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Revitalizing Plant Based Knowledge in North East India

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Fig 1. Location diagram of Meghalaya, North East India

Approximately two-third of India's population (833 million people) resides in rural areas, with one-fourth (216 million people) living below poverty line, forced to endure inadequate infrastructure, as well as poor access to services, resources, and markets. Rural connectivity during emergencies remains an important infrastructure need, which is particularly relevant for North East India, one of the most remote, underdeveloped, and ecologically sensitive areas of the country. Inhabited by indigenous tribal communities and characterized by dense tropical rainforests, distinct orography and heavy monsoon rains that often lead to flash floods and landslides, this region is at a threshold of transformation with the nexus between poverty, population explosion, and environmental degradation emerging as a critical threat. Community-based collective grass root practices are being severely challenged and replaced with inappropriate solutions. One such threatened community-based and sustainable infrastructure practice is the *Ficus elastica*[1]-based living root bridge technology pioneered by and unique to indigenous Khasi and Jaintia tribes of Meghalaya.

Living Root Bridges

Locally known as *jing kieng jri,* living root bridges are *Ficus elastica* based bridges within dense subtropical moist broadleaf forest ecoregion of Meghalaya in North Eastern Indian Himalayas. Ranging in span from 15 to 250 feet, these bridges are grown by the Khasi and Jaintia tribes over a period of 15 to 30 years and last for several centuries, demonstrating their exceptional endurance and resilience. With low cost, high robustness, remedial impact on the surrounding environment, keystone[2] performance in local ecology, and support for other flora and fauna, *Ficus* based living root bridge technology offers an exemplary model for sustainable infrastructure solutions and warrants further study in order to inform future living plant based constructions.

Study of the bridge growth process reveals use of native plant based material, handmade tools, and community based expertise across multiple generations (Figure 2). This human-plant interaction instills a deep connection with the environment and reinforces a sense of interdependence. However, despite their many positive attributes, living root bridges are being gradually replaced with inappropriate solutions, such as steel suspension bridges and reinforced cement concrete bridges, which have an adverse affect on fragile tropical ecosystems. Our efforts to reverse this trend will involve revitalizing plant-based knowledge through a socio-scientific-entrepreneurial framework. Successful project implementation will ensure biodiversity protection, riverbank protection, soil quality improvement, and livelihood opportunities for the communities. This will gradually align *Ficus* ecology with socio-economic development, and ensure long-term socio-

ecological resilience creating an exemplar for other tropical and sub-tropical regions around the world.

Growth

Fig 2. Khasi tribes and living root bridge growth process

Understanding the underlying growth process[3] of living root bridges is critical for improving its overall performance and value. The horticultural technique involves a four-stage process over a time period of approximately 15 to 30 years (Figure 2). This process includes: a) appropriate site selection and nurturing of *Ficus* plants on riverbanks; b) developing a temporary bamboo bridge and an *Areca Catechu*[4] root guidance system for nurturing and directing the young *Ficus* aerial roots; c) recurrent inosculation of aerial root fibers to create an integrated, seamless root network; and d) successive addition of heavy stones, timber, leaves, and soil to plug gaps and improve the strength of the bridge. During this process, the bamboo scaffold is inspected annually to monitor its deterioration in wet conditions and the increasing diameter of the *Ficus* roots. With time and use, the bridge develops exemplary strength and resilience, withstanding turbulent weather and eventually transforming into a living ecosystem for a range of flora and fauna (Figure 3) including mushrooms, orchids, other epiphytes, birds, and mammals.[5]

Rural Connectivity Project

As part of the statewide rural connectivity, conservation, livelihood and learning project in Meghalaya that will be undertaken, four concurrent initiatives will be established to inform and advance each part. The rural connectivity initiative will focus on appropriate plantation and propagation of *Ficus elastica* along rivers and streams up to an altitude of 600 meters above sea level (masl). This will be carried out in collaboration with local communities with priority given to inaccessible, poverty stricken, and vulnerable regions that are prone to flash floods, storm surges, and high soil erosion. These plantations will be nurtured over an extended time period to perform as robust bridges, creating a network of *Ficus* based infrastructure solutions throughout the state.

The conservation initiative will focus on preservation and protection of these bridges through a precise ethno-botanical study of all the living root bridges in the state. The study will reveal the

current state of these bridges and their relationship with the local communities, eventually creating a reference for subsequent research, development, and livelihood.

The livelihood promotion initiative will create a green design cooperative that offers 'living plant' based development solutions that combine indigenous plant knowledge with advances in contemporary science that can be applied to other tropical and sub-tropical regions. Adapting the living root bridge as a biome for growing orchids, food, medicinal, and aromatic plants could increase the value of this horticultural technology for local communities and align local nutritional needs with *Ficus* ecology. Potential local food based products that can be integrated with these bridges include honey, pepper, ginger, areca nut, cashew, strawberry, mushroom and mandarin. Growth of medicinal and aromatic plants can create a platform for nature-based responsible trade with potential markets in herbal medicine, cosmetics and perfumes. Other possible interventions include redesigning the bridge to support non-powered vehicles, and adaptation of the *Ficus* aerial root inosculation process for creating plant based furniture, lamps, and woven sculptural artifacts.

The learning initiative will connect indigenous communities with the scientific community to study the growth, performance, and critical thresholds of the living root bridge technology. Focus will be on understanding the aerial roots of *Ficus elastica* and their relationship with the environment. Sharing the findings through a common platform will ensure community based learning and feedback from all stakeholders. Key areas for scientific improvement include expediting the bridge growth process and ensuring structural safety during initial growth stages[6]. Specific areas for experimentation include testing this horticultural technique for different inosculation methods and applying it to other tropical plant species, e.g. *Ficus benghalensis,* which could contribute to the application of this solution to a wider global region. The overall objective of the rural connectivity project is to demonstrate the potential of this horticultural technology and apply traditional knowledge for addressing contemporary challenges.

Fig 3: Butterflies and mushrooms on Living Root Bridge

Confluence

A research, demonstration, and experimentation field station has been proposed to initiate the rural connectivity project in Meghalaya. This station will serve as an essential link between all stakeholders and will provide continuous opportunities for collaboration and inclusion. Indigenous communities will work in close partnership with members from the conservation, entrepreneurial, scientific, and government communities to understand, improve and replicate the living root bridge technology throughout the state. Various local, national, and international groups are currently being engaged to discuss and consolidate this project.

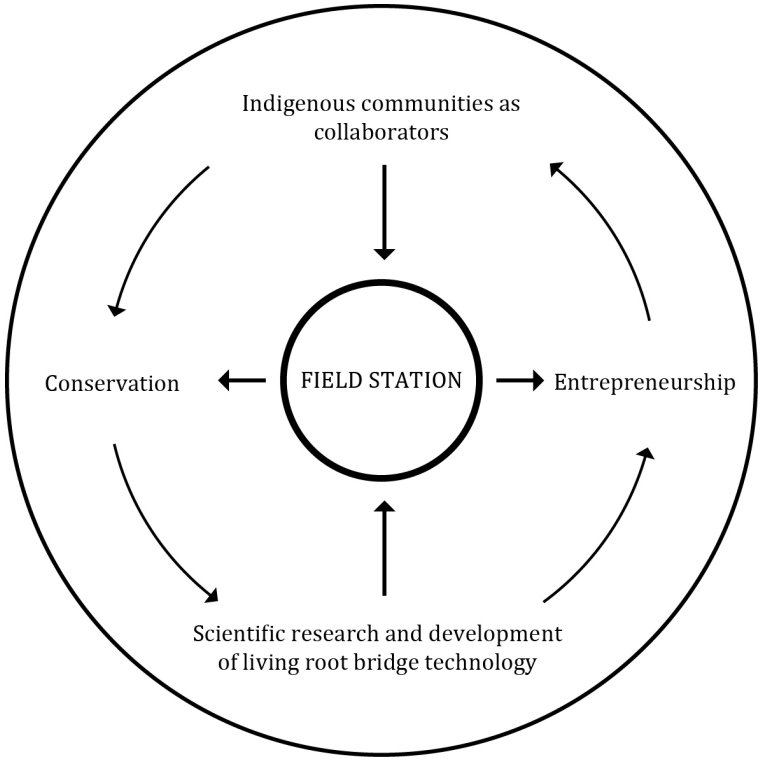

Fig 4: Field station as a pivot

This paper has discussed the extraordinary attributes of the living root bridge technology and its potential application for meeting rural connectivity needs through a convergent vision. Combining conservation, research, and grass root entrepreneurship can offer authentic solutions for revitalizing traditional knowledge and integrating it with contemporary needs.

References

[1] Native from the Himalayas to Malaysia, *Ficus elastica* (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] A keystone species is a plant or animal that plays a unique and crucial role in the way an ecosystem functions. Without keystone species, the ecosystem would be dramatically different or cease to exist altogether. http://education.nationalgeographic.com/education/encyclopedia/keystone-species/?ar_a=1

[3] 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, pp. 2-3.

[4] *Areca Catechu* (betel nut) is a slender palm that can grow to 30 m (100 ft). It is cultivated from East Africa and Arabian Peninsula across tropical Asia and Indonesia to the central Pacific and New Guinea. http://agroforestry.org/images/pdfs/Areca-catechu-betel-nut.pdf

[5] Shanahan M., SO S., Compton S. G. and Corlett R. *Fig-eating by vertebrate frugivores: a global review*, Biological Review (2001), 76, pp. 529-572.

[6] 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, pp. 5-6.