-driven academic research. All handloom workers and associates will be benefitted from this research.

All relevant and associated papers related to ornamentation have been studied with handloom keyword search as the total number of research papers was less than 100.

Complex ornamentation during weaving is possible as new and advanced handloom technology evolved. In the 2nd century, four handlooms were found in Laoguanshan, Chengdu, and south-west China, which can do pattern ornamentation. There were two systems for the movement of warp and weft with two different prime movers to produce complex patterns using multi-shaft action [9]. Jin silk was weaved through

these pattern looms, and slowly the technology spread across Europe and Eurasia [8].

It is difficult to fulfill the high-demand for ornamented fabric like Jamdani saree through traditional handloom; therefore, attachments like jacquard and advanced production technique are need of the hour to survive handloom weavers [5]. Complexity in weaving based on weave type, color, patterns, and techniques of the fabric helps to decide the type of handloom to be used for weaving. Pattu weaving is an example of traditional ornamentation design requiring an extra weft insertion technique for faster weaving [6].

Seamless, woven garments are also an opportunity for handloom as they cannot be weaved in a power loom with other advanced techniques. It is a waste-free technology similar to additive manufacturing technology. The garment-wise shape will be different to avoid the laying, cutting, and sewing process in traditional garment manufacturing [7]. Cost advantage will be an essential factor for surviving this technology, but it has increased its market share in the textile market over the last two decades.

Ornamentation during weaving can be done using extra weft, extra warp, or both extra warp and weft. Tappet shedding, dobby, or jacquard attachment helps to make a shed for extra weft insertion based on the complexity of the weave and butti or butta. Extra weft can be inserted manually through a new mechanized device named Chaneki. Chaneki was invented in Sualkuchi to insert an extra weft of multi-color other than the color of the base fabric [3].

Dobby handloom, as shown in Fig. 1, manages to weave medium-level ornamentation, but it requires an extra person to assist the weaver in changing the next set of the warp through the dobby mechanism.

Jacquards is an advanced attachment to weave ornamented fabric. A handloom with single jacquard is shown in Fig. 2.

Double jacquards are also used in a single handloom for complex ornamentation, as shown below in Fig. 3. Tappet shedding, dobby, single jacquard, or double jacquard attachment are used based on the number of a different set of warp to be lifted to complete a motif for multiple weft insertion manually or through a Chaneki device.

Also, handlooms use double warp beams for ornamentation during weaving, as shown in Fig. 4. These looms are used to weave terry towels and other weave patterns.

In ordinary fabrics in which a figure is formed by floating the warp or weft threads loosely, the strength of the cloth is reduced. Ornamentation in grounded fabric by floating ground weft and warp threads produces figures. Durable and prominent fabric is produced when ornamentation is done during weaving itself.

The advantages of figuring with extra yarn are:

(1) Bright colors in sharp contrast with the ground fabrics may be brought in the desired proportion.
(2) Pleasing combinations may be produced.

The disposal of extra warp or weft threads in places where they are not required to form figures is of great concern. This problem can be avoided by using Chaneki device. In normal case

Fig. 1 Dobby handloom.
Source https://Indiamart.com

(1) The extra yarn is allowed to float loosely on the background fabric.
(2) In transparent fabrics where it can be seen, the extra yarn is allowed to float loosely on the back, and then it has to be cut away by stitching or embedding to increase durability.
(3) In compact fabrics, the extra threads are bound on the underside of the cloth either between corresponding floats in the ground texture or through special stitching threads.
(4) The extra threads are interwoven on the face of the cloth in the form of small auxiliary figures or floats that add interesting full textures to the material.

In producing warp figures, we need a dobby mechanism with two warp beams, one for the ground fabric and another extra warp sheet for figuring.

In producing weft figures, we need a dobby mechanism with a drop box to add weft yarns for the ground fabric and another one for figuring.

There are three ways to do ornamentation during weaving, as below.

1.1.1 Extra Warp Figuring

Only Two series of warp and one series of weft are used in this figuring.

Continuous figuring (one or more colors)—extra warp removed at backside at the end.

Fig. 2 Handloom with jacquard

Fig. 3 Double jacquard in a single handloom. *Source* YouTube

Fig. 4 Double warp beam in a single handloom. *Source* Historische Handweberei-web MUSEUM OEDERAN

Intermittent figuring (one or more color) such as striped pattern—do not require trimming of warp.

Lappet weave—deduction of extra warp yarn like a round patch on ground fabric that looks like an embroidery design. Lappet weaving is long-lasting and durable if not cut off backside yarn.

Advantages of extra warp figuring as compared to extra weft figuring as below:

(1) Productivity of the loom is more as a single pick is inserted.
(2) No special picking box & uptake motions are required.
(3) No limit on the number of colors that can be used.

Disadvantages of extra warp figuring as compared to extra weft figuring as below:

(1) Two or more warp beams are required instead of one.
(2) In dobby weaving, the draft will become more complicated.
(3) Stronger yarn is required for figuring.
(4) Extra ends are subjected to greater tension during weaving than extra pick. Thus extra warp effects show less prominently as compared to extra weft figuring.
(5) If extra threads have to be removed from the underside of the cloth, it is more difficult & costly to cut away extra ends than extra picks.

1.1.2 Extra Weft Figuring

Extra weft figuring is easier than extra warp design; continuous and intermittent figuring can also be done.

Following weave pattern can be figured with extra weft figuring.

Twill weave.
Hopsack weave.

Fig. 5 Multiple shuttle boxes in the handloom. *Source* YouTube

Swivel weave—ornamented yarns are dominant, weft travels only a few warps, not in full width, multiple pirns kept in the required position, identified through the front and back side, also called Jamdani technique. Reversal fabric is also possible.

Multiple shuttle boxes (Fig. 5) can ease this work by using extra weft but is not recommended as the sley become heavy for beat-up and requirement of the bulky frame.

1.1.3 Extra Warp and Weft Figuring

Spot or dot fabrics—a wide range of motifs are possible across length and width with extra warp and weft figuring. Back float may be cut or uncut based on the requirements.

Accordingly, these fabrics are called Clipped and unclipped fabrics.

Standard dotted swiss fabric is a popular design, through floacking, printing like fiber attached as velvet fabric.

Double jacquard helps to weave ornamentation across the length and width of the fabric, as shown in Fig. 6. These ornamentations can be done with or without an extra warp.

There is no need for a second warp beam for an extra warp only at borders; instead, use lease rods for the purpose. These warp yarns are not passing through the eye of healds. In Assam, this kind of design is added through the stitching. Buti (ornamentation-like spot design across the width) can be made through a device called chaneki developed by Inventor Deepak Bharali from Sualkuchi, Assam, India. Detail comparisions of extra warp and extra weft figuring are shown in Table 1.

It decides whether it should do extra warp or weft depending on the required functions and type of figure. Warp figuring is for expansive fabric, whereas weft

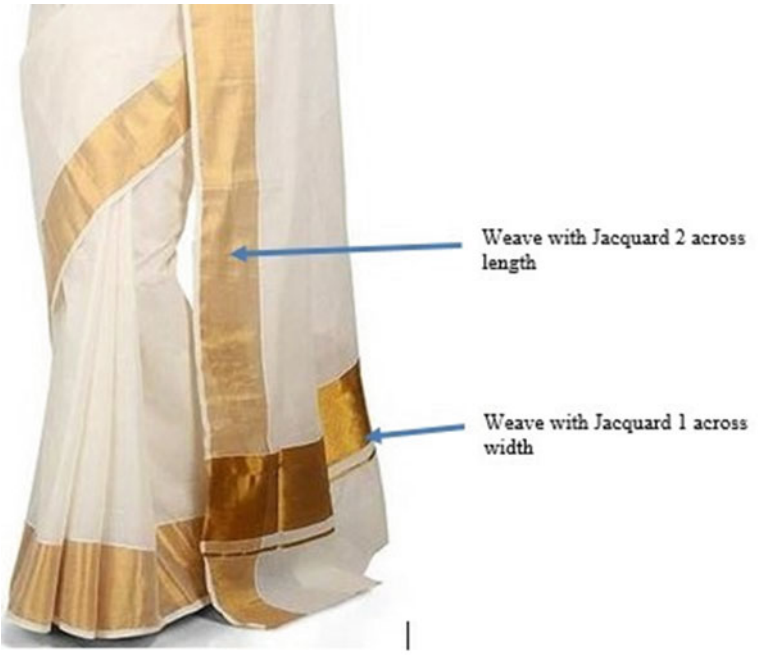

Fig. 6 Fabric ornamentation produced with double jacquard in a single handloom

figuring can be done in cheaper fabric relatively. When the weaver does not need prominent figuring, opt for an extra warp to keep uniform light or dark-colored extra warp uniformly, whereas extra weft can be used where prominent color is required. Weft figuring will not leave many floats at the back, so disposing of them is easy; thus designers can be free enough to do more design.

1.2 Handloom Export Data with Revenue Generated Per Product Segment

Following products have the highest export in descending order based on overall revenue generation in 2020–21 and the last ten years' export history through line charts in Figs. 7 and 8 [1].

(1) Floor coverings

(i) Mat and mattings, including Bath mats, where cotton predominates by weight—478.89 INR Cr
(ii) Carpets, Rugs, and mats of handloom—224.40 INR Cr
(iii) Cotton Durries of handloom (including Chindi durries, Cotton chenille durries, Rag rug durries, printed durries, druggets)—104.53 INR Cr.

Table 1 Comparison of extra warp and extra weft figuring

Extra warp figuring	Extra weft figuring
Require no additional shuttle box and special take-up mechanisms	Require drop box with modified take-up mechanism
Needs additional warp beams (2 or more)	Require only one warp beam
High production rates due to insertion of only one weft	Comparatively lesser production due to the use of dropbox for insertion of 2 or more series of weft yarns
Advantage of producing stripped and spotted effects by alternately arranging the figuring threads	Possibility of weaving only spotted designs
Require warp yarns of good strength	The strength of the yarns is not important
Generally requires more complicated draft plans	Simpler draft plans
Exhibits the figured effects less prominently	Exhibits the figured effects more prominently
Scope for the introduction of more colors	Restricted scope for colors limited to the capacity of the shuttle boxes
Difficulty and expansive in disposing of the extra threads at places where they are not required	More economical and easier to dispose of the weft threads
Poses a constraint in repeat size when working on an ordinary type of jacquard	No such problems

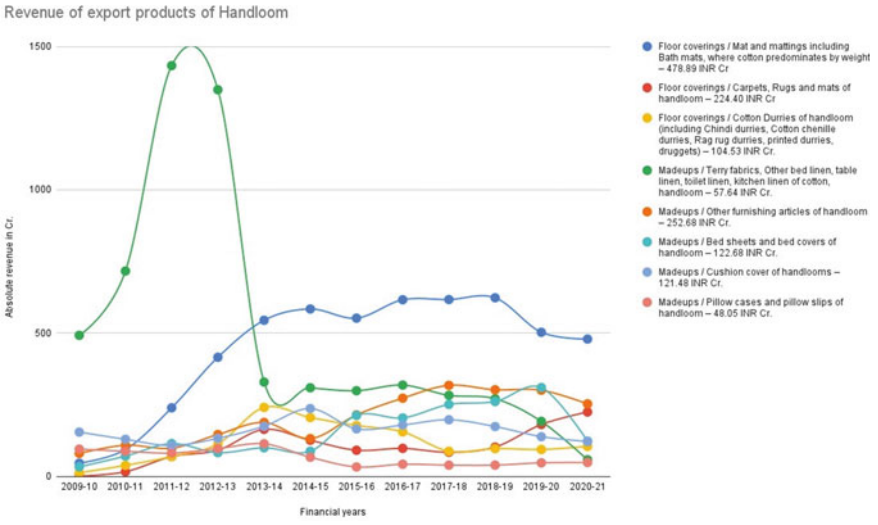

Fig. 7 % growth in revenue of exported handloom products—part 1

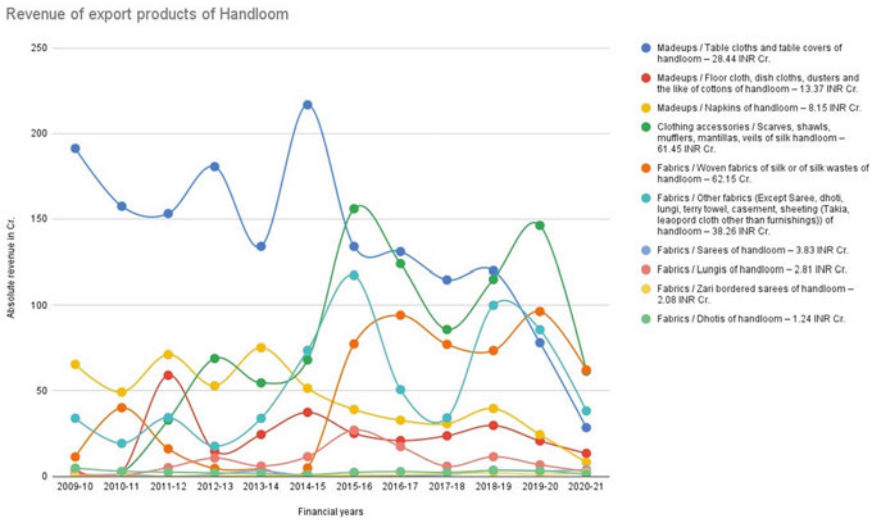

Fig. 8 % growth in revenue of exported handloom products—part 2

(2) Made-ups

(i) Other furnishing articles of handloom—252.68 INR Cr.
(ii) Cushion cover of handlooms—121.48 INR Cr.
(iii) Bed sheets and bed covers of handloom—122.68 INR Cr.
(iv) Terry fabrics, Other bed linen, table linen, toilet linen, kitchen linen of cotton, handloom—57.64 INR Cr.
(v) Pillow cases and pillow slips of handloom—48.05 INR Cr.
(vi) Table cloths and table covers of handloom—28.44 INR Cr.
(vii) Floor cloth, dishcloths, dusters, and the like of cotton of handloom—13.37 INR Cr.
(viii) Napkins of handloom—8.15 INR Cr.

(3) Clothing accessories

(i) Scarves, shawls, mufflers, mantillas, veils of silk handloom—61.45 INR Cr.

(4) Fabrics

(i) Woven fabrics of silk or silk wastes of handloom—62.15 Cr.
(ii) Other fabrics (Except Saree, dhoti, lungi, terry towel, casement, sheeting (Takia, leaopord cloth other than furnishings)) of handloom—38.26 INR Cr.
(iii) Sarees of handloom—3.83 INR Cr.
(iv) Lungis of handloom—2.81 INR Cr.
(v) Zari bordered sarees of handloom—2.08 INR Cr.

(vi) Dhotis of handloom—1.24 INR Cr.

The product-wise revenue trend in the last ten years is shown below to choose the product in demand for export during weaving to increase earnings. Profitability needs to be checked by reducing activity-based costing from the selling price.

Mat, carpet, rug, other furnishing articles of handloom, woven fabric of silk or silk waste, sarees of handloom, zari bordered sarees of handloom are showing uptrend revenue-wise. Few products show a downtrend only during the Corona period, like bed sheets and bed covers along with scarves, shawls, mufflers, mantillas, and veils of silk handloom. It can be checked alternate products supplied by the competitor with their market share for making unique selling propositions through intervention at various levels.

2 Methodology

This study is all about the assumption of increasing the earnings of the weavers by weaving value-added products with ornamentation. The methodology adopted is direct observations of the weaving process in the field and market data of plain-woven and ornamented fabric. It is observed that weavers earn significantly less while weaving plain fabric compared to ornamented fabric. So, plain weaving handloom is simple without any other attachment; however, a jacquard/dobby attachment is required for weaving ornamented fabric. So, the newly designed handloom was conceptualized to facilitate both plain and ornamented fabric with an attachment for dobby or jacquard. Assumption considered for the research was validated from handloom export data of individual handloom products. Therefore, it has explored the available tools to weave ornamented fabric. The demand for handloom products with ornamentation in the market is explored and identified to increase the production of the product in demand based on the requirements of overseas markets.

2.1 Concept of Improved Handloom

It is challenging to stop plain weaving in the exact position for ornamentation by extra weft insertion during weaving in existing semi-automatic handlooms. It is necessary to keep the shedding motion independent for ornamentation during weaving. Also, independent shedding motion is required as it requires multiple shed formations for extra weft insertion to generate the motif using dobby or jacquard attachment. The remaining motions of picking, beat-up, take-up, and let-off can be synchronized as it does not affect the ornamentation capability of the handloom.

Therefore, a new handloom has been designed and developed as a semi-automatic handloom, as shown in Fig. 9, with synchronized motions except shedding motion focusing on high-value customized weaving. Customized weaving with small batches

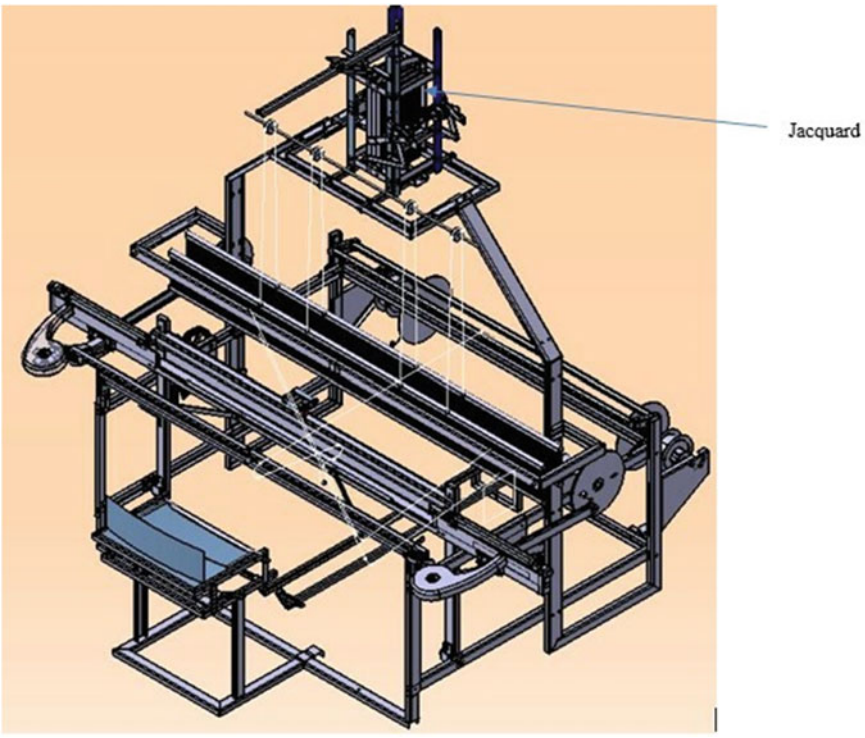

Fig. 9 Semi-automatic handloom with jacquard

is an advantage for handloom, which will not be feasible and economically viable for the power loom sector. Weavers will surely increase their income following this approach.

3 Findings and Discussions

There are weavers in Varanasi who weave only high-value handloom products. It is required to focus on weaving only one or two designs having demand in the market after taking intellectual property rights. In the absence of IPR, it is pervasive to copy the high-demand design by power loom stakeholders. These can be weaved in batches based on the requirements.

Another way to weave unique design handloom products for celebrities is by building a valuable brand in the high-value category [2].

All well-known traditional design and their current weaving process can be combined to generate high-end designs by increasing ornamentation capability in an improved handloom. All current fabrics and designs are shown in Fig. 10.

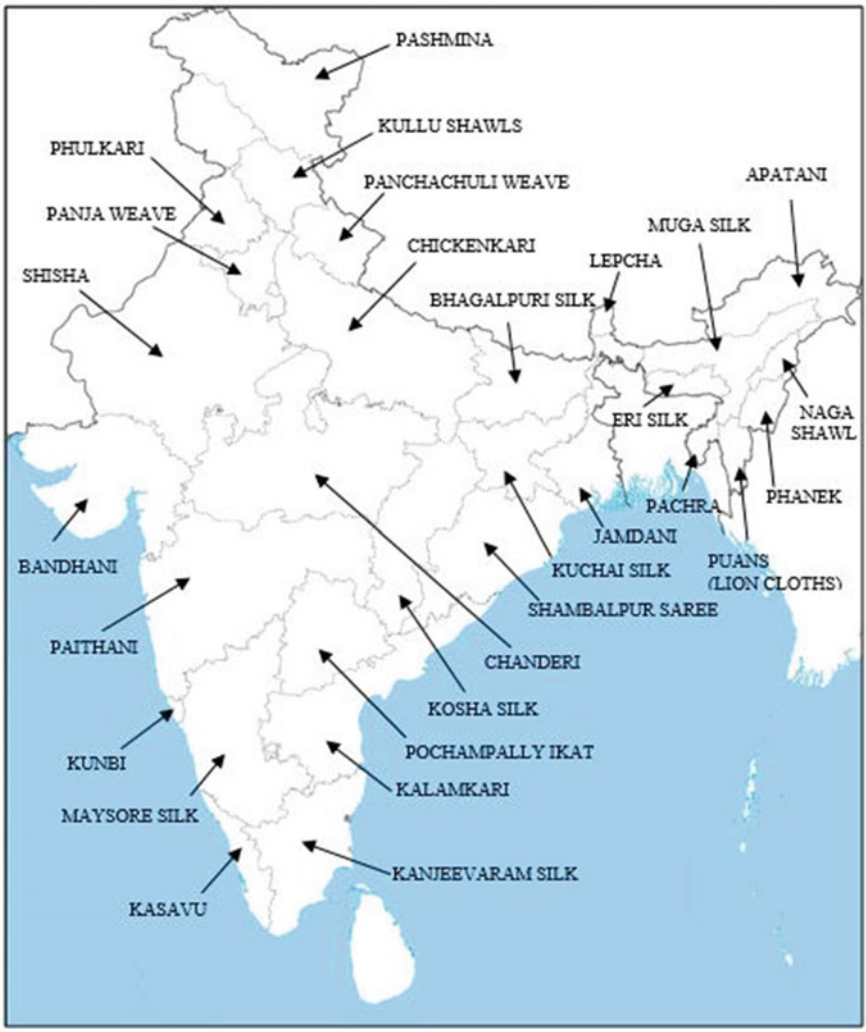

Fig. 10 Handloom fabrics of India

Integration of Chaneki with this new semi-automatic handloom is future work. It will substantially increase its ornamentation capability. The fabric of the world can be explored, which can be considered value-added export fabrics.

Best practises of 3590 handloom households earning more than 50000 rupees per month can be studied and shared among other enthusiastic, interested weavers, along with necessary handholding at the initial stage.

4 Conclusion

Weavers will be more innovative through the ornamentation process. Also, it will increase their earnings by weaving ornamented fabric. The focus should be on premium customers, weaving high-demand export products, and weaving luxury fabric.

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Overview of Sustainability Assessment Methods and Evaluation Tools for the Residential Sector

Kratika Piparsania and Pratul Chandra Kalita

Abstract Multiple criteria-based approaches are used to provide credits to various identified indicators in sustainable building evaluation tools. Sustainability frameworks are essential for directing appropriate planning, assessment, and implementation inside the building. As a result, the residential sector is one of the most significant public objectives driving urban expansion and strongly influences long-term sustainability. When three components of sustainability (environment, economic, and social) are addressed, will the housing project be termed sustainable? The relevance of sustainability evaluation methods and indicators in attaining housing sustainability is examined in this study. The study's goal is to present and evaluate the sustainability assessment approaches to see how they interact with sociocultural indicators or serve as an extension of the social sustainability component inside the scope of the building. The study is a result of information analyzed from various sources, including research papers, policy documents, and evaluation tools. The article explores the similarities and differences and how the overall evaluation might be improved for a more holistic approach to sustainable development.

Keywords Sustainability assessment · Sustainability indicators · Residential sector · Evaluation tools · Sustainability metrics

1 Introduction

The term "sustainability assessment" comes from the Brundtland Report, published during the United Nations meeting in Rio de Janeiro in 1992. In its Agenda for the Twenty-First Century (Agenda 21), sustainability was established as a measurable development element [1]. Sustainability assessment is the methods and procedures

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used to evaluate the potential effect of actions before they are carried out. This allows decision-makers to make more sustainable decisions [2]. The goal of sustainability assessment is to: (1) improve understanding of the concept and its context-specific interpretation; (2) incorporate sustainability challenges into decision-making by measuring impacts; and (3) encourage sustainability initiatives [3].

Sustainable development and its assessment are crucial for achieving sustainability and have received extreme attention [4]. Sustainability evaluation integrated assessment, integrated sustainability assessment, and impact analysis are some of the words and approaches used [5]. In addition, evaluation approaches are being utilized to aid policymakers and have become standard planning practice. As fresh perspectives on impact assessment for planning and decision-making on sustainable development, "Integrated Assessment" and "Sustainability Assessment" are proposed [6].

2 Sustainable Building Assessment

The notion of sustainable building evaluation arose a decade ago to measure and enhance the built environmental performance and sustainable goals [6]. Measuring and assessing sustainability remains a big problem and a source of contention over what it entails and how to carry it out. This is because it incorporates cross-disciplinary elements and human value-based metrics [7]. There are no universally acknowledged indicators for describing the natural habitat and its connections with sustainable development's social, cultural, and economic components [8]. This dispute could be due to the absence of a universally recognized definition of the concept that considers social, cultural, and human context factors, as compared to approaches that focus on tangible aspects and metrics of sustainability, or when integrating quantity and quality factors [9].

2.1 Systems for Evaluating Sustainable Buildings

Building rating systems are multiple criteria-based credit evaluation techniques that award points for several pre-determined indicators. These indicators include various categories that influence overall building sustainability [6]. Sustainable and green building rating systems are commonly used evaluation systems for the building and urban environment [10]. These systems are intended to establish a method for evaluating various performance measures during building design, pre- and post-construction, operations, maintenance, and, in certain situations, deconstruction [3]. They test a building's performance consistently and harmoniously using pre-established standards, regulations, parameters, or criteria [11]. To establish grading in rating systems, scoring techniques are defined, which are based on four primary components [12]. Figure 1 depicts the categories of the scoring systems.

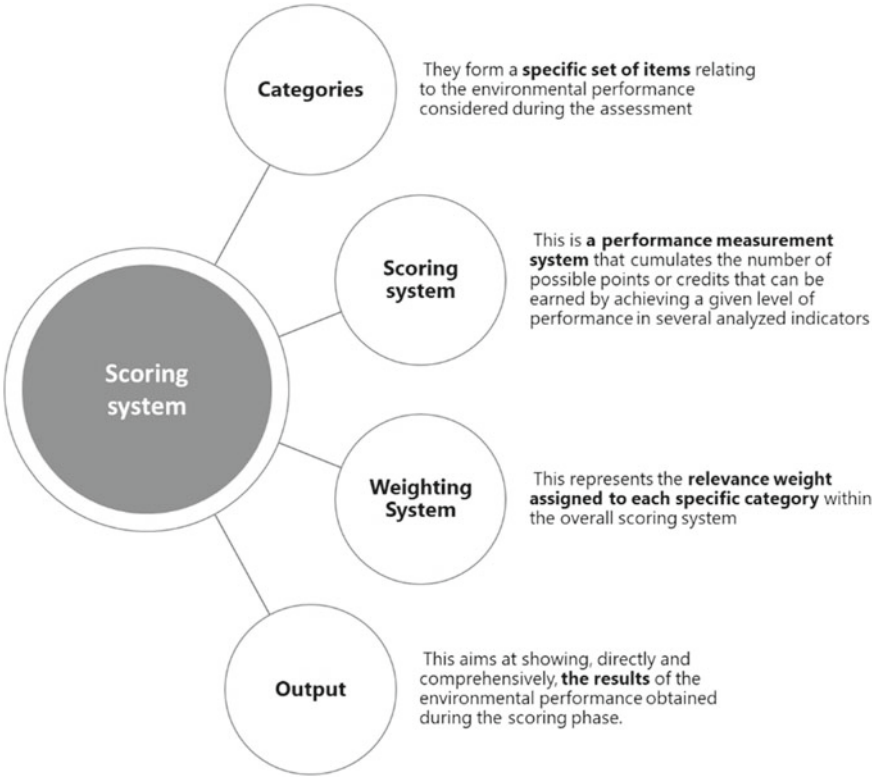

Fig. 1 Categorization of scoring system for grading. *Source* Author

End-users and other shareholders in the construction procedure benefit greatly from criteria and category-based assessment methodologies. They promote significant improvements in the building's overall performance, stimulate the adoption of construction solutions better suited to the building's intended use, and promote a better knowledge and communication of user needs. They also help integrate environmental, social, functional, and cultural problems more effectively than quantitative-based techniques like LCA [13].

2.2 Current Building Rating Systems

Building assessment methods are designed to address sustainability in various building categories, such as commercial or residential buildings, at various scales, ranging from a single building to a neighborhood, community, or an entire city [14]. According to Ali and Al Nsairat, the greenest building rating systems are BREEAM in the United Kingdom, CASBEE in Japan, LEED in the United States of America,

and GB Tool in Canada. However, these tools are frequently chastised for lack of understanding of economic and social issues; also, the sustainability criteria in some of the tools are not prioritized for decision-making.

With the launch of BREEAM in the 1990s, the notion of environmental green building evaluation rating and certification methodologies was established. As a result, several countries have realized the value of such a tool in supporting and providing additional perspectives to construction developers and other stakeholders in assessing their projects regarding sustainability and their development principles. The progress of building rating systems in terms of both measurable and qualitative components of sustainability has been considerable since the advent of BREEAM.

Green or sustainable building evaluation methods are now widely regarded as a critical component of long-term development in the built environment [11]. Many government and non-government organizations have suggested sustainable building assessment techniques throughout the world, including LEED (USA), CASBEE (Japan), and SB Tool (international), as well as Indian grading systems (GRHIA and IGBC). Domestic and international legislation and the business requirement for ecologically evaluated and sound goods have influenced these methodologies [15]. The evaluation techniques also adhere to the UN's three sustainability sectors and their goals.

The subsequent building grading systems were selected because they are widely acknowledged as the most known and trusted tools worldwide. Furthermore, the Indian green building rating system symbolizes the research case study's national rating system. These methods were examined to determine which elements and indicators had the most impact on the building's overall performance. A review of the obtainability and incorporation of socio-cultural indicators for sustainable development is also presented, along with helpful suggestions for improvement. Only residential strategies were evaluated in these rating systems' first and most recent editions. The study concentrates on well-known and well-respected methodologies that employ a qualitative methodology to examine both human and natural systems in the urban environment.

The Building Research Establishment created the Building Research Establishment Environmental Assessment Method (BREEAM) to establish best practices in sustainable design, construction, and management [16]. BREEAM employs a weighing and assessment methodology that includes comparing indicators to established standards and levels of performance and awarding credits in 10 categories. Each area includes several criteria, including pre-weighted points that might be cumulative or based on performance under EIA guidelines established by the UK government and the European Union. The evaluation scale is pass, good, very good, excellent, and outstanding, these credits are combined to generate a single overall score [16].

The valuation procedure in BREEAM is categorized into three stages aligned with pre-construction, like planning and design during the construction of new projects. The corresponding scores are obtained when a building is classified as a green building and passes or surpasses a baseline indication. The final BREEAM ratings are then used to determine the ranking grade. The max credit points are 150.

Evaluation stages are marked according to percent: Outstanding (≥85%), Excellent (≥70%), Very Good (≥55%), Good (≥45%), Pass (≥30%), and Unclassified (<30%) [16].

LEED, a third-party green building certification program, which is globally known and adopted for designing, constructing, and operating high-performance green constructions [17]. It started as an independent initiative by US Green Building Council in 1998 to evaluate and assess different types of buildings. LEED (Leadership in Energy and Environmental Design) is the globally widely used green building rating system. It was the Indian Green Business Center (IGBC), under the Confederation of Indian Industries (CII), that facilitated the LEED rating of the United States Green Building Council [17]. The certification is for all building types and phases, including new construction, interior fit-outs, operations and maintenance, and core and shell, and has also released some country-specific editions. The most recent LEED version, LEED v4.1, lifts the bar on construction requirements to consider energy efficiency, water conservation, site selection, material selection, daylighting, and waste reduction [17]. By combining the most relevant terminology from the BD + C and all other residential-focused grading systems with the goals of the residential market, it introduces a novel approach to residential projects. We have considered here the version specifically adapted for India. The LEED v4.1 Multifamily Residential grading system has four main objectives: establish leadership, make goals more attainable, track achievement, and grow the market [17].

The Japanese Sustainable Building Consortium created the Comprehensive Assessment System for Built Environment Efficiency. This approach may be used at different phases of a building's life cycle (design, new construction, existing buildings, and renovation projects) [18]. The CASBEE rating system for construction projects is distinct from other rating systems. It is accomplished via the use of a metric known as Building Environmental Efficiency (BEE), which is calculated as the ratio of two metrics: built environmental quality (Q) and built environmental load (BEL) (LRQ evaluates how the daily amenities for building occupants have improved within the perimeter of the virtual enclosed space. The negative aspects of environmental consequences that go beyond the immediate region are calculated by LR [14]. The three subcategories that make up the Q and LR scores, which range from 0 to 100, are determined using an assessment form. Each category (quality of service, on-site outdoor environment, internal environment, resources & material, off-site environment, and energy) has a corresponding weight [18]. Each category is given a score between one and five, with five representing the highest rating (the highest point of accomplishment). The score and rating can be shown in a variety of ways, giving users further options on how to use the data.

IISBE manages SB Tool, a software application of the Sustainable Building Challenge (SBC) evaluation technique, which has been developed as the Green Building Challenge procedure since 1996 by a consortium of 14 nations. SB Tool is unusual because it was built from the ground up to represent the many goals, technology, construction traditions, and cultural values of other areas and nations [14]. The SB Tool may be used for projects ranging from a single structure to a whole city and has been translated into various languages. Its approach allows for quickly adding local

criteria and language and adjusting indicator weightings based on areas of priorities and certain conditions [19]. Site selection, project planning and development, environmental loadings, energy and resource consumption, interior environmental quality, building system functionality and controllability, long-term effectiveness, and social and economic indicators are the seven factors that the tool examines. Individuals, society, and nature are pre-weighted in SB Tool, with values ranging from 1 to 5 [19].

The Ministry of New and Renewable Energy, Government of India, and TERI developed GRIHA in 2005. It recognized the Green Rating for Integrated Habitat Assessment (GRIHA) as India's national rating system in 2007 for any finished structure [20]. It is a tool for assessing and rating a building's environmental performance. GRIHA v.2019 certifies all new construction projects with a built-up area of more than 2500 m^2 (excluding parking, basement area, and typical facilities). The projected outcomes determine a structure's worth on its lifespan [20]. It is a three-tiered green building design evaluation method in which facilities are graded. The 34 criteria of the GRIHA grading system are divided into four sections: site selection and planning, resource conservation and efficient use, building operation and maintenance, and innovation. This version has considered user input, improved ease of implementation and acceptance, and other factors not considered in earlier editions [20].

GRIHA's goals align with the realization of SDGs, especially those that affect the scope of sustainable building development. GRIHA integrates various relevant Indian construction, energy, water, materials, and waste management codes to act as a tool to promote the implementation of these codes. Griha v. 2019 is divided into ten environmental parts, further subdivided into 29 standards, covering all the necessary parameters that must be considered when creating a "green building." The additional part of "innovation" is the rating system, which rewards project teams that make more effort to achieve environmental and social sustainability.

SVAGRIHA is designed as an extension of GRIHA and is specially developed for projects with a floor area of less than 2500 m^2. SVAGRIHA can help plan and evaluate individual apartments, small offices, schools, motels, and commercial buildings. The evaluation includes only 14 standards, and the interface consists of a simplified calculator [20].

Envisioned in 2007, the Confederation of Indian Industry (CII) with the Indian Green Building Council (IGBC) created an exclusive rating system focusing on the design of green homes and launched it in 2009. The council provides various services, including creating a new green building rating system and certification services [21]. The rating system was created to address national concerns and stimulate dwellings, including traditional Indian architectural techniques and current technological advancements. Green new/existing buildings, green residential societies, and green residences are included in the IGBC Green Building Rating Systems. It is a voluntary and consensus-based approach that helps buildings become more efficient and environmentally friendly [21].

Green Homes, developed by the Indian Green Building Council (IGBC), is the first rating system designed specifically for the residential sector in India [21]. It is

founded on well-established energy and environmental principles and balances well-established procedures and new ideas. The system is intended to be both comprehensive and straightforward to use. Site Selection and Planning, Water Conservation, Energy Efficiency, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process are all covered by the IGBC Green Homes rating system. The International Green Building Council (IGBC) has also created a green building rating system for Affordable Housing and Green Residents [21].

Since 1990, standards and rating systems have been extensively developed to assess the environmental performance of green buildings. This section explored a few green building rating systems from developed and developing countries. Table 1 displays a brief about all these systems. These systems have been analyzed in detail based on their context, guidelines, weightage of indicators, socio-cultural indicators, terminologies, stakeholder participation, and user involvement.

3 Discussion

3.1 Weightage of Criteria

The current green building rating system greatly influences environmental aspects like energy, resources, site context, and similar categories with multiple terms in different rating systems. The intangible aspects of social and cultural indicators are not considered while building these systems. The most commonly targeted sectors amongst all assessment methods are environmental, the most dominated, water management, energy, material, and resources. Over fifty percent of the criteria in these methods depict environmental aspects.

3.2 Existence of Socio-cultural Indicators

The assessment methods studied here have not taken social and cultural indicators in their system to a considerable extent. The health and well-being aspect of the user is also restricted. These aspects' intangible nature limits the applicability and hence is isolated. The tools analyzed in the study do not consider a related approach towards adopting social and cultural indicators w.r.t. to user needs and sustainable development. Non-environmental aspects considered in the methods mainly focus on socio-economic concerns like transportation, access to amenities, other services, and safety. A construction project might receive a sustainability certificate under existing assessment techniques without fully considering sustainable development features. Furthermore, when cultural and social sustainability are recognized as pillars of sustainable development, none of the developed methods has made cultural indicators an obligatory criterion. More focus should be placed on tying environmental practices

Table 1 Overview of the rating systems

Name	**BREEAM**	**CASBEE**	**SB-Tool**
Developed by	Build research establishment (BRE)	Institute for building Environment and Japan sustainable building consortium (JSBC) and energy conservation (IBEC)	International initiative for sustainable built environment (iiSBE)
Origin	United Kingdom	Japan	International
Method of evaluation	Checklist on excel	Technical guideline excel sheet and software	Software and excel tool
Stages of evaluation	Building and neighborhood-scale. Applicable for new, refurbished, and existing buildings	Building, neighborhood, district, and city level. Applicable for new and existing buildings	New, refurbished, and existing buildings
Assessment method	Pre-weighted categories	BEE ranking chart built on ratio ranking	Logarithm-based weighting system
Categories and weightage	Governance-8, Resources and energy-47, transport and movement-158 Land use and ecology-18, Social and economic well-being-31	The tool has a total of 80 sub-criteria, divided into two main clusters: environmental quality and environmental loadings, shown as Q and L. The final score is calculated as BEE = EQ/EL	Site selection and project planning & development-8, Social & economic aspects-5, Energy and resource consumption-21, Cultural & perceptual aspects-5, Indoor environment quality-21, Environmental loadings-25, Service quality-15
Performance rating	Outstanding = >85% Excellent = 70–84% Very good = 55–69% Good = 40–54% Pass = 25–39%	Poor: BEE < 0.5 Fairy Poor: BEE = 0.5–1.0 Good: BEE = 1–1.5 Very good: BEE = 1.5–3; or BEE $\geq$ 3 and Q < 5 Excellent: BEE $\geq$ 3 and Q $\leq$ 5	−1 Poor 0 1 3 5 Excellent
Name	**LEED**	**GRIHA**	**IGBC**
Developed under	United States Green Building Council (USGBC)	Ministry of new and renewable energy (MNRE)	The Energy and Resources Institute (TERI)
Origin	USA	India	India
Method of evaluation	PDF guideline book and excel checklist	PDF guideline book and excel checklist	PDF guideline book and excel checklist
Stages of evaluation	Multifamily Midrise or BD + C residential project	All new construction projects (multi-dwelling units) with a built-up area >2500 m^2	Individual and multi-dwelling residential units

(continued)

Table 1 (continued)

Assessment method	Pre-weighted categories	Pre-weighted categories	Pre-weighted categories
Categories and weightage	Integrative process-1, Location and transportation-15, Sustainable cities-10, Water efficiency-12, Materials and resources-13, Energy and atmosphere-34, Indoor environmental quality-16, Innovation-6, Regional priority-4	Sustainable Site Planning-12, Construction Management-4, Energy Efficiency-18, Occupant Comfort-12, Water Management-16, Solid Waste Management-6, Sustainable Building materials-12, Life cycle costing-5, Socio-economic strategies-8, Performance metering, and monitoring-7, Innovation-5	Sustainable design-20, Water conservation-23, Energy efficiency-20, Materials and resources-18, Resident Health & Wellbeing-14, Innovation & design-5
Performance	Four level certification (Certified/silver/gold/ platinum)	25–40* 41–55** 56–70*** 71–85**** 86 or more*****	Four level certification (Certified/silver/gold/ platinum)

to inhabitants' social and cultural well-being and requirements since this is a critical issue for the housing project's long-term viability.

3.3 Involvement of Users and Residents

Users and occupants can be involved when ideating the indicators for assessment and determining the criteria to be considered. Citizen and community initiatives, according to James [3], give innovative and transferable solutions to intractable social and environmental problems. Users can also take part in the weighting of several factors. Building assessment can be improvised using a consensus-based weighting system for distinct categories. Architects and developers can utilize user feedback by considering their input and determining whether suggested changes are necessary to match economic development and social demands.

3.4 Stakeholder Contribution

The analyzed tools only consider taking an expert opinion (professionals, consultants, academicians) while selecting criteria and incorporating weightage. User involvement is not considered in tools w.r.t. weightage and feedback process. The user's interest in the tool's development is not considered. It can be observed that the user's

involvement cannot be seen during the assessment period at any developing stage: pre-construction, developing phase, or post-occupancy.

3.5 Adaption to the Local Context

The current systems were developed to provide a generic approach to sustainability assessment. These systems do not consider local or regional context while adapting the method. Few focus on the local materials and technologies, but a more prominent strategy is still needed to encourage the utilization of locally accepted methods. Innovation is one standard indicator seen across all tools, which can be ideated to incline toward local innovation strategies.

4 Conclusion

This study analyzes six sustainable building assessments regarding their origin, criteria, processes, weighting, performance, and sustainability indicators. We can see that the sustainability metrics indicated in these tools have various priorities depending on context and country, particularly in developing countries. On the other hand, sustainable building grading tools are similar because they usually consist of optional criteria. The process of selecting standards and assigning weighting is frequently subjective as well. Although current sustainable building assessment methods include a mix of quantitative and qualitative indicators, they prioritize environmental and physical aspects over socio-cultural factors.

The ideas and standpoints on socio-cultural components are still included in understanding the vernacular and traditional approach of the society, their needs, and context. The compatibility of the strategy implemented to achieve sustainability is not considered/given much attention based on the regional and local context of the residents. These strategies receive furthermore little consideration when it comes to developing countries. The analysis indicates a lack of balance across various sustainability characteristics. This disparity suggests that the problem of integrated sustainability has yet to be adequately communicated within the developed framework for building assessment. The indicators directed towards environmental aspects continue to outnumber other, less physical elements. While tangible indicators are essential for accomplishing environmental sustainability goals, other indicators and their importance in achieving intra-generational and social fairness have been disregarded. The usability and utility of generalizing tools in many contexts and regions are also recurring challenges in sustainable building assessment methodologies.

A more customizable evaluation tool is still needed to satisfy geographically particular environmental, social, or cultural goals. Experts and specialists responsible for determining the indicators must consider local norms and strategies to

encourage community participation and development. User and resident interaction is also encouraged in identifying the indicators.

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