

Title: Revitalizing traditional knowledge: Living Root Bridge as a Biome

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Abstract: Living root bridges are *Ficus elastica*¹ based bridges within dense tropical rainforests of Meghalaya in North East India. Grown by indigenous Khasi² tribes, these bridges endure extreme environmental conditions and last for several centuries with positive remedial impact on the environment. With 1) minimal cost, 2) community based participatory growth process, 3) high robustness³, 4) support to other biota, and 5) keystone⁴ role of *Ficus* specie, living root bridges exemplify a unique relationship between human beings and nature. These bridges offer an extraordinary opportunity to apply traditional living plant based knowledge for sustainable community-based development and entrepreneurial solutions. Despite these attributes, living root bridges are being replaced by inappropriate solutions owing to the nexus of population explosion, poverty and environmental degradation. This paper highlights the value of combining conservation, research and entrepreneurship for revitalizing traditional knowledge, and proposes a socio-scientific-entrepreneurial framework to adapt living root bridges as a biome for growing orchids, food and medicine. By aligning *Ficus* ecology with local development needs the project merges economy with ecology. To demonstrate the potential of living root bridge technology the author proposes a state-wide rural connectivity, conservation, education and livelihood project.

1. Introduction

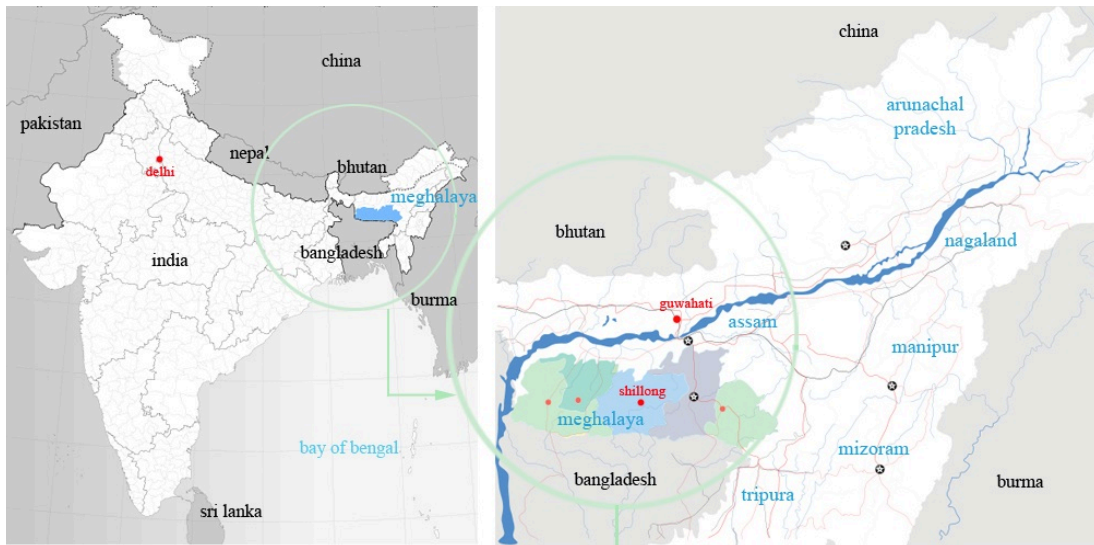


Fig. 1: Location diagram of living root bridges

The indigenous Khasi tribes of Meghalaya demonstrate a high degree of self-sufficiency and resilience⁵. This is partly owing to their remote location and distinctive environment⁶, which has led to numerous sustainable practices based on shared and purposeful cooperation. Relevant systems include the practice of sacred groves⁷, classification of land and forests⁸, a village-durbar based local governance method, and laws of inheritance and kinship. In addition, a unique eco-theandric⁹ vision of reality contributes to a sacred relationship between Khasi tribes and nature, instilling deep interconnectedness between all living and non-living beings. These traditional knowledge systems and management practices offer a compelling opportunity to learn and develop novel sustainable solutions for the contemporary context: solutions, which combine ancient wisdom with contemporary needs to create hybrid solutions.



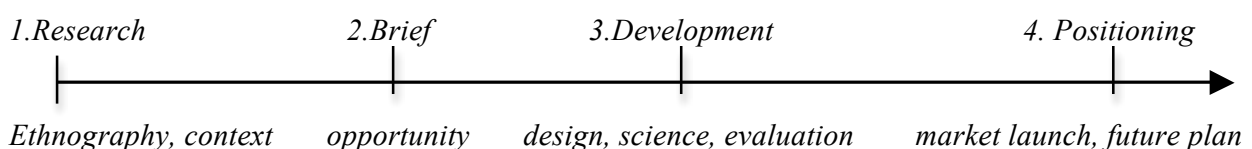
Fig. 2: Khasi tribes and living root bridges of Meghalaya

Khasi tribes' sacred relationship with the natural environment is exemplified in the living root bridges of Meghalaya (Fig 2). Locally known as *jing kieng jri*, this indigenous horticultural technology uses *Ficus elastica* aerial roots to grow bridges across rivers and streams. The underlying growth process uses locally available plant based material, local tools, and local community based expertise involving men, women and children across multiple generations.¹⁰ Key attributes include low cost, high robustness, remedial impact, carbon sequestration, and support for other biota. Key benefits include a deep awareness about interdependence between human beings and nature, rainforest regeneration, riverbank protection, biodiversity protection and soil quality improvement.

Despite these attributes living root bridges are undervalued as a contemporary infrastructure solution and being replaced by inappropriate solutions owing to its long gestation period, low safety during early growth stage, need for suitable conditions (soil, water, sunlight and nutrients), and need for a sensitized local community. In addition, the nexus of population explosion, poverty and environmental degradation, poses multiple challenges from a rural development perspective and necessitates innovative adaptations of traditional knowledge. The author proposes a socio-scientific-entrepreneurial project to study, improve and adapt these bridges as a biome for growing food, medicine and orchids. This will eventually align *Ficus* ecology with economic needs of the community and transform the potential application of this knowledge. Further implementation of this technology for a state-wide rural connectivity, conservation, education and livelihood project is envisioned to demonstrate its potential benefit at a regional scale.

2. Revitalizing traditional knowledge

The author proposes a convergent strategy by connecting the domains of 1) conservation, 2) scientific research, and 3) grass root entrepreneurship to revitalize traditional knowledge. This strategy would result in critical exchange of knowledge, resources and expertise across three complementary domains, and result in a robust solution, which is informed by different viewpoints and perspectives. In addition, this strategy would create links between past and present, thereby creating authentic solutions with local communities in a symbiotic, participatory and immersive method. Resultant solutions will respond to the current context and ensure knowledge transmission to the next generation. Three related case studies, which have explored this convergent strategy for the traditional craft of weaving are highlighted here. The first case study demonstrates the revitalization of traditional Kolhapuri leather footwear making by systematic and deliberate combination of handcraft with machine craft for a new bi-cultural product category (Fig 3). The hybrid product language combined semantic and syntactic elements from contemporary sports footwear with traditional chappals for the contemporary user. The project developed through collaboration between Toehold artisans cooperative in Athani, Karnataka and Indian Institute of Technology Mumbai¹¹. Research involved addressing concerns related to comfort, ergonomics, customization and product market. Current annual turnover of the 200 artisan cooperative is \$1 million. The second case study demonstrates revitalization of natural fiber weaving with Cane Concepts in Dimapur, Nagaland. Local skills, natural materials and indigenous sense of beauty inspired the process and product range. A series of lamps and furniture solutions were developed through hands-on experimentation, demonstrating natural colour application, alternate material options, new morphologies and the benefit of standardisation, efficiency and packaging (Fig 4)¹². In the third case study, traditional timber louver was used as a reference to develop a low cost tropical building technology with Flying Elephant Studio in Bangalore (Fig 5). A four stage iterative process informed by periodic feedback was followed in all three cases as listed below.



This iterative process can be used for revitalizing traditional knowledge across all domains, industries and scales. It is important to highlight that revitalizing traditional knowledge requires sensitivity and commitment from a social and scientific viewpoint. Inspiring local communities to experiment is faced with stiff resistance in the early stages. This changes gradually with hands on experimentation, a deepening relationship and blurring of boundaries between the innovator and the

maker. With time, the new identity echoes a transformational journey from past to present, and offers a new sign of hope for the maker and the tradition.

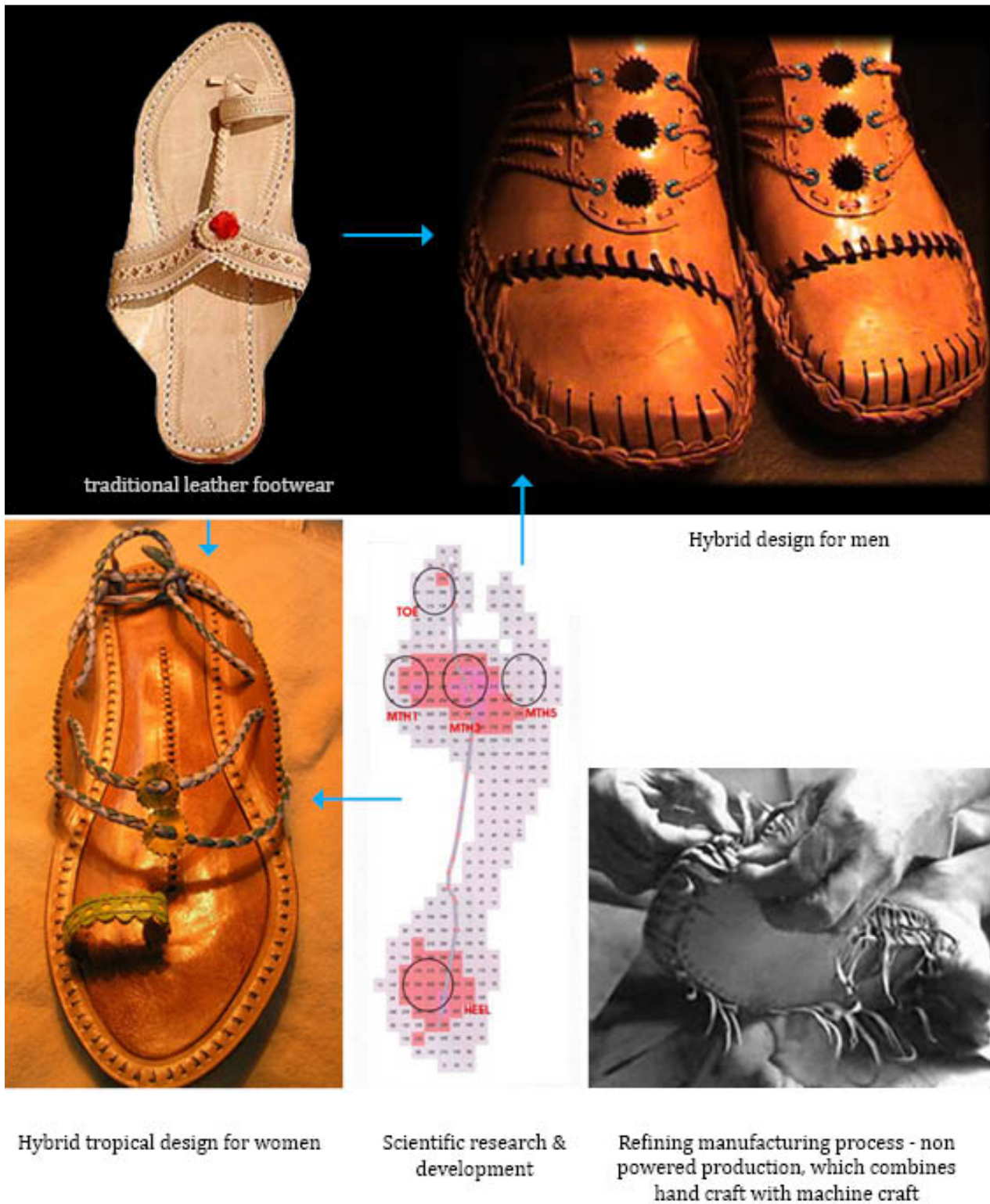


Fig 3: Bi-cultural hand made leather footwear, Athani and Mumbai

This hybrid product category assimilated processes from modern sports footwear and traditional hand-woven leather slippers from India. A transformatory product and material language was developed, to systematically merge handcraft with machine craft.



Basket weaving in bamboo & ratan



Local grass developed as an alternative material option



Locally available, natural herb based colouring technique developed and applied for new designs to create new community based grass root entrepreneurial opportunities

Fig 4: Natural fiber weaving research and development, Dimapur and Mumbai

This project focused on three interconnected research domains: materials, morphology and structure. The material research developed alternative material options with colours using local herbs. The morphology developed new forms using moulds and alternative sources of energy. The structural research leveraged weaving as a performative feature, which provides strength to the overall form and plays a critical role in furniture making.



*Fig 5: Pressed woven bamboo research for tropical building façade technology, Bangalore
This building technology development project leveraged traditional bamboo basket weaving and timber louvers to develop a low-cost building façade technology for mainstream use*

3. Revitalizing Living Root Bridge technology

3.1 Conservation

The author proposes a precise survey and ethno botanical study of all living root bridges in Meghalaya. Findings from this investigation will create a reference for subsequent research and development, and highlight grass root entrepreneurial opportunities. This survey will also reveal the local communities relation with these structures and the current status of the bridges to define the overall scope of conservation challenge and corresponding action needed. It is important to highlight that preservation and protection of existing living root bridges is critical for scientific research and development since existing bridges are test beds for measuring the performance of these structures, and their impact on the surrounding environment. In addition, in-situ research is envisioned as part of the scientific investigation to test its bridge performance under various conditions.

3.2 Research and development

An accurate scientific investigation of the living root bridge technology will need expertise from the fields of social science, material science, environmental science, plant science, bridge engineering and architecture. The author proposes a transdisciplinary research consortium to realize this study. Key areas of scientific research include study of the growth and physiology of *Ficus elastica* aerial roots and their symbiotic relationship with the environment. Key areas for scientific improvement include accelerating the overall bridge growth process and increasing safety of the bridge during early stages.¹³ Specific areas of scientific and entrepreneurial experimentation include testing this technology for other tropical plant species, e.g. *Ficus benghalensis*, and adapting it as a biome to grow orchids, food and medicine.



Fig. 4: Trans-disciplinary research consortium connecting botany, ecology, material science, structural and civil engineering, social science, environmental science and architecture

3.3 Grass root entrepreneurship



Fig 5: Orchids, mushrooms and butterflies growing on Living Root Bridge

Creating ecology based grass root entrepreneurial opportunities is critical for a self-sustaining development model. Living root bridges perform as pedestrian bridges for remote mountain villages and offer novel plant based entrepreneurial solutions. Aligning rural development and local economy with *Ficus* ecology through adapting the bridge as a biome for orchids, medicine and food for humans is proposed as a solution. Based on local climate, local horticultural knowledge and authors' observations of the flora and fauna on the living root bridges (Fig 5), these bridges can be used for growing various medicinal plants, aromatic plants, fruits, spices and vegetables. Preliminary discussions with local communities and representatives from Meghalaya Basin development authority¹⁴ have highlighted possible success of this vision. Potential products, which can be tested, include black pepper, areca nut, ginger, cashew, mushroom and mandarin. In addition, these bridge ecosystems can be tested for producing honey and silk (Fig 6). Other allied plant based industries, e.g. cosmetic industry, can emerge through such initiatives. A precise ethno botanical as suggested under the conservation agenda would reveal the value and potential of these bridges. Leveraging the living root bridge technology for ecology-based trade can contribute to socio-economic development. It is important to highlight that defining resource thresholds is important for long-term sustainability of this vision. Other entrepreneurial interventions discussed with local stakeholders include redesign and widening of the bridge to support non-powered

vehicular movement, potential adaptation of the *Ficus* aerial root inosculation method for creating furniture, lamps and fences, and creating a green infrastructure and design cooperative, which offers ‘living plant’ based development solutions to other tropical and sub-tropical regions.

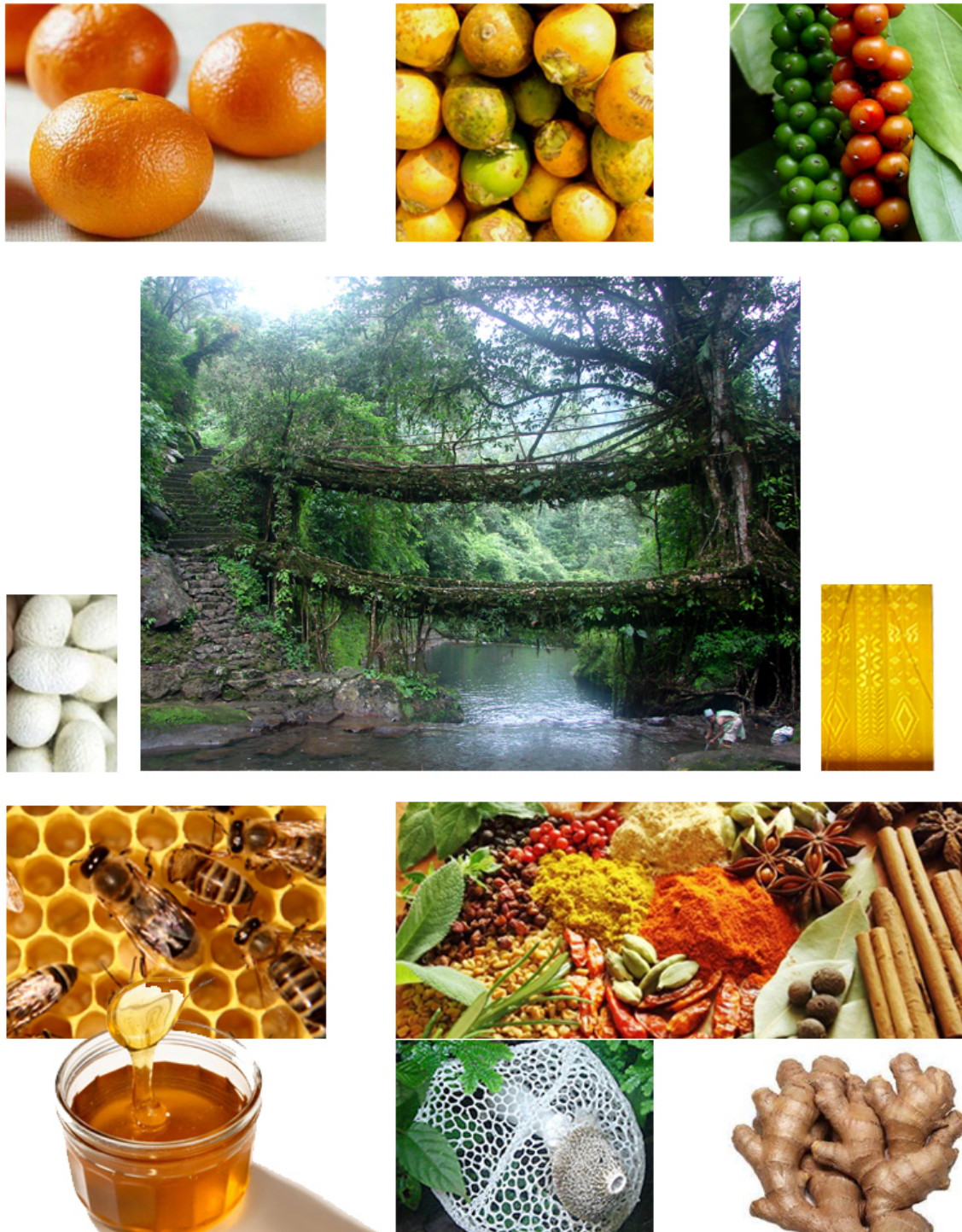


Fig. 6: Living Root Bridge as a biome for food, herbs, spices, medicine, silk and honey

3.4 Transdisciplinary consortium

The author proposes establishing a research, demonstration and experimentation field station in Riwai village located along the Indo-Bangladesh border in East Khasi Hills of Meghalaya. The station will perform as a key link between indigenous communities and members from the fields of

conservation, scientific research and entrepreneurship (Fig 7), and allow seamless exchange and collaboration. Riwai village has a mature living root bridge, which is a critical infrastructure link and is maintained by local communities. Tourists visiting Mawlynnong village visit this bridge and contribute to local economy. This field station will also act as a demonstration station to implement the state-wide rural connectivity, conservation, livelihood and education project. Stage one of the rural connectivity project will focus on propagation and appropriate plantation wherever necessary of *Ficus elastica* along streams and rivers situated in south- and north-facing mountain slopes of Meghalaya near inaccessible villages with a strong community structure. Priority will be given to poverty-stricken, environmentally degraded and vulnerable regions prone to flash floods, storm surges and high soil erosion. Eventually these plantations will be nurtured and grown to perform as robust, fertile and productive river crossings (Fig 8). Successful implementation of this project will ensure livelihood promotion, forest regeneration, riverbank protection, biodiversity protection and soil quality improvement along the river network.

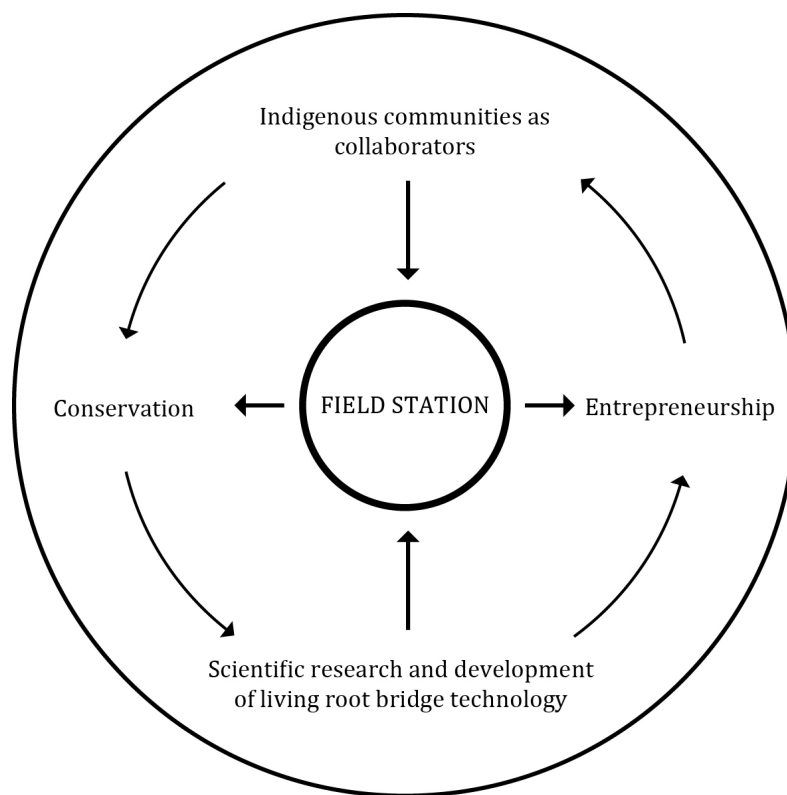


Fig. 7: Field station performing as a link

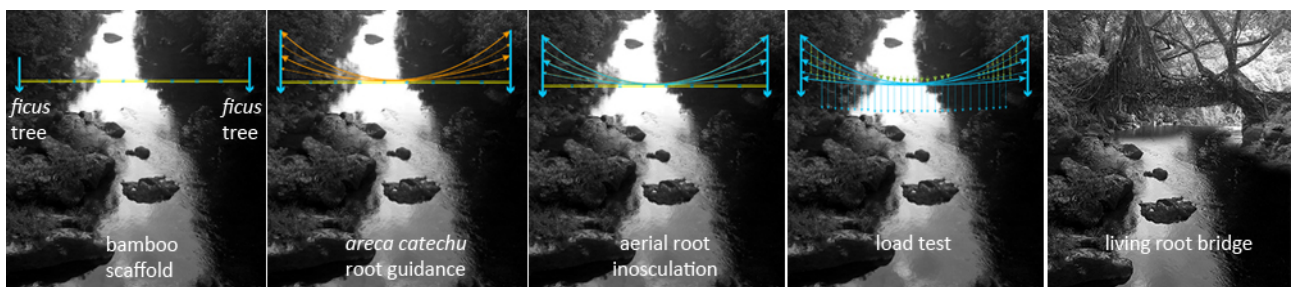


Fig. 8: *Ficus elastica* plants grown into productive living root bridges in a state-wide rural connectivity, conservation, livelihood and education project

Potential scientific research partners in the transdisciplinary consortium include North Eastern Hill University Shillong, Indian Institute of Science Bangalore and Department of Science and Technology Delhi. Possible conservation partners include Himalayan Environmental Scientific

Conservation Organization, Ashoka Trust for Research in Ecology and the Environment, Nature Conservation Foundation Mysore, The International Union for Conservation of Nature Delhi, Aaranyak Trust and Samrakshan Trust. Meghalaya state forest department and Meghalaya Biodiversity Board is proposed as a key partner in this project and Indian Institute of Management Shillong is anticipated as an entrepreneurship partner. Meghalaya Basin Development Authority has expressed interest to anchor the project locally (Fig 9).

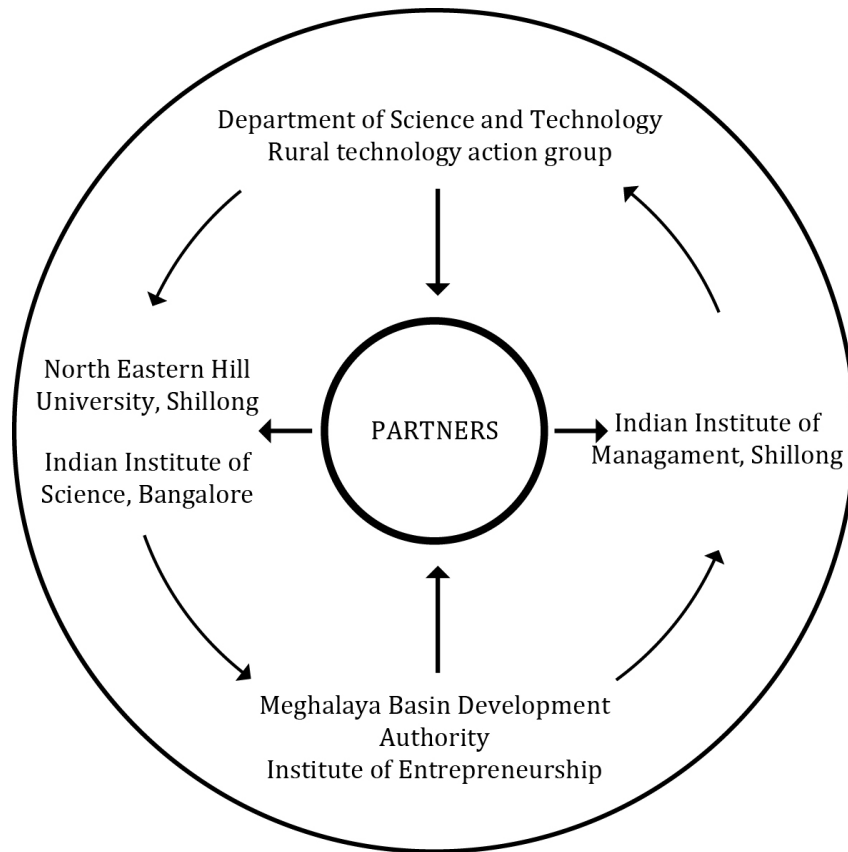


Fig. 9: Transdisciplinary collaboration



Fig. 10: Local communities of Meghalaya

4. Concluding remarks

This paper proposes a convergent strategy and vision for revitalizing traditional knowledge and propagating the living root bridge technology. It highlights the potential of radical innovation and inclusion to balance individual economic needs with collective ecological needs. Successful realization of this vision would transform local community members into ‘green engineers and entrepreneurs’ who will grow living plant based structures in other tropical regions and nurture a sacred relationship between humans and nature. Living root bridges and khasi tribes can inspire a healthy and symbiotic future, which restores the balance between humans and the environment.

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6. References

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- [5] Resiliency is the ability of a system to adapt to external disturbances. <http://www.stockholmresilience.org/21/research/what-is-resilience.html>
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