Title: Revitalizing traditional knowledge in North East India by combining conservation, research and entrepreneurship: Living Root Bridge case study

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Abstract: Living root bridges are *Ficus elastica*[1] based bridges within dense tropical rainforests of Meghalaya in the North East India. Ranging in span from 15 feet to 250 feet, these bridges are grown by Khasi[2] tribes over a time period of 15 to 30 years, and last for several centuries. With 1) exceptional robustness[3] under extreme climatic conditions, 2) minimal cost, 3) progressive increase in load-bearing capacity, 4) carbon sequestration, 5) remedial properties on surrounding soil, water and air, 6) collective grass root involvement based on human-plant interaction, 7) support to other plant and animal systems, and 8) keystone[4] role of *Ficus* plant species in local ecology, living root bridges offer an extraordinary opportunity for revitalizing traditional living plant based knowledge to ensure long term socio-ecological resilience[5] for tropical regions. Despite these attributes, living root bridges are being replaced by inappropriate solutions owing to increasing resource needs, lack of awareness and the nexus of poverty, population explosion and environmental degradation. The author highlights the value of combining conservation, research and entrepreneurship for revitalizing traditional knowledge, and proposes a socio-scientific-entrepreneurial framework to adapt these bridges as a source of food, medicine and nutrition for local communities.

1. Revitalizing traditional knowledge in North East India

North East India represents an eclectic mix of cultures and beliefs, which show immense wisdom in their understanding of the environment and its contribution to a society's survival and well-being. As a collective society, which is gradually transforming and integrating with the mainstream, it presents a unique context for studying ancient practices and developing ingenious hybrid solutions, which are inclusive, authentic and sustainable. By integrating different viewpoints and balancing individual needs with the needs of a community, the author proposes a mergence of ecological and economic concerns, and developing solutions together with local communities in a non-hierarchical, symbiotic, participatory and immersive manner. Here traditional knowledge and contemporary thought will be given equal value, and solutions will develop through rigorous field tests and objective analysis. The author proposes a three-pronged approach to work with traditional knowledge, which focuses on 1) conservation, 2) scientific research and development, and 3) grass root entrepreneurship. Connecting these domains (Fig 1) will create a fertile ground for traditional knowledge to grow and adapt in response to changing realities at a local, regional and global level. Adopting these fields as essential pillars for working with cultural heritage and ancient wisdom will lead to novel solutions, which are resilient and representative of different sections of society, and allow transmission of this knowledge to younger practitioners.

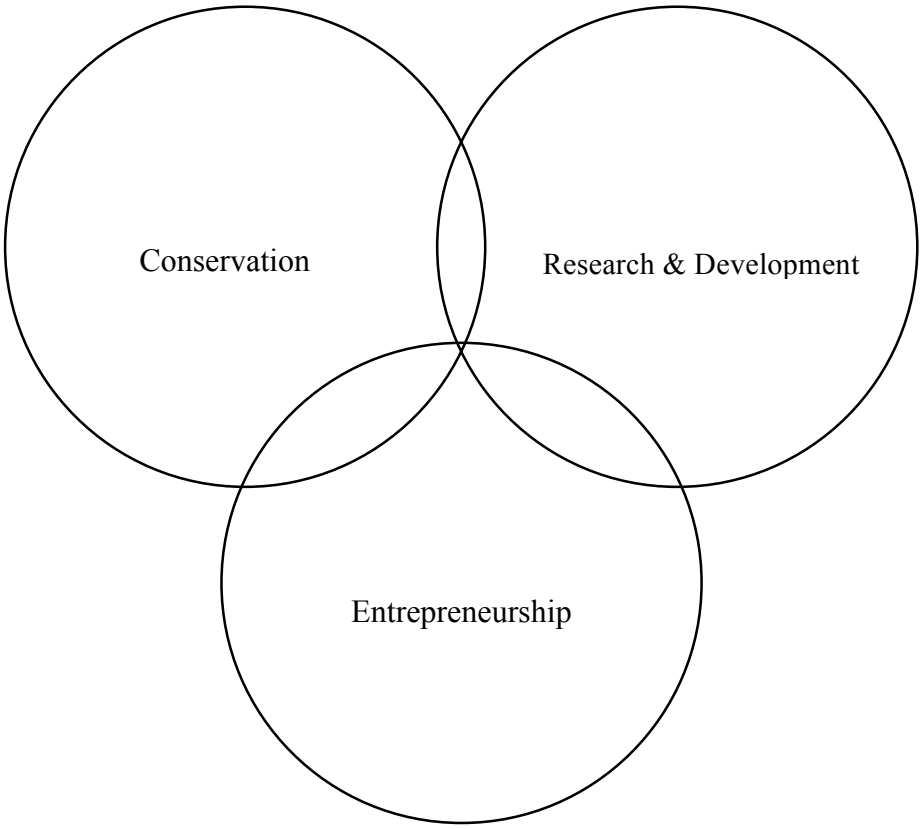


Fig. 1: Pillars for working with traditional knowledge

2. Living Root Bridges

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

Indigenous Khasi tribes (Fig 2) of Meghalaya are viewed to be an offshoot of the Mon-khmer branch of the Austro-Asiatic stock and are believed to be due remnants of the first Mongolian overflow into India.[6] Demonstrating a high degree of self-sufficiency, which in part is owing to their remote location and distinctive environment[7], Khasis have developed numerous sustainable practices based on collective and planned cooperation. Through an elaborate attempt to balance individual needs with the needs of the larger community, they have nurtured an ecosystem, which acknowledges the interdependent and interconnected nature of all life. Relevant systems worth highlighting include the practice of sacred groves[8], coherent classification of land and forests[9], an independent village-durbar based system of governance, an eco-theandric[10] vision of reality, laws of inheritance and succession, and laws of consanguinity and kinship. These ecology related management practices are an indispensable part of Khasi life and critically contribute to resiliency within the community.

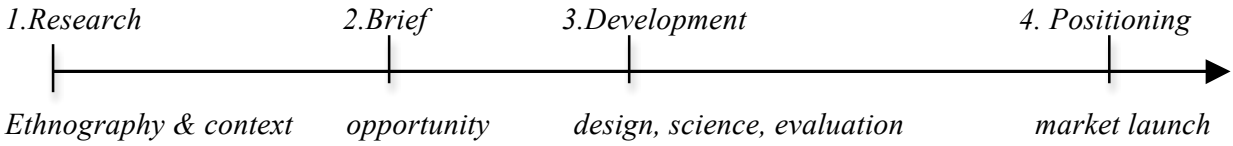
Khasi tribes' intimate and symbiotic relationship with their natural environment is epitomised in the living root bridges of Meghalaya (Fig 2). Locally known as *jing kieng jri*, this indigenous technology uses the aerial roots of *Ficus elastica* to grow bridges ranging in spans from 15 feet to 250 feet over a time period of 15 to 30 years. Situated in heavily forested and wet places, which are prone to flash floods and storm surges, the underlying growth process of these plant-based systems involves nurturing the aerial roots of *Ficus elastica*, and guiding them across rivers and streams. The supporting horticultural technique uses locally available plant based material, local tools, and community based expertise.[11] Key advantages of the living root bridges include low cost, high robustness, remedial impact on surrounding environment, carbon sequestration, community involvement in the growth process, progressive increase in load bearing capacity, and support for other plant and animal systems. Despite these attributes living root bridges are being replaced by inappropriate solutions owing to its long growth phase, low safety during initial growth stage, need for appropriate growth conditions (soil, water, sunlight and nutrients), and a sensitized community support for nurturing its growth and maintenance. In addition, the nexus of poverty, population explosion and environmental degradation in North Eastern India, poses complex challenges from a development viewpoint and highlights the need for adapting this traditional knowledge. The author proposes a transdisciplinary socio-scientific-entrepreneurial research framework to understand, improve and adapt these bridges for local needs. By aligning local economy and rural development requirements with *Ficus* ecology, the author proposes to use living root bridges as a source of food, medicine, nutrition, and other plant and animal based allied products for all round development and well-being.

2.1 Conservation

Preservation and protection is the first step in a sequence of successive measures required for working with traditional knowledge. This creates a reference for all subsequent action. In the context of North East India this stage assumes critical importance owing to rapid changes occurring across all domains of the society. With specific reference to ecology related practices, conservation assumes high priority owing to the inherent nature of a living ecosystem. Once lost or damaged, remediating and restoring such ecosystems to their original performance is a challenge. Old growth forests and sacred groves are a key reference in this context. In the case of the living root bridges, the author proposes a state-wide mapping, ethno botanical study to reveal the current state of these bridges, their overall performance, and the local communities relation with these structures. This will lay a foundation for evaluating the scale of the conservation challenge and facilitate an appropriate local strategy. It will also reveal critical insights for scientific research and development.

2.2 Research and development

Working with traditional knowledge requires a precise understanding and assessment of the process and product. Well-informed immersive research has the potential to alter the way we 'see' and 'value' a process or a technology, and create superior solutions, which lead to all round development. The team has to find a critical balance between the 'old' and the 'new', and celebrate aspects, which demonstrate potential, and in turn therefore sacrifice other aspects, which do not contribute to the overall performance. It is essential to work with a sense of innovation and experimentation to develop solutions, which respond to current needs and realities of the society. Another aspect of working in this context is accepting that 'identity' is a rational and dynamic phenomenon. Identities, people, products, perceptions and beliefs are always in a state of flux and this constant change is essential for growth of a system. In order to respond to contemporary concerns and opportunities, and to apply traditional knowledge and skills, the communities must develop a sense of openness and balance between past and present. The author would like to highlight two research and development case studies from Nagaland, which explored a new product range and application for the traditional craft of weaving (Fig 3 and Fig 4). Developed with the indigenous Angami tribes of Khonoma and Dimapur, the development process was inspired by local skills, natural materials and indigenous sense of beauty. In the first case (Fig 3) a new range of lamps were developed through experimentation, which focussed on developing natural colour based process, and alternate material options (kona grass). In the second case (Fig 4), traditional timber louver was used as a reference to develop a low cost tropical building technology. A four stage iterative process informed by periodic feedback was followed in both cases as listed below. This process can be used for revitalizing traditional knowledge across all domains, industries and scales.



It is important to highlight that revitalizing traditional knowledge requires extraordinary sensitivity and commitment from a social and scientific viewpoint. The underlying processes have evolved over an extended time period and reached a state of equilibrium, and changing this requires absolute dedication. Inspiring local communities to experiment and improvise is faced with stiff resistance in the early stages, where the results are not immediate. This however gradually changes 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.

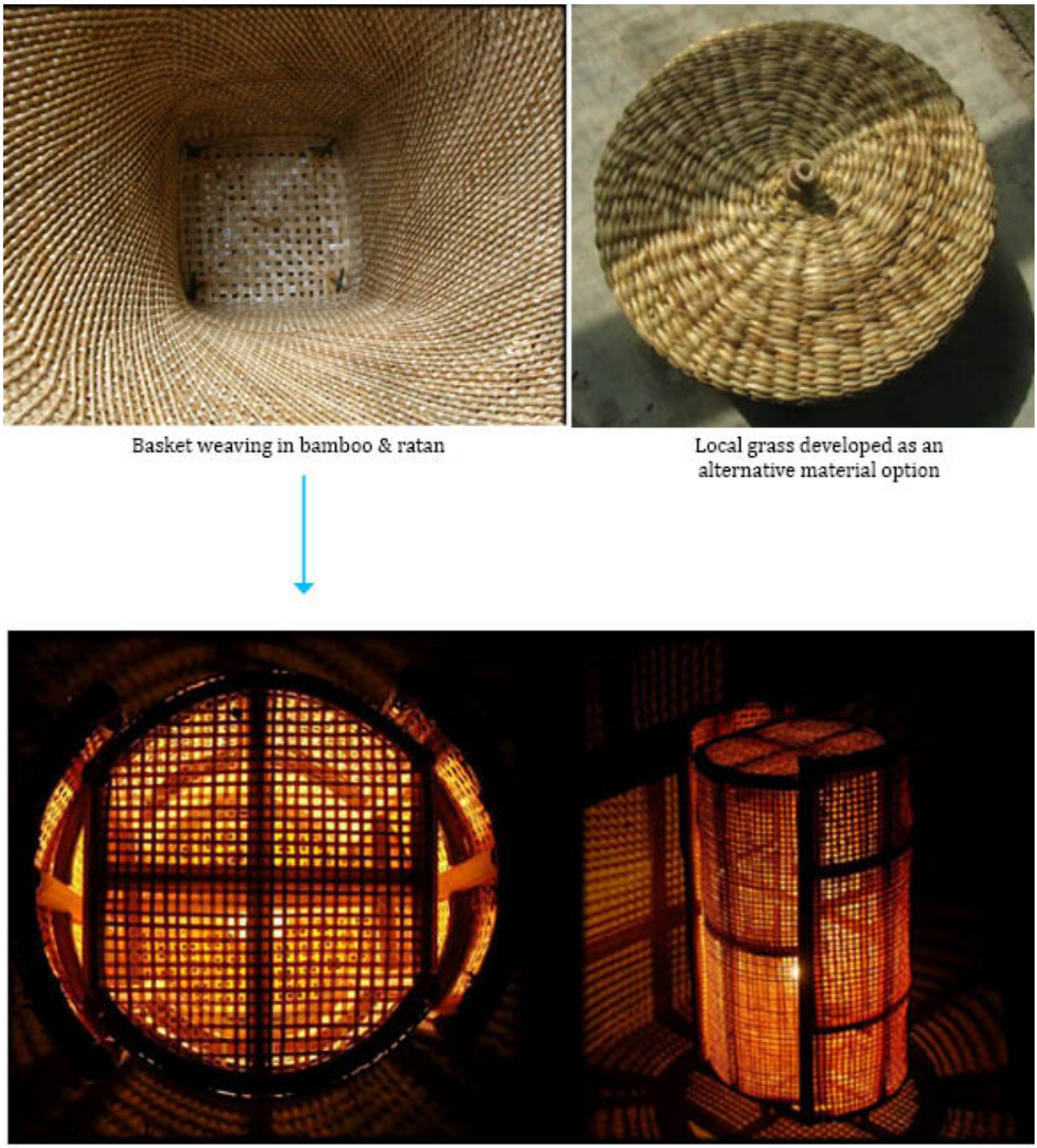


Fig 3: Natural fiber weaving research and development, Nagaland

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. Please see link for further details: http://www.sanjeevshankar.com/cane2.htm

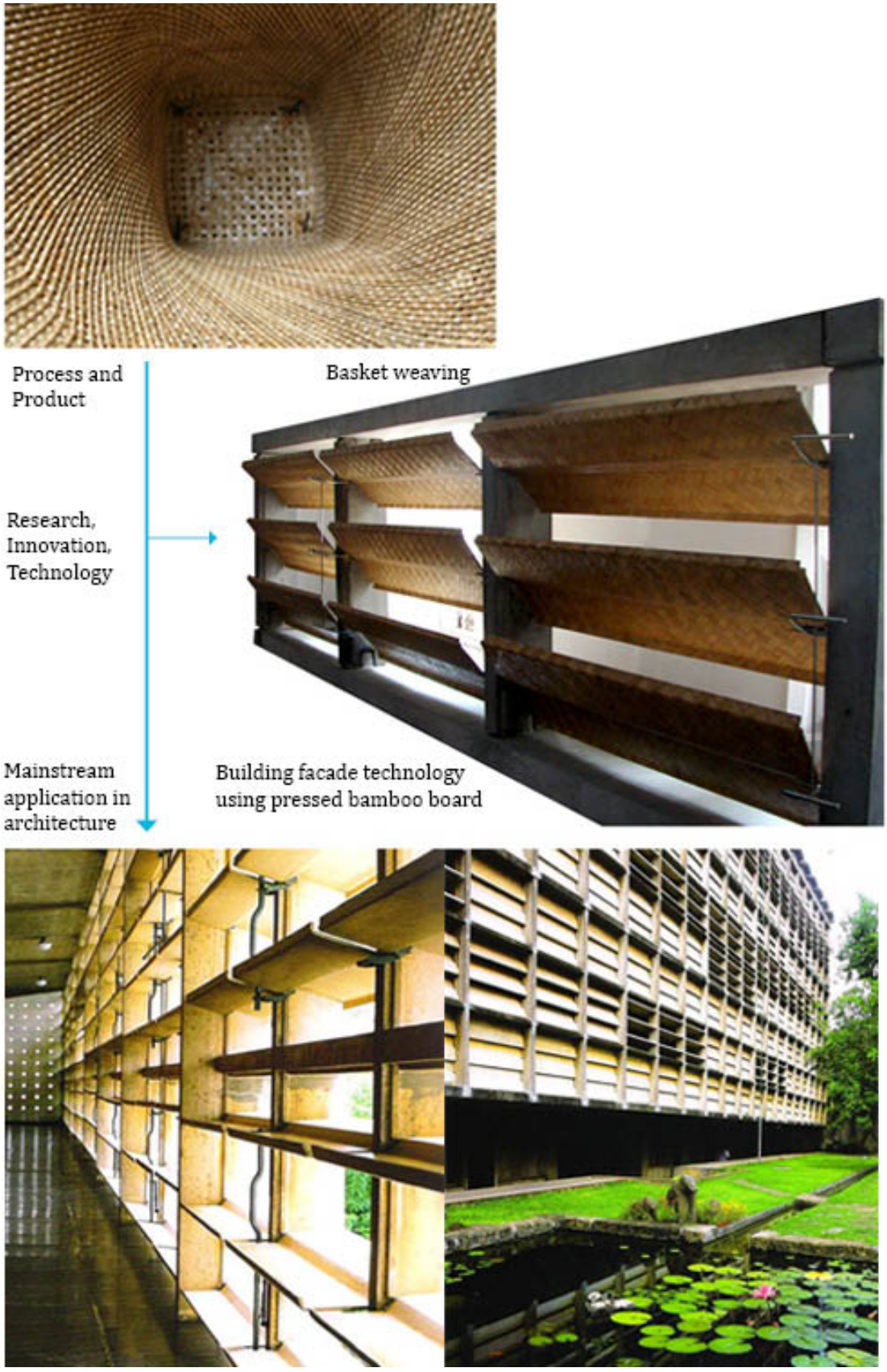


Fig 4: Pressed woven bamboo research and development for building façade technology
This building technology development project leveraged traditional basket weaving process and timber louver systems to develop a low-cost building façade technology for mainstream use

In the case of living root bridges, the author proposes a precise scientific investigation focussed on understanding, improving and propagating the technology. This investigation will require transdisciplinary expertise from the fields of botany, ecology, bridge engineering, material science, environmental science and social science. Key areas for improving the living root bridge technology include 1) long gestation period of 15 to 30 years, 2) low-safety during early growth stage, 3) need for ideal growth conditions and 4) need for community support. Testing the horticultural technique for other native plant species e.g. *Ficus benghalensis,* would offer greater flexibility and choice, and this constitutes a key research area. Findings from this research can lead to an improved living root bridge growth process, which can subsequently inform a state-wide rural connectivity, conservation, education and livelihood project.

2.3 Entrepreneurship

Creating ecology based grass root entrepreneurial opportunities is critical for a self-sustaining development model in North East India. In the case of the living root bridges, the author proposes aligning local development needs with *Ficus* ecology to alleviate the nexus of poverty, population explosion and environmental degradation. Potential adaptation of the bridge technology as a host biome for orchids, mushrooms, other epiphytic plants and food for humans and other biota is proposed as a critical value-addition and livelihood promotion strategy. This will transform the bridge into a source of food, medicine and nutrition for local communities. Other key value-addition interventions include redesign of the bridge to support vehicular movement, potential adaptation of the *Ficus* aerial root inosculation method for developing furniture, lamps and fences, and creating a grass root 'design and grow' cooperative for providing infrastructure development solutions to other tropical regions.

Fig 5: Living Root Bridge as a source of food and nutrition for humans and other biota

3. Concluding remarks

North East India offers a compelling and unique context for ecology based novel development solutions, which combine traditional wisdom with contemporary thought. Living root bridges demonstrate the intimate relationship between khasi tribes and the forest, and offer solutions for the future. These structures highlight the essential human value of living with sensitivity and respect for all life, and can inspire a new balance.

4. Acknowledgements

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5. References

[1] Native from the Himalayas to Malaysia, Sumatra and Java, *Ficus elastica* (or India rubber tree or India rubber fig) is a broadleaf evergreen shrub or tree that may grow to 50-100' tall in its native habitat. http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/plant-finder/plant-details/kc/b597/ficus-elastica.aspx

[2] The term "Khasi" means "born of the mother". For a detailed elaboration, see Shangpliang R. *Forest in the Life of Khasis*. New Delhi, Concept Publishing Company, p. 1, 2010.

[3] Robustness is used to describe a system that can survive extreme external variations. For a detailed elaboration, see Weinstock M. *Self-Organization and the Structural Dynamics of Plants*, AD Emergence: Techniques and Technologies in Morphogenetic Design, Vol 76, No 2, 2006.

[4] A keystone species is a specie that plays a unique and crucial role in the way an ecosystem functions. http://education.nationalgeographic.com/encyclopedia/keystone-species/

[5] Resiliency is the ability of a system to adapt to external disturbances and yet remain within critical thresholds. http://www.stockholmresilience.org/21/research/what-is-resilience.html

[6] Bareh, H. 1985. *The History and Culture of the Khasi People*. Guwahati: Spectrum Publications, p.15.

[7] North East region is a global hot spot for bio-diversity. Characterized by a varied physical geography, it is marked by distinct orography, heavy monsoon rains and a diverse range of flora and fauna. Shangpliang, R. 2010. *Forest in the Life of Khasis*. New Delhi: Concept Publishing Company, p.5.

[8] 'Sacred groves' (or *Law Kyntang)* are fully developed virgin forest patches from pre-agrarian age. Removal of timber or forest produce from these groves, is prohibited. Tiwari, B.K. *et al*. 1999. *Sacred Forests of Meghalaya*. Regional Centre, National Afforestation and Eco Development Board, NEHU, Shillong, p.14.

[9] Khasi Land Tenure system deals with three types of land in Khasi hills, viz., community land (or *Ri Raid)*, privately owned land (or *Ri Kynti)* and Government land. Community land is managed and owned by the community and performs the role of an emergency reservoir for the benefit of all people. Shangpliang, R. 2010. *Forest in the Life of Khasis*. New Delhi: Concept Publishing Company, p.17.

[10] An eco-theandric vision of reality refers to a firm belief in God, Nature and Man as one single indivisible entity. Khasis idolize the earth as "mother earth", which is a seamless and indivisible combination of land, forest, rivers and streams. Vidyarthi, L.P. and Rai, B.K. 1976. *Tribal Culture of India*. New Delhi: Concept Publishing Company, pp.111-140.

[11] For a detailed elaboration about the living root bridge growth process, research possibilities and future application see Shankar S. *Living Root Bridges: State of knowledge, fundamental research and future application,* International Association for Bridge and Structural Engineering Conference: Providing Solutions to Global Challenges, Geneva, Switzerland, September 23-25, 2015. http://www.sanjeevshankar.com/pdf/Living-Root-Bridges-by-Sanjeev-Shankar-IABSE-Conference-Geneva.pdf