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Honey Bee Network

# Working Paper 178

ANIL GUPTA, CHINTAN SHINDE, ANAMIKA DEY, RAMESH PATEL, CHETAN PATEL, VIPIN KUMAR,  
MAHESH PATEL

## Honey Bee Network in Africa: Co-creating a Grassroots Innovation Ecosystem in Africa



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# **Honey Bee Network in Africa**

## **Co-creating a Grassroots Innovation Ecosystem in Africa**

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and Mahesh Patel



**Honey Bee Network**

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# Abstract

This paper presents a case study of the Honey Bee Network's decentralized model for collecting, verifying and disseminating grassroots innovations and provides a roadmap for its replication in Africa. The Honey Bee Network brings together governmental and non-governmental institutions, members of academia, scholars and a large number of volunteers. Through the Network's activities, locally-designed solutions and traditional knowledge with the potential to be refined and scaled up are scouted and members of the Network work with the innovators to help their ideas reach their commercial or non-commercial potential. The Network has been involved in the sharing of grassroots technology developed in India with Kenya, notably a food processing machine, seed sowing device, and a small tractor. Through these pilot programs, actors at the grassroots had a chance to collaborate and co-design solutions adapted to the Kenyan context. This experience revealed a willingness in Kenya to further invest in grassroots innovation initiatives, and Network members identified many conditions that would make Kenya the right choice for an African network hub, such as a rich traditional knowledge system and institutional willingness and recognition of the dynamism of the informal sector. Lessons from the Network's experience in Kenya and its technology transfer program are collected and turned into recommendations for the development of a sister Network in Africa.

Keywords: grassroots innovation, technology, agriculture, India, Kenya

JEL codes: O30, O31, O32, O33, O34, O35

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# List of Acronyms

AAIN	African Agribusiness Incubators Network
CHIN	China Innovation Network
DIY	Do-it-yourself
FMC	Fund Management Committee
GI	Geographical indication
GIAN	Gujarat Grassroots Innovation Augmentation Network
GTIAF	Grassroots Technological Innovation Acquisition Fund
ICCIG	International Conference on Creativity and Innovation Grassroots
IIMA	Indian Institute of Management Ahmedabad
IITB	Indian Institute of Technology, Bombay
INSTAR	International Network for Sustainable Technological Applications and Registration
IPR	Intellectual property right
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KEBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
KENRIK	Kenya Resource Centre for Indigenous Knowledge
KIPI	Kenya Industrial Property Institute
KTM	Kilomo Tech Machineries
KU	Kenyatta University
MVIF	Micro Venture Innovation Fund
NACOSTI	National Council for Science, Technology and Innovation
NIF	National Innovation Foundation
NITP	Nairobi Industrial and Technology Park
NMC	Numerical Machining Complex
NMK	National Museums of Kenya
NRDC	National Research Development Corporation
PAUSITI	Pan-African University Institute for Basic Sciences, Technology and Innovation
SIDBI	Small Industries Development Bank of India
SRISTI	Society for Research and Initiatives for Sustainable Technologies and Institutions
SSSL	Sadbhav Sanshodhan Laboratory
TePP	Technopreneur Promotion Program
TUFE	Tianjin University of Finance and Economics
TUK	Technical University of Kenya
TVET	Technical and Vocational Education & Training
USAID	United States Agency for International Development
USPTO	United States Patent and Trademark Office

# 1 Introduction

The Honey Bee Network's ("the Network") mission is to spread creativity and innovation across the world by scouting, documenting and disseminating grassroots innovations by common people. As it developed, it began promoting innovations by technology students and educators for use at the grassroots level as well. The organization's driving principle is to improve the living conditions of rural communities by conserving resources, improving productivity and reducing costs through frugal innovations and drawing upon traditional knowledge. For the last 30 years, the Network has documented and shared tens of thousands of innovations in open source that were developed by individuals with little to no outside help.

The goal of this study is to provide background to support similar initiatives that foster independent, decentralized and bottom-up development in Africa. The idea is to learn lessons, get feedback from major stakeholders in Africa (in this case, in Kenya) and explore opportunities for operationalizing various strategies for inclusive development. The central questions driving this study are the following: (a) to what extent can location-specific solutions stimulate creativity and innovation and lead to improved livelihood in other regions, and (b) based on the Network's prior experience, what initiatives can be piloted in the African context to trigger the development of a bottom-up innovation network in the region.

Highly import-dependent economies develop barriers to the evolution and diffusion of indigenous/local innovations and institutions. This study aims to provide insight to help reverse this dependence and trigger an endogenous innovation system through collaboration between Indian, African and other global institutions that believe in fostering a decentralised and diversified approach to experimentation, innovation and entrepreneurship.

In this study, we first describe the history of the Honey Bee Network and context in which it operates. We then describe different approaches that the Network adopted in order to build knowledge and value-chains, identifying key obstacles. In Part 3 we detail the Network's role in scouting innovations, working with innovators to improve upon them and diffuse them in the Indian and in some cases global context. Part 4 demonstrates how the Network has promoted the sharing and adaptation of grassroots innovations from India of to Africa through technology transfer programs and draws lessons from the Network's experience. Part 5 makes the case for the development of a sister network in Africa, focusing on Kenya as a potential hub, and provides recommendations to successfully foster an African branch of the Honey Bee Network.

The framework presented in this study may help potential partners speed up the process of institution building that is necessary to complement the existing local culture, values, knowledge system and community institutions.



## 2 Honey Bee Network: Principles, Structure and Processes

### 2.1 History of the Honey Bee Network



Although academic efforts to document traditional knowledge long predate the Network, literature on the subject is often considered ethno-botanical or ethno-zoological research and their findings were thus never shared with the communities providing the knowledge. These communities remain furthermore uncredited for their contributions. Likewise, when such knowledge was commercialized or used to develop commercial products, the benefits were not shared with the knowledge providers. It is in this context that the idea of the Honey Bee Network evolved in the late 80's, not only to correct the asymmetry of power and influence in the formal and informal sectors but also to create a more reciprocal, responsible and respectful relationship between them (Gupta *et al.*, 2016).

The conventional development lexicon does not recognize that economically poor people may have other types of wealth. Therefore, the Network had to develop new vocabulary to enrich the development discourse. While the 'poor' may lack material resources, many local communities and individuals are very rich in knowledge, as well as cultural and institutional resources. That is why the Honey Bee Network has never approved of using the expression 'bottom' or 'base of the pyramid', as the expression distracts the attention of scholars, activists and policy makers from the resources in which materially poor people are rich. Although they may be at the bottom of the economic pyramid, they are not at the bottom of the knowledge, innovation, ethical and institutional pyramids.

The Honey Bee Network drew inspiration for its name from the behaviour of a honey bee which cross pollinates flowers without short-changing them. The idea of building upon the creative and innovative pursuits of economically poor but knowledge-rich farmers, artisans, mechanics, workers, men and women and even children forms the basis of the Network's approach.

The Honey Bee Network was founded in 1988 by a group of students, teachers, farmers, artisans, roadside mechanics and others who aimed to find local solutions to the problems faced by communities at the grassroots level. The Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI) was founded in 1993 to give back-up support to the Network. It continues as a voluntary organization working in the field of educational, technological, cultural and institutional innovations and promotes viable and sustainable traditional knowledge systems.

The Gujarat Grassroots Innovation Augmentation Network (GIAN) was set up in 1997 to link innovation with investment and enterprise. It was the first grassroots innovation incubator in India and one of the first worldwide. It currently focuses primarily on innovation in the Indian provinces of Gujarat, Maharashtra and Goa and collects innovations by students of Industrial Training Institutions and polytechnics/diploma colleges from all over the country.

The National Innovation Foundation (NIF) was set up by the Network in the year 2000 to scale up the work done by GIAN and SRISTI and to expand the activities of the Network to a much broader scale. The NIF's original guiding principle was to unleash the creativity of the informal sector and children. In 2010-11, it became a full-fledged institution of Department of Science and Technology of the Government of India. By formally integrating with the public sector, government control increased, as did the scale of support for grassroots innovations<sup>1</sup>.

### 2.2 The Honey Bee Network Philosophy

There are four main principles of the Honey Bee Network philosophy: [a] whatever is learnt from the people must be shared with them in a local language, with or without value addition, in order to enrich

---

<sup>1</sup> Prof Anil K. Gupta has since stepped down as Executive Vice Chairperson of NIF (2000-2018) and continues as a member of the Board of Directors.

the collective understanding of the ways in which different individuals and groups have solved specific problems, [b] the cross-pollination of ideas across languages and other cultural barriers fertilizes the imagination of communities and encourages further experimentation, [c] both scouts and innovators should be acknowledged by name for their contributions, and [d] any benefit arising from the commercial or non-commercial dissemination of innovations should be shared with those who contributed knowledge or innovations in a fair and just manner, with or without value addition.

## 2.3 Development of the Innovation Value Chain

In its early years, the Network focused on scouting, documenting and disseminating farmers' innovative practices, some of which had been part of their traditional knowledge systems. In many instances, a common local community practice may represent an innovative idea to another community. As it continued operating, the Network recognized the need for validating and adding value to innovations, using them to develop products and to pool best practices. This required building linkages with science and technology institutions and building internal R&D capacity. The Network's first initiative was to demonstrate the viability of protecting Intellectual Property Rights in India and in the USA (and later under Patent Cooperation Treaty) and also to demonstrate the business potential of some of the patents filed. Nonetheless, these rights were not allowed to impede peer-to-peer learning. In fact, through a concept called Technology Commons, patented technologies are allowed to be copied or improved upon by fellow self-employed farmers, healers, or mechanics but were required to be licensed for use by industry.

Initially, risk capital was one of the weakest links in the value chain, because there were no funding windows for grassroots innovation anywhere in the world. The creation of a Micro-venture Innovation Fund (MVIF) was first proposed at the International Conference on Creativity and Innovation at/for/from/with Grassroots (ICCIIG) in 1997. By 2003, it became a reality with the help of the Small Scale Industry Development Bank of India (SIDBI) after an announcement in the parliamentary budget speech by the then Finance Minister. The transition from *micro finance* to *micro-venture finance* is one of the Network's most important contributions, though the wide-scale adoption of this model in the developmental finance community still remains limited. Diffusing innovations through commercial and non-commercial channels was the Network's next challenge. Partnerships with various stakeholders were built up to advance this goal. Policy papers, workshops and dialogues at the national and global levels have generated feedback on how to best expand the space for grassroots and inclusive innovation. Gupta and Mathur (1984) detail the action-research approach used to develop standards for grassroots innovations for the first time in Kenya, which is potentially more effective than writing just the policy briefs.

## 2.4 Scouting and Documenting Innovations

The formal sector cannot address multifarious societal challenges through top-down and centralized approaches. In agrarian economies, the formal agricultural research and extension system tends to be spread thinly and is unable to reach or properly service many rural communities.

The limits of the formal system present an opportunity for informal innovation systems for a number of reasons. The formal system often develops technology at technologically well-endowed research stations with levelled, well-prepared, drained, fertilised and irrigated fields. On the other hand, many farmers (especially small scale farmers) face highly variable conditions and many constraints. Therefore, several improved varieties and other technologies developed by the formal sector do not perform as well in their fields.

In this context grassroots innovations play an important role. Due to their localised nature, they have a closer fit at the local level but may lack robustness across highly diverse locations. Niche-specific solutions play a critical role in ecosystem viability. Another advantage of grassroots innovations is their higher flexibility, cost-effectiveness, affordability and also their modularity in many cases (Gupta,

2016). Innovations providing solutions to localized problems fulfil an important niche-specific need, despite their potential ineffectiveness when disseminated on a wider scale. Though in a few cases, particularly dealing with farmer-bred crop varieties, the diffusion at large scale has indeed been achieved primarily through word of mouth publicity besides recognition through national awards.

Through a meticulous scouting and documentation process, SRISTI collects information about the following:

- a) Grassroots innovations, namely products, processes/practices, service and systems developed by creative individuals on the fringe of or outside the formal economy;
- b) Traditional knowledge with or without location or community-specific improvements;
- c) Innovations in education, especially novel pedagogies employed by school teachers, but also by children;
- d) Innovative and empathetic technological engineering student projects;
- e) The knowledge, life experiences and wisdom of elders;
- f) Informal common property resource management and other institutions;
- g) Outstanding examples of cultural expression from the rural and urban hinterland.

Summer scout volunteers do the majority of the scouting; these students spend their summer break collecting information of the type listed above in and around their home village. The SRISTI field staff and/or collaborators then go to these villages and verify the recorded claims. The SRISTI team scouts for innovations during regular field trips as well.

In the course of a Shodhyatra Learning Walk, SRISTI staff and volunteers complete a 100 to 150 kilometre-long walk through remote regions of India to explore untapped knowledge as well as to disseminate the knowledge SRISTI and the Honey Bee Network have accumulated over the years. This is one of the Network's most important ways to collect and disseminate innovations at the grassroots level.

So far, the Network volunteers have walked a length of more than 6000 kilometres across the country. This includes the Shodhyatra course that Professor Anil Gupta, the founder of HBN and an scholar in the area of grassroots innovations, teaches at the Indian Institute of Management Ahmedabad (IIMA) for his students. His students walk in the Himalaya region twice a year to learn from four teachers: teacher within, among peers, in nature and among common people. Table 1 illustrates the ideas collected through various scouting channels

Table 1: Ideas collected through various channels

No.	Channel Name	Innovations/Traditional Knowledge Scouted
1	Summer Scouting	31840
2	Shodhyatra	11175
3	Other methods	620
Total		43635

## 2.5 Verification, Validation and Value Addition

Verification by post, telephone or in person is conducted by third party researchers/SRISTI or GIAN staff to maintain credibility and ensure due diligence. Since the ratio of innovation to traditional knowledge practices is low, scouting will not yield many of the former unless these are explicitly sought out and prioritized. There are different challenges associated with the discovery and recording of different types of innovations. For instance, mechanical innovations or innovations in farming



implements have a sparse geographical distribution because of the small number of mechanics in each village. In regions of low population density, the search process requires extensive travelling. Finding innovations and/or traditional practices requires a keen eye for detail and deviant research<sup>2</sup>. Innovations by women are even more difficult to locate because of the cultural norms around communication and gender roles in many countries.

The proliferation of mobile phones, notably among farmers, has made verification easier. However, some farmers will discontinue a practice even if it was very useful at one time once new practices and technologies have been introduced. For example, when BT cotton varieties became popular, many herbal pesticides were discontinued. After the emergence of pest resistance in BT cotton, these practices made a resurgence.

Agricultural practices and innovations are then validated in SRISTI's natural product lab-SRISTI Sadbhav Sanshodhan Laboratory (SSSL) or through on-farm research and occasionally through on-station trials. Once validated, SSSL adds value to the practices and develops a product formulation based on the original practice. These are shared as do-it-yourself (DIY) technologies, as well as directly on commercial basis as a low-cost solution<sup>3</sup>, or they are licensed on non-exclusive basis to small or medium scale entrepreneurs. Mechanical and many other Innovations such as new crop varieties for farming or utilities for other sectors are validated by NIF and a network of formal R&D institutions (public institutions, universities, etc.).

## 2.6 Dissemination

Most of the data collected by SRISTI is available in the form of multi-language databases on SRISTI's website<sup>4</sup>. Moreover, by means of newsletters in six Indian languages and English, this information is spread to rural regions and urban centres. The findings are circulated in the formal sector (universities, researchers, development organizations, etc.) by means of several publications, websites, periodic conferences like International Conference on Creativity and Innovation at Grassroots (ICCI.org), summer school on inclusive innovations (ss.sristi.org), workshops and newsletters.

### 2.6.1 *Leveraging collective social capital of the network*

Members of the Network include innovators, students, farmers, entrepreneurs, engineers, policymakers, government officials, and teachers, as well as homemakers. These stakeholders can join SRISTI, GIAN and the Network through various other networks or directly.

For example, the state Department of Education supported the 40<sup>th</sup> Shodhyatra learning walk in Gurez Valley, Jammu and Kashmir, by providing access to school buildings for the participants to stay in at night, and it also sent some officials to learn and share the pedagogy of bottom-up learning. This type of participation further increases the reach and involvement with the Network. After several shodhyatras, a debriefing session is held with senior government officials and sometimes also with the chief minister of the state. After the Odisha Shodhyatra, a meeting was organised with the state chief minister and a follow-up plan for the search and spread of grassroots innovations was drawn up. Likewise, a meeting with the chief minister was organised after the Mizoram and Uttarakhand Shodhyatras. A presentation was made to the state chief secretary after the recent Shodhyatra with IIMA students in Meghalaya, Dec 7-12, 2019.

During the last two Annual Traditional Food Festival called the Sattvik organised by SRISTI, local college student volunteers helped market the products made by fifty rural women groups from different

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<sup>2</sup> The word: Deviant research, New Scientist, [Volume 195, Issue 2622](https://doi.org/10.1016/S0262-4079(07)62418-X), 22 September 2007, p 56 [https://doi.org/10.1016/S0262-4079\(07\)62418-X](https://doi.org/10.1016/S0262-4079(07)62418-X), this article underlines how the word 'deviant research' was first used by Anil Gupta in 1987, describing the grassroots innovators as social deviants.

<sup>3</sup> through the not-for profit company sristiinnovations.com

<sup>4</sup> <http://www.sristi.org/wsa/> open source databases, besides techpedia.in and gyti.techpedia.in

regions. These women groups were sponsored by the Union Ministry of Women and Child Development. Students and the women groups also learned about selling and marketing from each other. Such linkages between youth and the elders have to become an essential part of the Network's ethos embodied in the 'caring and sharing economy'.

### *2.6.2 Engaging with the top leadership*

Linking micro initiatives and groups with macro-level policy and institutions in a mutually advantageous manner is critical for scaling up. During a meeting with the then Chief Minister of Gujarat, Shri Narendra Modi (the current Prime Minister of India), the SRISTI team shared a compilation of non-chemical ways of controlling pests in cotton. Mr. Modi found the idea useful for farmers and instructed the Department of Agriculture to circulate that list of sustainable practices across Gujarat within three days. Several regional leaders are becoming conscious of the increasing cost of cultivation and decreasing margins for farmers. The emerging crisis in agriculture does provide a unique opportunity for scaling up sustainable frugal innovations.

### *2.6.3 Mobilizing the postal network*

The postal department has one of the highest outreach capabilities in most regions of the world. In India, every post office covers about 10 to 15 square kilometres and four to five villages in rural areas. The postal staff is trusted by the people due to the consistency of their services year round, despite rain or storm. SRISTI contacted the Postmaster General of Gujarat and the postal department agreed to deliver and paste three posters in every single village, one at a cooperative milk collection centre, one in a village council/panchayat office, and one in a school, at the cost of five rupees per village. This approach promoted extensive dissemination and created awareness about the Network's activities and specific grassroots innovations. This is an easily scalable model that can be tried in different parts of the world. While the scouting efficiency was low, the dissemination efficiency was high in this case.

### *2.6.4 Dissemination through media*

Reuters India has started a paid market and weather information sharing service for farmers and integrated the dissemination of farmer-generated grassroots innovations into the service in collaboration with SRISTI. In some cases, the farmers whose innovations were shared through mobile services received hundreds of calls from various other farmers wanting to know more about the innovations.

Out of all the media outlets writing about innovations in English or in Hindi, it was the Hindu Business Line newspaper which received the most responses because they provided the innovators' contact information. Interest was not limited to the local region, with some calls even originating from opposite sides of the county. Several regional papers have taken an interest in spreading the word about the innovations and various activities of the network, writing articles, columns or profiles of Network innovators.<sup>5</sup> This has generated multiple business and mentoring opportunities for the innovators. The Network has been featured in many programs of international media outlets, such as the BBC, CNN, Financial Times, NHK Japan, French TV 24, GEO Germany and numerous other channels and magazines. The role of radio and newspapers in spreading innovations and seeking new innovators is quite an important one. Despite the growing and increasingly widespread coverage, regional and district-level newspapers remain highly important because they reach villages where other channels might not, spreading benefits to the grassroots.

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<sup>5</sup> To illustrate, Rajasthan Patrika, Agrowon, MINT, Divya Bhaskar, Sakal, The Telegraph, DNA, Times of India etc.

### 2.6.5 *Dissemination through feature films*

Feature films are an immensely powerful entertainment medium. Several popular films have featured grassroots innovations to a varying extent. For example, *3 Idiots* was a blockbuster film critiquing the modern education system that gained worldwide popularity. Any reference to the three innovations showcased in the film triggers immediate recall among many people in India and south and south-east Asia. Another movie, *Padman*, is based on the life of a grassroots innovator who has invented a sanitary napkin machine. Several other grassroots innovators were also featured in the film. The film significantly raised awareness about the issue of menstrual hygiene in India (less than 7 to 10 percent of rural Indian women use manufactured napkins).

Aside from the dissemination mechanisms mentioned above, voluntarism is at the heart of the successful dissemination of the Network's grassroots innovations. The majority of individuals who are connected to the Network do so in a voluntary capacity. Some of these individuals became collaborators of the Network and contribute enormously to the database. Many have initiated Honey Bee magazines in local languages.<sup>6</sup> Even further afield, a Chinese version of the Honey Bee has been developed thanks to the proactive efforts of Professor Zhang Liyan of the Tianjin University of Finance and Economics (TUFE).

Any innovation is considered successful if it either imparts social or commercial benefits onto the innovator or is diffused as an open, DIY innovation, or if knowledge of its existence spurs on innovative activities in others. The Network helps innovators benefit from their innovation by connecting them with investors and/or entrepreneurs or helping them become entrepreneurs themselves through risk capital (MVIF); mobilising product orders to enable them to scale up; and connecting them with relevant institutions to help them achieve recognition. Even small contributions by various individuals involved in the value chain are celebrated in the Network.

## 2.7 **Financing innovation: The Micro-Venture Innovation Fund**

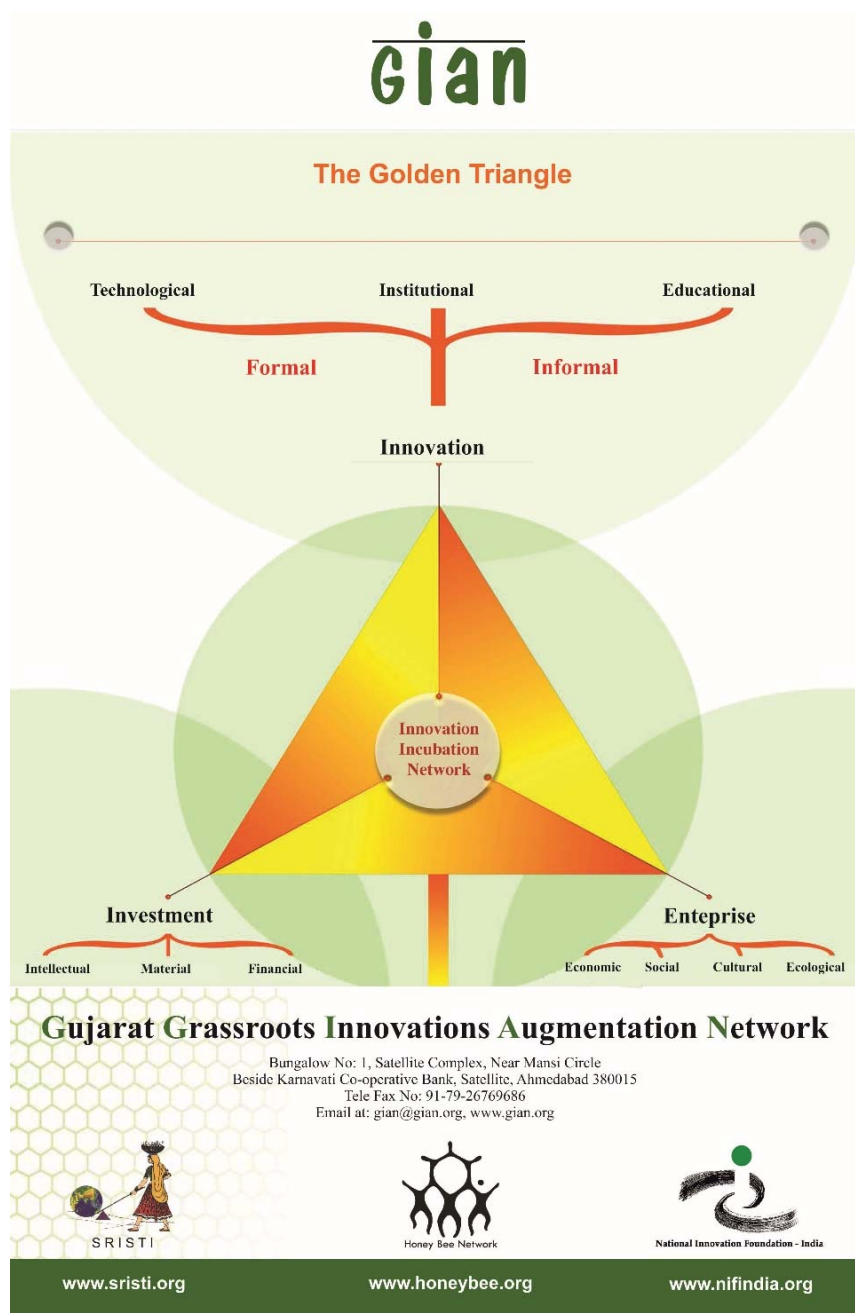
SRISTI proposed the concept of a Micro-Venture Innovation Fund at the First International Conference on Creativity and Innovations at the Grassroots, 1997 (ICCIG-1) at IIMA. SRISTI tried to persuade policymakers of the importance of such a fund to help innovators become entrepreneurs. GIAN was set up in 1997 to link innovation, investment and enterprise (see Figure 1 adapted from the original triangle which dealt with social or economic enterprises) with the help of the Gujarat state government, along with SRISTI, IIMA and state development corporations.

SRISTI helped scale up GIAN's risk fund model into NIF's Micro Venture Innovation Fund (MVIF), drawing upon the research at IIMA and SRISTI. In the Budget Speech for the 2002-03 financial year, the then Union Minister of Finance announced the creation of a Micro-Venture Innovation Fund supported by SIDBI through NIF.

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<sup>6</sup> Local language newsletters include Aama Akha Pakha (in the Odia language), Ini Karshakan Samsarikkatte (in Malayalam), Loksarvani (in Gujarati), Num Vali Velanmai (in Tamil) and Palle Srujana (in Telugu).

Figure 1: Golden Triangle model of GIAN



The financial support under MVIF is provided to grassroots innovators without requiring a co-signer and collateral and is based on documents signed by the innovator only. MVIF invests in innovations at a very early stage with a high risk of failure. MVIF often invests in technologies where the market is limited or does not yet exist.

The NIF extends MVIF support to the innovators directly and through regional incubators like GIAN. The NIF and GIAN teams conduct market research and develop a proposal on behalf of the innovators. A Fund Management Committee (FMC) processes these proposals. Once approved by the FMC, the innovations are funded with a reasonable moratorium period and at low interest rates<sup>7</sup>. The NIF and GIAN teams are present every step of the way, from collecting background information, preparing the documents, mentoring innovators, to providing handholding support to the innovator. The team also

<sup>7</sup> Initially 12%, the innovators found this to be too high, thus it was reduced to 5%.

monitors and evaluates projects. Ensuring that the innovator pays all the taxes and complies with all the ethical and legal requirements takes time, as the innovator is learning throughout the process.

These funds have had decent recovery rates. The NIF recovered more than 75% of the investment during the first phase 2003-2016, where they provided micro-venture funding to 193 projects<sup>8</sup> mentored by the Honey Bee Network volunteers and staff.

## 2.8 Commercialization and Benefit Sharing

SRISTI Innovations, a Section 8 not-for-profit company and SRISTI sister company helps with the commercialization of products that have been validated and value-added by SRISTI's Lab. The profits generated from the sales of these products are shared with the knowledge-holders using SRISTI's benefit-sharing framework. Some technologies are transferred to small firms, often on a non-exclusive basis, ensuring a fair sharing of benefit with the knowledge-holding individuals, innovators or communities. SRISTI hopes that the beneficiaries use the benefits received from technology transfer for the well-being of the community, women, the conservation of nature, and for finding new innovations. The knowledge providers/innovators are requested to follow the following benefit sharing formula. Although it is not mandated by SRISTI, many beneficiaries choose to share the benefits along similar lines. On the other hand, some do not, due to debts and a lack of understanding of the framework.

Table 2: Benefit Sharing formula

Innovator	30%
Nature	5%
Community	5%
Innovation fund	20%
Innovation activity/on-farm trial (experimentation)	15%
Scouting/dissemination and facilitation of innovation with particular focus on women	5%
Contingencies for dealing with natural hazards	5%
Institutional administrative expense	15%

## 2.9 The Honey Bee Network Approach to Intellectual Property Rights

The Network recognises the need for protecting the intellectual property rights of the individuals, as well as the need to protect those of communities who possess unique knowledge and innovations. However, the Network does not enforce intellectual property rights (IPRs) against fellow farmers, mechanics, artisans or other self-employed people so as to encourage peer-to-peer learning. The prior art searches are done in-house and applications are filed on *pro bono* basis by Intellectual Property firms and attorneys with the assistance of the Network. To date, 1046 patents have been filed by the NIF in India. Out of these, 68 patents have been granted. SRISTI, GIAN and NIF have also filed eight patent applications with the United States Patent and Trademark Office (USPTO), out of which five have already been granted.

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<sup>8</sup> Total Fund Disbursed: INR 3,40,37,637 (approx USD 508,000)  
 Repayment (as of date): INR 2,13,01,676 (approx USD 318,000)  
 Projects supported: 193 as of Dec 31, 2017

### *2.9.1 Intellectual property and grassroots innovations*

In many developing countries including India, many innovative technologies that are suitable for social diffusion may have very low potential for market-driven diffusion. For instance, growing Okra around cotton fields to trap pests attracted by its early flowering is an open source innovation. Making herbal pesticides from (toxic) plants that cattle do not eat is both a DIY innovation and could also be a commercially viable product. Some of these technologies take a long time to develop into products or services on top of the time needed for regulatory approvals.

The Grassroots Technological Innovation Acquisition Fund (GTIAF) was set up to expand the public domain and compensate innovators who may not have the ability to wait for uncertain commercial returns. Public funds at NIF have been used to create private rights for grassroots innovators. GTIAF acquires the rights to innovations without barring the innovator from continuing to use it. These rights can be licensed at little or no cost to micro or small entrepreneurs, and this widens the public domain. The idea is that the state and not the innovators should bear the costs of societal open learning. If the institution is able to license it to a third party for a higher sum or generate more revenue, these funds are shared with the innovators even though they may have licensed out their rights.

### *2.9.2 Application of traditional intellectual property rights to grassroots Innovations*

The use of conventional IPRs to protect innovations presents many challenges for grassroots innovators. First of all, most innovators lack knowledge of IPRs and believe in sharing their knowledge openly. Many innovators decide to share their innovation openly with others (following the philosophy of 'technology commons') and use IP protection only as a means of preventing others from monopolizing it. The Network believes in sustaining the spirit of open, reciprocal, responsible and mutually respectful innovation. Concurrently, if companies wish to commercialize an innovative product, they may need to use IP as a means of keeping a competitive advantage.

Many small and medium entrepreneurs who license grassroots innovations value the branding advantage imparted by the receipt of a national award. These are given to some innovations following a rigorous screening process. Trademark protection may help in branding along with mention of the award.

The registration system such as the one proposed in INSTAR (International Network for Sustainable Technological Applications and Registration) (Gupta, 1999a) could give short term incentives to traditional communities and innovators for disclosing their unique knowledge; if the practice is then validated and deemed useful, it could then be given longer-term protection. Most countries have never compensated local traditional herbal healers, therefore a system that incentivises them to share their knowledge is needed. Seeking protection for their unique, uncoded and unrecorded claims under normal IP laws has been successfully tried by NIF. In a few cases, after pre-clinical trials, a few companies have shown interest in developing these innovations further into commercial products, and this has led to the licensing of many products.

Geographical indications (GI) protections have been used in many cases, but due to a lack of enforcement, they have not significantly benefitted communities.

Technology commons is an IP-related mechanism that has yet to be fully developed, whereby derivative innovations are pooled together under the same IPR. The concept of Technology Commons keeps the spirit of open sharing at the community level intact and provides for licensing to firms. There is a need for further work on developing a granular IP system that considers incremental and derivative innovations from the perspective of technology commons and thus hybridize open-source and IP protections system. This is a way to sustain community fellowship and the open sharing of ideas.

## 2.10 The Role of the Honey Bee Network in Supporting Grassroots Innovators

The institutional context in which grassroots innovations evolve can be better understood by studying the impact of their evolution and diffusion on various subsystems in particular cases.

The role that the Network plays for grassroots innovators in India can be best illustrated by the case of the Cotton Stripper. The Network has played a role in almost every step of the innovation value chain. Beginning with its discovery by a SRISTI summer scout, it was first incubated by GIAN and the innovator was provided with a small grant and mentoring support in 1998. From there, it has become a multi-million enterprise and has completely eliminated child labour from the process of cotton stripping. See case study in Box 1 and Appendix 1 for further detail.

From the Network's experience, the following insights can be gathered.

- **The importance of social embeddedness:** The level of social embeddedness of an innovation (Gupta, 1999b; Warschauer, 2003; Dobryakova and Kotel'nikova, 2015) affects a web of relationships among different actors in the community and around it. It implies that the direct and indirect effects of an innovations and its associated processes are not always initially apparent. For instance, how can an innovator deal with customer complaints when the solution is still evolving, especially when it can influence the innovator's future reputation? If a major recall with full compensation is needed due to a manufacturing defect, an innovator's ability to execute this recall back may shape his future business prospects. Communities consider and sometimes remember the larger social context of the technological change.
- **The importance of complementary community knowledge:** The labourers who work on multiple farms may have knowledge to supplement that of a farmer who knows a great deal about his own farm. Due to this fact, labourers can play an important role in smoothing the journey of an innovation from innovator to the users in the community.
- **Innovations and reducing child labour:** When the productivity of activities that typically involve child labour increases and it becomes more profitable, child labour tends to be eliminated.
- **The importance of including women:** Involving women in the generation, adaptation and diffusion of innovations has multiple benefits. Innovations in the realm of traditionally female activities or work can reduce the amount of hard labour performed by women and can also benefit their family and social welfare, as has shown to be the case when income reaches women. It must be acknowledged, however, that the HBN database has far fewer innovations by women than men due to a shortage of women field workers.

### Box 1: The Cotton Stripper

**The problem:** Dryland variety of cottons hold cotton lint tightly in partially opened balls. The lint used to be pulled out by women and children in a labour-intensive process, and the fibres in the air caused health problems.

**The Innovator:** Mansukhbai Patel, a farmer from Ahmedabad, was very familiar with the cotton value chain, having stripped cotton manually as a child and having later worked in a textile mill.

**Discovery:** in 1995, a student scout heard the story of a man who had developed a cotton stripping machine. He sold the machine to customers, which failed, and he returned the money to his customers.

Working with Network institutions, Mansukhbai received feedback and support through a German student of National Institute of Design, Ahmedabad to refine his design. After a process of trial-and-error, which involved lending out a functioning prototype to a ginning factory, Mansukhbai, with the help of GIAN, developed a model destined for commercial success.

**Marketing:** GIAN and students from the Nirma Institute of Management Studies conducted a market and feasibility study for the machine and elaborated a project management plan for commercial production. GIAN filed a patent application for the machine in India and in the USA.

With the help of the Network, a partnership firm was created to manufacture the cotton stripper. A mobile van service was also created to provide technical support post-sale.

**Dissemination:** The machine was presented at technology fairs and exhibition and received ample media coverage.

**Result:** The cotton stripper is 20 times more cost effective than the traditional cotton stripping process. It also helped eliminate child labour from the supply chain and decreased the hard labour performed by women farmers.

Figure 2: The cotton stripper machine in action







## 3 The Honey Bee Network Approach for Africa: Challenges and Synergies

### 3.1 Grassroots Technology Transfer from India to Kenya

Several international agencies have recognized the limits of conventional technology transfer and capacity building for rural development in Africa. This represents an opportunity to try a new approach: the transfer of innovations developed at the grassroots. To this end, the United States Agency for International Development (USAID) collaborated with SRISTI to support the transfer and adoption of three technologies:



The **Bullet Santi** by Mansukhbhai Jagani<sup>9</sup> is a multipurpose farming machine that can perform all the operations which can be carried out by a pair of bullock. The machine consists of a self-fabricated chassis, drive and power of an Enfield Bullet motorcycle in front and an attachment with two wheels at the rear with a tool bar to fit various farm implements, e.g. for ploughing, weeding and sowing seeds and spraying. See Box 2 and Appendix 2 for further details.



The multi-purpose **food processing machine** by Dharambir Kamboj<sup>10</sup> is a portable machine, which works on a single phase motor and can be used to process various fruits, herbs and seeds. It also works as a big pressure cooker with temperature control and auto cut-off facility, and offers a condensation mechanism, which helps in the extraction of essential oils and extracts from flowers and medicinal plants.



The **seed dibbler** by Mansukhbhai Jagani<sup>11</sup> can be used to sow seeds and apply fertilizer while reducing drudgery. Because of its easy access, the implement can be used for gap-filling, thereby maintaining the crop density.

As part of this process, grassroots innovators and entrepreneurs from India visited Africa to demonstrate how solutions developed in India can be used and adapted to the local context. Similarly, reciprocal visits of mechanics (jua kalis) and faculty of JK University of Agricultural Technology were organised to the innovators' place in India to gain hands-on experience.

The process of adapting and transferring grassroots technologies from India to Africa is well illustrated by the journey of the Bullet Santi, described in Box 2 and Appendix 2. This innovation, developed in

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<sup>9</sup> <http://nif.org.in/innovation/Bullet-Driven-Santi/87>

<sup>10</sup> <http://kissandharambir.com/>

<sup>11</sup> <http://nif.org.in/innovation/seed-cum-fertilizer-dibbler/802>

India under specific conditions proliferated widely and was improved upon by a number of actors. Transferring the technology to Kenya proved more difficult than expected as it required major adaptations. The Network facilitated knowledge sharing between Kenyan and Indian innovators to develop a marketable prototype for Kenya and worked with local institutions to set up a supply chain for components and establish a local market. This example illustrates how public policy alignment and pursuing a co-creative approach can foster and increase adoption of grassroots innovations. This is in contrast to the standard approach in conventional development processes consisting of independent transfers of technology.

#### Box 2: The journey of the Bullet Santi from India to Kenya

##### Part 1: India

**The Innovator:** Mansukhbhai Jagani is a mechanic from the region of Saurashtra in Gujarat. It was his friend coming to him with a problem that catalyzed his innovation. Hearing his friend's problem and seeing his friend sitting on a motorcycle gave him an idea.

**The problem:** Draft animal power was becoming an unviable way to complete farm chores such as harrowing, weeding, making ridges, spraying pesticides and hauling loads.

**The evolution of the Bullet Santi:** The Bullet Santi started out as an attachment behind a motorcycle used for the light farm work listed above. Though his innovation was patented with the help of GIAN and SRISTI in both India and the USA, Mansukhbhai did not enforce it, preferring instead to let small-scale producers copy and improve upon his design. The technology for the Bullet Santi was transferred to innovators and farmers through Jomo Kenyatta University of Agriculture and Technology (JKUAT) Kenya under a USAID-funded project.

##### Part 2: Kenya

**The problem:** The Bullet Santi was developed for the flat, sandy loam soils of Saurashtra. In contrast, the region of Kenya where the technology was targeted had heavier, deeper soils and undulating terrain, which demanded higher torque, greater stability and greater ground clearance of the equipment.

**Adaptive research:** Training visits were organized with the help of the Network for Kenyan engineers, producers, mechanics and other stakeholders to collaborate with Indian innovators. The Santi was eventually adapted into a small tractor and the design was approved by the Kenya Bureau of Standards.

**Collaborative learning:** Kenyan mechanics learnt to assemble the Santi and were shown supply chain management, including sourcing, assembly, maintenance and repairs.

**Marketing the Santi in Kenya:** The host institution, JKUAT registered a local enterprise, Kilimo Tech Machineries, to produce and market cost and labor-saving innovations to farmers. A joint committee of local partners, including the Jomo Kenyatta University of Agricultural Technology and the officials of the Kenya Bureau of Standards (KEBS) was set up to develop a standards framework to produce and sell the small tractor using financing from commercial banks. Once the standards were issued, an order of 20 tractors was placed to SRISTI to introduce the product to the market. The tractor was given a local name, the Shujaa, reflecting its Kenya-specific design.

**Developing the supply chain:** In the first phase, the tractors were imported from Saurashtra in India while arrangements were made to produce and source parts locally.

Figure 3: Evolution of the bullet Santi



#### FIRST MODEL

- Diesel Royal Enfield Bullet motorcycle
- Atul Chhakda's differential (*Chhakda* is a 3-wheeled local transport vehicle)
- Chain Sprocket-40 teeth for torque
  - Remolded tyres
  - Use of L-section Chassis



#### SECOND MODEL

- Strong Chassis using a C-channel
- Further augmentation of torque using a 50-toothed chain sprocket
  - Fiat differential
  - Mechanical lifting



#### THIRD MODEL

- Hydraulic lifting added
- Introduced some design interventions (which were not accepted by the consumers)



#### FOURTH MODEL

- Gear box with reverse gear ability
- Spacer rods added to rear wheels to change the wheelspan



#### TALLBOY MODEL

- Derivative innovation which can spray over the crop
  - Four wheels instead of three

SRISTI's technology transfer to Kenya was not only a transfer of innovations but also, to some extent, of the ecosystems that enabled these technologies to flourish in India. It was important to identify the relevant actors who could support these innovations and build their respective capacities or build upon existing capabilities. Training was provided to multiple community-level actors such as innovators, producers, individual farmers, mechanics, *jua kalis* (see Box 3 and Appendix 5), orchard owners, women self-help groups, etc. In this process, the team realized that the evolving ecosystem was not only suitable for the three technologies brought in from India by SRISTI; any grassroots innovation, whether from Kenya or elsewhere will need similar support system to thrive.

#### Box 3: *Jua Kalis* and the importance of the informal sector

Many East African countries have a strong network of informal sector artisans called the *Jua Kalis*. In Kenya alone, they provide a livelihood to about 10 million people. In Kenya, the *Jua Kalis* are a group of micro-entrepreneurs in the informal sector that have been partly recognized for providing various mechanical services to local communities. They are employed in metal fabrication, car repair, carpentry, casting iron and aluminium, as well as trade of scrap or refurbished goods.

Ever since the *Jua Kalis* were officially recognized, their access to credit has increased (Orwa, 2007). Many technical graduates join the *Jua Kali* sector. The *Jua Kalis* are now primed to become drivers of manufacturing-based growth. Across many economically disadvantaged counties, the *Jua Kalis* are a source of major employment.

Having proactive informal sector such as that of the *Jua Kalis* in East Africa is expected to lead to innovations in various products and processes. During its time in Kenya, the SRISTI team observed some innovations by the *Jua Kalis*. See the appendix for examples pictures of these innovations.

## 3.2 Lessons from the Kenya Experience

SRISTI's technology transfer experience in Kenya has generated many useful insights about cross-cultural learning; building capacity at the level of communities, in the *Jua Kali* cluster of mechanics, and even among policy makers; and establishing agencies and other independent stakeholders. SRISTI and the Network's capacity also significantly improved in the process. The reciprocal, responsible and respectful open innovation model (Gupta, 2016; Gupta *et al.*, 2016; Dey, Gupta and Singh, 2017; Gupta and Dey, 2017; Gupta, Dey and Singh, 2017; Dey, Singh and Gupta, 2018) has generated many lessons that can facilitate future efforts to transfer technology, co-create solutions, and embed an experimental and innovation ethic across cultures.

## 3.3 Technology Transfer-related Issues

During the transfer of the three technologies from India to Kenya, additional synergy between them could have produced further benefits. The demand for tractors is linked to the productivity of land by easing the constraint of turnaround time, labour availability and handling heavy soils. The farmer-bred varieties, herbal pesticides and other solutions collected by the Network should also have been shared with the communities with whom the mechanical innovations were shared.

Similarly, the food processing machine could have performed better in urban fringe areas where there is a stronger market for processed products. Tractors could have helped with inter-culture and transportation in addition to farm operations. In India, tractors generate income through transportation, and are only used in cultivation about one-third of the time. While framing such projects, sufficient freedom should exist to modify operational goals to facilitate the achievement of key objectives.

### 3.3.1 *The importance of social capital*

The role of mediating scientists is essential to building mutually respectful relationships. Scepticism around solutions designed by farmers is understandable when many new technologies have failed to solve the same issues. But the robustness of grassroots innovations and the willingness of innovators to learn and modify existing designs are very helpful in such exchanges. The design process is often a zigzag and not a straight line, and the back and forth movement to optimise *form, feature and functions* of a device or solution can only take place through trial and error.

The top leadership by the likes of senior scientists, the Deputy Vice Chancellor, Vice Chancellor, Governor of the states, the Chairman, Kenya Bureau of Standards and other stakeholders played a very important role in a successful exchange. The visit to India by some of them and their understanding of the ecosystem diversity and complexity and the role of formal and informal actors enabled the creation of mutual trust and respect.

The Honey Bee Network mobilised social capital while forging cross-cultural partnerships. The role of the Late Professor Calestous Juma of Harvard University who facilitated the initial contact with JKUAT cannot be minimized. Prof Juma's social capital, his friendship with Professor Anil K. Gupta and his respect for the Network for almost three decades paved the road for collaboration with mutual goodwill.

In most exchanges, such mediation may not be possible. But involving socially respected and reputed public intellectuals in institution-building efforts can indeed help create ethical clarity of intentions and purposes. Such mediation of stakeholders also facilitates communication and avoids any misunderstandings. These individuals may be leveraged while building purposive networks. In every society, there are lesser known selfless individuals who command enormous social and ethical capital in their communities. Their involvement in promoting creativity and innovation can be very helpful in legitimising the Network activities.

At the Kenya Resource Centre for Indigenous Knowledge (KENRIK), the National Museum of Nairobi, we met a relatively junior scientist responsible for preserving and enhancing traditional knowledge who commanded the respect of her juniors and seniors. She organised several interactions between the SRISTI team and healers and innovators, helped develop value-added products, and set up their own brand and enterprises. A network of dedicated colleagues, regardless of where they stand in the hierarchy, makes any exchange more collegial and mutually respectful. Attempts to seek legitimacy through a top-down approach might appear to make a group's entry easier, but if it is not sustainable, it may precipitate an equally rapid exit.

### *3.3.2 Ownership of the technology: name matters*

The remarketing of the Santi as the Shujaa is also critical to success. True ownership of an idea takes place when it is given a local name, which legitimizes the idea in the given socio-ecological context. If the knowledge and innovation-transfer agencies insist on their own brand name or identity, genuine ownership of the network philosophy and technological design may not take place easily. For the Honey Bee Network, it has been decided that all local-language versions of Honey Bee newsletters should carry locally suitable names chosen by the collaborators. Similarly, the China Innovation Network (CHIN), the strongest Network node outside of India, has its own identity though close collaboration with the Honey Bee Network.

A consensus has not yet emerged on a name for the Network in Kenya. However, the desire of the local stakeholders to have a local name for the innovation and the Network points to a sense of ownership among the Kenyan stakeholders.

### *3.3.3 Lessons in mutual capacity building*

Cross-cultural exchanges are sensitive and it is important to highlight reciprocal learning and constructive self-criticism. One-way learning models seldom sustain; it has been argued that two-way communication with two-way power is the most sustainable system (Gupta 1980). In the trips organized as part of the technology transfer program, Indian grassroots innovators learned as much about African community based enterprises and the challenges in variable agro-ecological conditions as did the counterpart communities, scientists, and policy makers (See the appendix for more detailed lessons and feedback from the experience of the *Jua Kali's* trip to India.)

There are many lessons for public policy, institution-building and the creation of knowledge networks, which can help facilitate widespread engagement in mutually beneficial technological exchanges between India, Africa and other regions of the world.

### **3.4 Supporting Industries**

Rajkot, located in the Saurashtra region of Gujarat where a large number of mechanical innovators are clustered, is a major manufacturing hub with state-of-the-art machinery available to many manufacturers. These industries produce a wealth of spares and scraps for other industries to use. Many grassroots innovators work with limited tools and often want to minimize the costs incurred in experimentation and prototype development. The industry in Rajkot provides them with low-cost materials to use for experimentation.

Complex machine parts can also be manufactured in the industries of Rajkot. For example, the final design of the Shujaa, the Kenyan version of an innovation developed by a local innovator required specific parts<sup>12</sup> that could be sourced from Rajkot. Due to the innovator's access to this industrial ecosystem, he could ask someone to develop parts as per his design requirements. The industries in Kenya are not at a stage where they can provide such support to innovators and producers. This remains a major challenge. Given the current status, it seems like the technology transfer process will require merging the manufacturing eco-systems of Kenya and India. In the age of distributed manufacturing, this should not pose any ideological or institutional problem. However, the tariff and taxes on imports of parts compared to wholly assembled units in Kenya will need to be considered.

There are many tasks ahead. For instance, KEBS should create standards for the food processing machine, as well as provide capacity building workshops for the local design and manufacturing of the dibbler in order to reduce drudgery in sowing. One of the reasons why a large quantity of fertile land remains fallow despite good rain is the time-consuming process of sowing crops. Policies that encourage the local manufacturing of various devices including the dibbler/manual seed sowing device can make this type of processing machine more accessible; links between the students of polytechnic schools and engineering colleges have to be forged, as both should be engaged with local innovators and industry.

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<sup>12</sup> It has an integrated transmission unit. Other producers use second-hand Jeep and Suzuki gearboxes with Fiat/Hindustan Motors differentials. The gearbox designed by Hiteshbhai was complex and required high precision.

## 4 Creating an African Honey Bee Network

SRISTI's team remained involved in Kenya following the technology transfer projects funded by USAID and orchestrated by SRISTI. In the last four years, the team had the opportunity to travel to 18 of Kenya's 47 counties to create widespread awareness of these innovations, build capacity among local mechanics or *jua kalis*, engineers from the public sector manufacturing company, and pave a pathway towards a locally adapted and co-designed solution.

### 4.1 Traditional Knowledge Systems in Africa

Over the last two decades, several African innovations and practices were recorded in the Honey Bee database.<sup>13</sup> SRISTI's team in Kenya observed abundant biodiversity and expected to find an equally rich traditional knowledge systems drawing upon this resource.

The team met an elderly couple, Saloni and Noltoijo Lepere, in a Samburu settlement near the Rumuruti, Laikipia county of Kenya and learned numerous traditional knowledge practices. Some of the plants that were reported include *olkiloriti*<sup>14</sup> and *seketet*<sup>15</sup> to treat stomach aches<sup>16</sup>. They also often used *olerai*<sup>17</sup> to treat the flu<sup>18</sup>. But few young people are aware of these uses, highlighting the precarious nature of the knowledge system in Kenya.

The basic building blocks of the innovation ecosystem are spontaneous problem-solving attempts by local communities.<sup>19</sup> There is an institution under the National Museums of Kenya (NMK), the Kenya Resource Centre for Indigenous Knowledge (KENRIK), which is tasked with the conservation of indigenous knowledge. KENRIK helped associate the scientific names of these plants to their Maa language names and played an organizing role. The institution has collected over 2000 traditional practices and has a database of medicinal plants in the region. Currently, the Centre has only six people and is facing budget cuts. Such institutions can be tasked with kick-starting the innovation ecosystem in Africa<sup>20</sup>. Similarly, institutions in other East African countries can collaborate to start building a larger database.

East Africa has a rich traditional knowledge and a robust informal sector which are supported by local institutions in a limited way. For an innovation ecosystem to evolve and yield sustainable results, these institutions need to collaborate under a larger shared vision.

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<sup>13</sup> Rich grassroots innovations and traditional knowledge systems in Africa have been documented in various issues of the Honey Bee Network newsletters during the last 30 years and in the book *Africa Calling*, available for free download from NIF website: [http://nif.org.in/africa\\_calling](http://nif.org.in/africa_calling)

<sup>14</sup> *Acacia nilotica* ssp. (L.) Willd. ex Del.

<sup>15</sup> *Myrsine Africana* L.

<sup>16</sup> International databases also include its related uses such as laxative which may relieve one's stomach; or anthelmintic effect and alleviate pain by killing intestinal worms; with no reference to relevant community; <https://pfaf.org/user/Plant.aspx?LatinName=Myrsine+africana> (plants for future, UK based database). Also see Abbasi et al. (2010) who provides no reference to specific knowledge providers nor any reference to sharing the findings back with the knowledge providers, which is typical of almost all ethnobotanical studies.

<sup>17</sup> *Faidherbia albida* (Delile) A.Chev.

<sup>18</sup> The bark of this plant has been reported for controlling diarrhoea and emetic use; it is also recorded to be used for catching fish. Traditional uses of these plants can be found at the following site <http://pza.sanbi.org/faidherbia-albida>, which does not reference the community. Similarly, its uses for malaria and fever are indicated in public databases without any reference to the healers or their communities.

<sup>19</sup> For examples of stories of individual creativity and the Network's expansion into Africa, see: Honey Bee, 8(4):3, 1997; 18(3) 20-21, 1997; 10(3):2, 1999; 10(2)5, 1999; 11(2) 7, 2000; 12(2):8, 2001, 13(1): 22-23, 2002; 13(2): 14-16, 2002; 13(2): 15, 2002; 18(3) & 18(4):22-23 & 30, 2007; HB19(1) January-March 2008 etc.

<sup>20</sup> KENRIK is a promising institution for setting up a Network node, as they are keen to get involved with the Network. There are opportunities in the current projects for mutual support.



## 4.2 Formalizing the Network in Africa

The Honey Bee Network operates in India as an informal network of like-minded organizations, institutions, collaborators, innovators, individual volunteers and other engaged stakeholders. In the three decades of its existence, the Network's informal organization has never been a disadvantage, although there are formal organizations that provide institutional support to the Network (e.g. SRISTI, NIF, GIAN, and SRISTI Innovations). Some stakeholders argued that this would lead to regulatory as well as credibility issues in the African context. This is something that can be discussed in further detail, and the best way forward can be worked out as the scouting process begins. Other concerns included choosing a name for the network and setting rules and a framework in which individuals and institutional actors will interact.

### 4.2.1 *Scouting and documenting innovations*

KENRIK is an institution formed in 1995 under the Centre for Biological Diversity of the National Museums of Kenya to document "endangered" indigenous knowledge. KENRIK has developed the following databases: Medicinal Plants of East Africa; Kenyan Recipes; a Survey of Economic Plants for Arid and Semi-Arid Lands; and over 2000 photographs of medicinal plants.

Though the institution has worked hard to document traditional knowledge, they need to scale up their efforts manifold in order to create a database resembling the Honey Bee Network's. In the past, KENRIK followed an approach similar to the Network's, where they would scout innovations through students. However, the scouting process was discontinued after the funding ran out. Kenyan policymakers require convincing on the potential long-term impacts that traditional practices and grassroots innovations can have. In addition, the Jomo Kenyatta University of Agriculture and Technology (JKUAT) and the Pan-African University Institute for Basic Sciences, Technology and Innovation (PAUSITI) have agreed to collect grassroots innovations from students after their visit home for summer break. The University of Nairobi, which conducts a lot of research on traditional knowledge is a potential partner that could do much to scale up the scouting and diffusion process.

### 4.2.2 *Verification, validation and value addition*

The preliminary verification of practices can be conducted by the partner institution that has collected the data. Prior art searches can be conducted by interns and students at KENRIK and JKUAT. The Kenya Medical Research Institute (KEMRI) validates many herbal practices. KEMRI could perform validations for the practices scouted by KENRIK, as it would still be within their mandate. For innovations that are more technology-intensive, universities such as the JKUAT, Kenyatta University (KU) and Technical University of Kenya (TUK) can play an important role. However, in the early stages, validation and value addition can be conducted in the SRISTI Sadbhav Sanshodhan Lab (SSSL).

### 4.2.3 *Commercializing innovations*

Both JKUAT and KU have innovation centres and business incubators. These institutes can take the lead in business development. The National Council for Science, Technology and Innovation (NACOSTI) can take the lead in creating a policy environment conducive to grassroots innovations. Professor Henry Bwisa, the Chairman of the African Agribusiness Incubators Network (AAIN) agreed to ask his students to develop business plans for the herbal entrepreneurs mentored by KENRIK.

## 4.3 Institutional Challenges

The Bullet Santi evolved in India without external support thanks to the pool of about 500 derivative and incremental innovators working on improving the technology. Though facilitated by patent non-enforcement, this pool emerged organically and relied heavily on the manufacturing ecosystem of Rajkot.

It is important to note that there is very little institutional incentive for risk-taking. The cost of failure in the Kenyan context is too high. Though capacity was built across all levels in Kenya, technologies have not yet been absorbed by entrepreneurial actors outside of the public sector farm machinery manufacturing company. Trained engineers often need time and trial-and-error to fix tiny mechanical issues. This is symptomatic of a larger problem; there is a need to build capacity for local institutions to make complex machines. Most supporting institutions also have large overhead costs, which makes it difficult to make affordable technologies. The bias in favour of imports rather than local design and manufacture needs to be tempered.

#### *4.3.1 Policy and regulation*

There is no doubt that a lack of policy support for grassroots innovations in Kenya is a major impediment to the success of such projects. Kenya heavily taxes the import of steel and subsidizes the import of agricultural machinery. This disincentivizes local manufacturing. In addition, the costs of labour, power and credit are too high for any industry to thrive. The Kenyan government has to take proactive measures to provide incentives for manufacturing, such as cheaper credit, no or very low taxes on imports of steel, components and subsidized power for small and medium enterprises.

Once the standards are created for innovative technologies, the regional transport authorities will be able to register to allow tractors to operate. Registration will also help to extend institutional finance to small farmers to purchase these tractors. Similarly, for herbal products, regulatory approvals are required for scaling up. For this, institutions like KEBS, NACOSTI and the Kenya Industrial Property Institute (KIPI) can be brought into the fold at a later stage.

#### *4.3.2 Intellectual property, open innovation and technology commons*

Teams from the Honey Bee Network have found Kenyan grassroots innovators and traditional knowledge holders to be well-informed about IP issues. While explaining the application of IPR protection for innovators and outstanding traditional knowledge holders, the contribution of IP law firms in India and abroad was highlighted, as their *pro bono* work minimized the costs of filing<sup>21</sup>. Participants had several questions in response to the sharing of open source databases about how intellectual property rights of the innovators are protected without compromising the goal of promoting peer-to-peer learning.

### **4.4 The Way Ahead: Recommendations For Success**

#### *4.4.1 The Honey Bee Network's foothold in Africa*

The Honey Bee Network is already recognized among African policy makers and has a foothold in the region. A few key events and introductions have given the Network a foothold on the continent.

The Commonwealth Science Council, London (since wound-up) played an important role in creating knowledge networks with Commonwealth members around various science, technology and innovation issues. Dr Ben Gubane, the former Minister of Science and Technology of South Africa and former chair of the Commonwealth Science Council, was so inspired by the Honey Bee Network philosophy and actions that he wrote a letter to the Science and Technology ministers of member countries, recommending them to follow this approach. He also organized a meeting of ministers in Limpopo Province of South Africa where he invited SRISTI to organize and exhibition of innovations.

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<sup>21</sup> The cost of filing was minimised to approximately 300 USD. If we calculate the average cost of filing without this assistance to be ten times this amount, then their contribution for about 1000 patents and plant variety protection amounts to USD 2.7 million. Similarly, the contribution of scientists who did not charge for their time while validating and adding value to innovators' knowledge was at least USD 10 million.

Several grassroots innovators worked with South African engineers and students to jointly develop a donkey cart and improve other technologies.

The Indian Government hosted a meeting of Science and Technology ministers in Delhi where grassroots innovators attracted attention. The Science and Technology Ministers of Zimbabwe and Mozambique signed an MoU with NIF for capacity building for grassroots innovation.

While the Prime Minister of India, Shri Narendra Modi, visited South Africa, an agreement was signed between NIF and the Department of Science and Technology of Republic of South Africa. Hopefully this will lead to further exchanges of ideas and innovations.

Individual scientists and scholars often make significant contributions to the Network in their individual capacity. Paul van Mele (then at the African Science Centre) is one such proactive scholar who has contributed outstanding innovations and given due credit to individual and community innovators. Today, his work is one of the most important sources of African community knowledge in the public domain.

The Network's existing recognition in Africa and the interest and engagement of prominent academics and policy makers in the region has created good conditions to foster an African branch of the Honey Bee Network.

#### *4.4.2 Recommendations for scouting, documentation, publication & dissemination:*

- a) **Linking students with the innovation network:** It is critical to establish linkages between students in universities and Technical and Vocational Education & Training (TVET) institutions and the innovation ecosystem.
- b) **Mobilizing volunteers:** A meeting for volunteers from various agricultural and other universities, including those who have published papers on local knowledge and innovations, should be called to gauge their interest in getting involved with the Network.
- c) **Translating the database:** The Honey Bee Database needs to be translated into French to be of use to Francophone countries in Africa. Though the reach of English is widespread in countries such as Kenya, Nigeria, and Ghana, there is no substitute for content presented to people in their local (or at least national) language. A Swahili language version of open source Honey Bee Network database would be a good start. This could be shared with local communities in Swahili-speaking communities to encourage people to experiment and share their own solutions (including failed experiments).
- d) **Translating the newsletter:** The first African Honey Bee Newsletter will be based in Kenya and will be translated into Swahili to benefit East African readers.
- e) **Sharing at conferences:** A special session can be organised for the African Network partners at the ICCIG taking place January to February, 2019. This can also be an occasion to share published case studies on cross-cultural learning and sharing grassroots innovations.
- f) **Using social media:** A new social media campaign will be launched sharing one African innovative practice or solution every day for a month.

#### *4.4.3 Strengthening the informal sector in Africa*

African countries should seek to emulate Kenya's semi-formalization of the *jua kalis*. As a start, African governments can provide a common space to these innovators as well as tax incentives. Incentives for innovation, such as awards, should be developed in collaboration with the national and/or provincial governments. Kenya already has county-wide *jua kali* exhibitions. These can be arranged at the

national level in African countries or at the continental levels to promote more innovation, e.g. Pan-African Grassroots Innovation Medals.

Kenya and Nigeria have many incubators and a burgeoning startup culture. In order for these to be more inclusive, governments can mandate these incubators to allot 5 per cent of funding for grassroots enterprises.

#### *4.4.4 Setting up the Network*

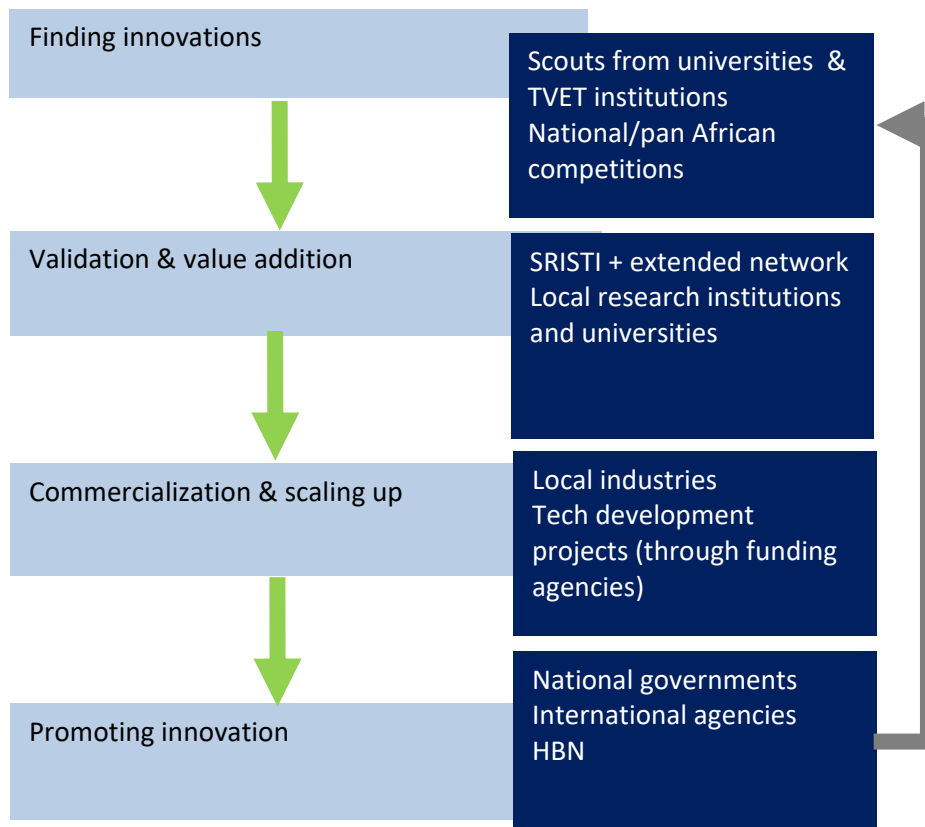
African scholars should agree on a common definition of grassroots innovation. Efforts should focus on building a consensus while accommodating local constraints. SRISTI can provide validation and value-addition support to all African networks in the initial stages. A pan-African capacity-building grassroots innovation workshop can be organized for local universities and other likeminded actors. Here they can develop validation processes and add value to grassroots practices and innovations discovered in their respective countries.

#### *4.4.5 Creating a market to support local innovations*

A market place for grassroots innovations is needed for a network to succeed. Funding agencies should focus on scaling up local innovations that help the local economy and are also fair and non-exploitative of people and ecosystems. Shea butter, for example, is a natural ingredient that was used in Africa for thousands of years which was commercialized a few decades ago and now has benefited many local communities in West Africa.

An integrated model of engagement is proposed below. This study has laid out a collaborative pathway, which is to be collectively paved for the further exploration of grassroots innovations in Africa.

Figure 4: Proposed model of grassroots innovation network in Africa



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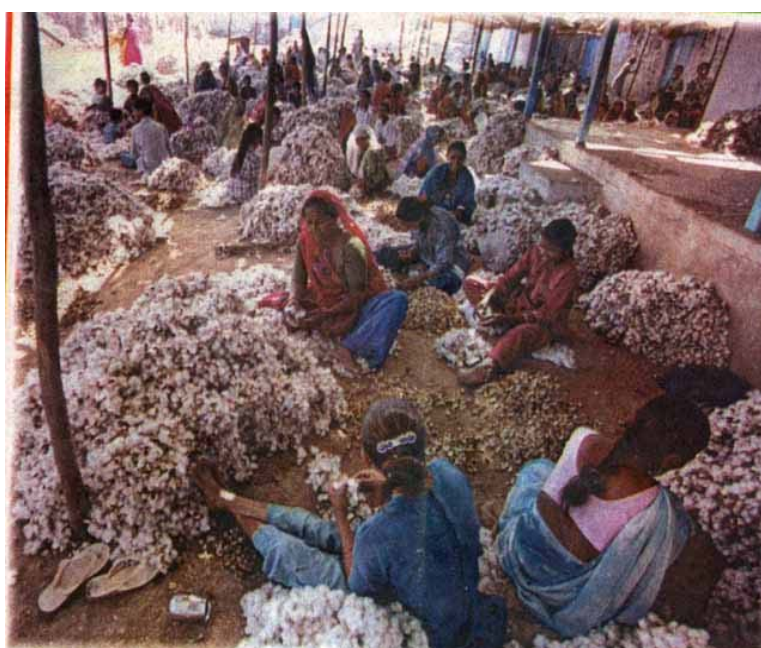
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## Appendix 1: The Cotton Stripper

### *Genesis*

Dryland cotton varieties typically grown in certain parts of India require labour-intensive processing, which is often done by women farmers and with child labour. These varieties, such as Kalyan V 797 have cotton lint held tightly in partially opened balls. The cotton boll is pulled out of shells manually in a slow and tiring process, and the process leaves fibres in air that cause health problems. In 2001, after several iterations, Mansukhbhai Patel developed the cotton stripper, which automated the stripping of shells from cotton bolls. As a farmer, Mansukhbhai was very familiar with the cotton value chain. As a child, he had stripped cotton manually. After joining a textile mill in Ahmedabad, Mansukhbhai gained a deeper understanding of the functioning of various machines.

Figure 5: Women separating cotton lint from cotton balls



Mansukhbhai is now a successful entrepreneur. He has set up multiple business offices and factories – one manufacturing unit for cotton stripper, three ginning factories, two nails and wire making units, and a corporate office.

### *The Role of The Honey Bee Network*

Mansukhbhai Patel is one of the rare innovators with acumen for both innovation and entrepreneurship. It is quite probable that he would have succeeded on his own. However, the existence of the Honey Bee Network certainly made his journey shorter. The Network has supported Mansukhbhai throughout the innovation lifecycle. The innovation was discovered through SRISTI's scouting and documentation process. Later, GIAN took up this innovation, provided investment and mentoring support and played a crucial part in transforming it into a successful enterprise. Mansukhbhai later joined the Governing Board of GIAN to support other innovators like himself.

### *Scouting the innovation*

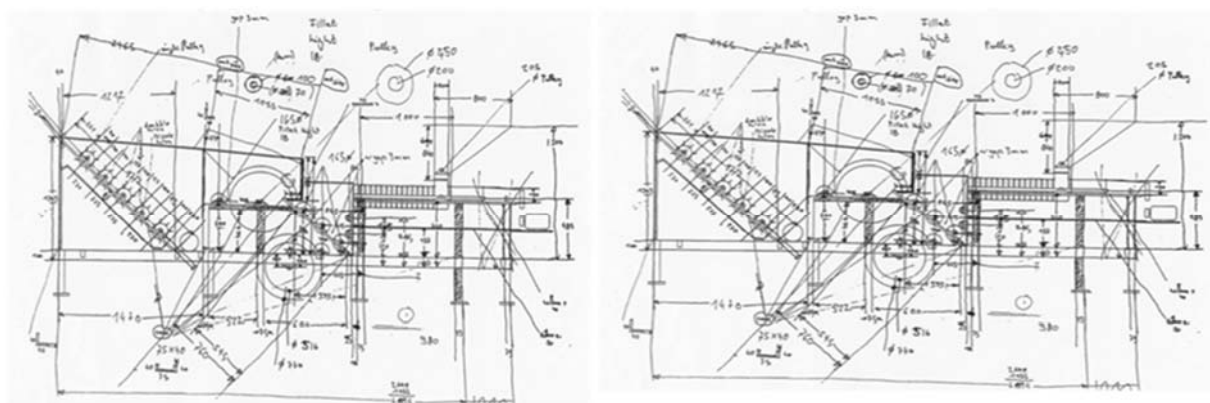
In 1995, Hirendra Rawal, a student of a rural Gandhian institution, and a summer scout was on the lookout for innovators. He heard the curious case of an innovator who had developed a cotton stripping machine that had failed. The villagers recounted how the innovator, Mansukhbhai Patel took back the machine from his consumers and returned the money he had collected. Hirendra found

Mansukhbhai's whereabouts and went to meet him and sent his field notes to SRISTI. It was at this point that the Network got more actively involved.

#### *Technical support: a German connection*

Professor Kishor Munshi of the Industrial Design Centre (IDC), an Indian Institute of Technology, Bombay (IITB) was invited by GIAN to assess the design. He suggested changes to the alignment of the drums, an adjustment of the spike shaft so that the hopper does not get clogged at the bottom. A collecting mechanism was suggested for the waste shells. GIAN also sought help from the National Institute of Design in Ahmedabad and a design student on exchange from Germany, Alexander Bošnjak, took it up as his final year project.

Figure 6: Alexander Bosnjak's designs of the cotton stripper



As the son of Mansukhbhai once recalled, what they learned from Alexander was not specific design inputs, but more importantly, the principles of design thinking. His machines improved considerably thereafter, although these interventions did not immediately solve the problem. They did, however, nudge the innovator closer to the solution. After the first few models, Mansukhbhai rented out the fifth model to the local ginning factories for feedback.

GIAN helped in the value addition and research and development activities, especially on the sixth and seventh model which became a huge commercial success.

#### *Market Research and Feasibility Study*

GIAN, with help of students at the Nirma Institute of Management Studies, conducted a detailed and comprehensive market and feasibility study for the machine. The study also included developing a project management plan for the innovator for commercial production. The report found that the market had been waiting for such a machine for a long time and that there would be significant demand; the study predicted a standing demand of almost 350 machines from the Gujarat market only.

The innovator took over the manufacturing responsibilities and GIAN helped Mansukhbhai become an entrepreneur. Chetak Agro Industries, a partnership firm, was created to manufacture the machine, and the workshop was based in Viramgam Taluka in the Ahmedabad district.

#### *Funding Support*

GIAN arranged a working capital loan for the production unit from the State Bank of Bikaner and Jaipur to initiate production. The unit was still running short of the required funding for full-fledged production. Additionally, due to the monsoon conditions, the debt financing strategy had to be reconsidered, since bad monsoon conditions could have rendered all the calculations irrelevant, making it difficult for Mansukhbhai to service the debt.



GIAN also helped Mansukhbhai secure INR 580,000 under the Technopreneur Promotion Program (TePP), the Department of Scientific and Industrial Research, New Delhi in 1998-99. This small grant proved to be a turning point and helped him become a millionaire.

### *IP Support*

When a complete commercial prototype of the Cotton Stripper machine was developed, with modified design and added technical features, it was ripe for market launch and commercial production. In order to protect the intellectual property rights of the innovator, a patent application was filed in India and in the USA by GIAN in collaboration with SRISTI. The Indian application was filed with the help of the National Research Development Corporation (NRDC) in 2001 and awarded in 2006.<sup>22</sup> GIAN filed the patent in 2002 in the USA (through pro bono help Tom Turano of the IP firm THT, later merged with K & L Gates based in Boston) after considering the potential demand by American entrepreneurs and investors to market the product in other countries.<sup>23</sup> It was granted by the US Patent Office in 2003,<sup>24</sup> and SRISTI and GIAN received the patented designs.

Despite the patent protection, there were attempts to copy the design for commercial purposes. GIAN sent notice on behalf of the innovator to invite the imitators to a discussion and explore licensing opportunities. However, since these units had simply copied the idea without possessing the tacit knowledge, they were unsuccessful and were driven out of the market. The importance of the tacit knowledge garnered by Mansukhbhai through almost a decade of research and development thus proved very valuable to him in safe-guarding and improving his innovation.

A mobile van service was initiated to provide post-sale support. Breakdowns during the cotton season could result in heavy losses to cotton farmers. The company provides a one-year warranty for the product. The company also provides post-warranty support; the customer is charged for actual parts and transport expenses only (no labour charges levied).

### *Diffusion*

The machine was displayed at several technology fairs and exhibitions, such as the Indian Science Congress, Pune & Swadeshi Fair, and in New Delhi to generate market feedback. It received ample media coverage. Successful demonstrations were also arranged in different parts of the Gujarat. The demonstration helped convince the consumers about the use and efficiency of the machine.

### *Impact of the innovation*

The cotton stripper is 20 times more cost effective than the traditional method. Stripping cotton is a pre-ginning process. Initially the women farmers and child labourers had to strip cotton and then give it to the ginning factories. With the factories buying this machine, it not only eliminated the use of children but also saved the farmer women from this drudgery and increased the productivity of the process.

### *Obstacles to scaling up*

The area where Kalyan cotton is cultivated is limited to the Saurashtra region of Gujarat. This type of rainfed cotton has a highly uncertain production process and has led many farmers to shift to BT cotton varieties. Since the bolls of BT cotton split open spontaneously upon maturity, the relevance of the machine will decrease. Fortunately, Mansukhbhai has diversified his businesses. There is also no doubt that public policy support in the initial stages may have sped up the process of innovation and diversification.

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<sup>22</sup> Patent number: 198755.

<sup>23</sup> GIAN received assistance from SRISTI and *pro bono* support from Tom Turano, partner at Test, Hurwitz and Thibault (THT), LLP, Boston (it has now merged with KLN Gates).

<sup>24</sup> Patent number: US 6,543,091 B2

### *Key takeaways*

**The intermediary function of the Network** and its institutions is important not only for scouting innovations, but also for solving the problems of grassroots innovators in a collaborative manner. All relevant skills cannot usually be found in one single organization or place, but networks enable collaborations with other organizations to help grassroots innovations reach their potential.

**The ethical capital** earned by Mansukhbhai when he returned the money of dozens of his dissatisfied customers who found his machine defective benefited him. The scout who traced Mansukhbhai was intrigued by his story of returning the customers' money when the innovation underperformed.

**Collaboration** with the ginning factory helped scale up the cotton stripper. Now that he has integrated the stripper with ginning factories, farmers no longer need to strip cotton and can sell their raw cotton bolls to the ginning factory directly.

## Appendix 2: The Bullet Santi

### *Genesis: Potential customers drive design innovations*

When a friend of Mansukhbhai, a local mechanic from Gujarat, approached him to find a solution for affordable draft animal power, given the declining viability of bullocks for farming, it triggered a chain reaction. Seeing his friend sitting on a motorcycle, he asked him to leave the bike with him so that he could try making some adaptations. The Bullet Santi was first developed in 1993-94 by Mansukhbhai Jagani. The Bullet Santi started out as an attachment behind a 350cc Royal Enfield Motorcycle which was used for light farm work such as harrowing, weeding, making ridges, spraying pesticides and hauling loads. Though GIAN and SRISTI helped Mansukhbhai Jagani patent this innovation in India as well as the US, he never enforced the patent, saying that he alone could not meet the market demand and that it was wrong to rob a farmer of a good technology. He therefore allowed and encouraged other small-scale fabricators to imitate, improve upon and produce the Bullet Santi. This allowed more than 500 businesses to flourish. About 15,000 units are currently plying the fields of Saurashtra. This was one of the three grassroots innovations transferred by SRISTI to Kenya through JKUAT under a technology transfer project with the help of USAID India<sup>25</sup>.

Figure 7: The first model of the Bullet Santi



### *Evolution of the Bullet Santi in India*

Diffusion happened at a faster pace than it would have if only the innovator manufactured it, as multiple people started fabricating the motorcycle Santi and numerous derivative innovations. In the last 23 years, many follow-on innovators have made important changes to the technology, which has allowed it to grow and thrive in Saurashtra. The latest models have drastically improved the performance and adaptability over the first prototype.

### *Transformation from Bullet Santi to Shujaa<sup>26</sup>*

The technology of the Bullet Santi was transferred to innovators and farmers through JKUAT Kenya under a USAID-funded project. The Bullet Santi was developed and fine-tuned for the flat, sandy loam soils of Saurashtra. In contrast, the project region in Kenya had heavier and deeper soils with

<sup>25</sup> See details of the project here: <https://www.youtube.com/watch?v=eUkK68vxCL4>

<sup>26</sup> Some of the factual details in this case draw upon existing descriptions of the innovation (GIAN, 2010; Manu, 2010). However, the majority of the information about the transfer of the technology to Kenya is shared for the first time.

undulating terrain in many villages. This situation demanded a higher torque, greater stability and greater ground clearance of the equipment. As a result, the innovators, technologists, engineers and project staff in both India and Kenya pursued several cycles of adaptive research.

The host institution, JKUAT, registered a local enterprise called Kilimo Tech Machineries to produce and market new products to help the farming community by removing drudgery and improve efficiency while reducing the cost of farming.

### *Capacity-building activities*

Throughout the project multiple learning and trainings visits were organised in both directions for the Kenyan engineers, producers, mechanics and other stakeholders such as members of academia. Indian grassroots innovators visited Kenya to solve problems faced by local *Jua Kalis* and mechanics in adapting the Santi. It eventually became a small tractor. The *Jua Kalis* learnt the entire process of disassembling and assembling the Santi together. They were also exposed to supply chain management, including sourcing off-the-shelf components, producing specific parts, assembling, maintenance, and repair. Their visit to India focused on the following three main activities:

#### 1. Exposure to various models of the Bullet Santi

The Bullet Santi and its contemporary variations are produced in five districts of the Saurashtra region. About 150 producers manufacture the Santi and more than 500 others service the Santi. This is the derivative innovation economy. It was important that the Kenyan *Jua Kalis* view not just the lead technology but also the way that variations emerge in the local regions. These variations reflected the changes in cropping pattern, soil structure, farm operations at different stages of crops like cotton, and constraints such as the non-availability of old motorcycles. They visited key pioneering producers in the villages of Mota Devaliya, Chittal and Liliya before beginning to work on production.

#### 2. Hands-on assembling training

The *Jua Kalis* worked together with four key innovators – Mansukhbhai Jagani, Shailesh Dodiya, Rasikbhai Rathod and Hasmukhbhai Chauhan – and learned about the specifications of the spares, fabrication of the chassis, the mounting of components of the chassis and the clutch, differential assemblies and other finer details. Dharambir Kamboj, the innovator of the multipurpose food processing machine, also joined the visit. The *Jua kalis* helped in dismantling and reassembling the food processing machine. They also used it to make juice, jams and aloe vera gel.

#### 3. Understanding the ecosystem of other industries that support the Santi economy

The *Jua Kalis* visited Rajkot, which is where the spares of Santi are sourced. It must be noted that the Santi uses many second-hand parts such as the gearbox and differential drive, salvaged from old used or discarded automobiles. These have a much longer life than the whole car and can thus be used. This example of a circular economy demonstrates how grassroots innovators are often the best propagators of multiple life cycles. It was thought that the *Jua Kalis* should understand that this economy did not emerge in isolation. Rather, several supporting factors have contributed to its thriving growth in Saurashtra. Many specific key parts are also often outsourced to producers in Rajkot. Supporting services such as foundries and precision turning are easily found in Rajkot. In Kenya, Nairobi and Kisumu can serve as hubs for the Lower Eastern and Western Kenya regions. *Social embedding of innovation lifecycles in industrial clusters whenever possible is a useful lesson from this experience.* However, there are many regions in North-east and eastern India where such linkages have not yet been feasible due to poor infrastructure.

The *Jua Kalis* learned various skills. They made several drawings and took pictures of the machines and vowed to work on the designs. Several options on how to secure funding for their prototypes were discussed.

### *Development of supporting ecosystems*

In April, 2017, Kilomo Tech Machineries (KTM) was registered as a limited liability company. JKUAT, which hosts Nairobi Industrial and Technology Park (NITP), expressed its willingness to provide land as well as to buy some stake in the enterprise. In addition, NITP has submitted a proposal to the Ministry of Industrialization to provide the working capital required to procure and/or produce the tractors on a large scale. Mr. Paul Apondi and Peter Nyariki have played active roles in the adaptive research and will be important stakeholders in the company, with Apondi taking the leadership role. JKUAT is committed to buy stake in the company and, later on, strategic investors may be involved.

By way of initial strategy, it has been decided that the company would go through two phases. During the first phase it would import mini-tractors/Santi derivatives from India produced by the informal sector in Saurashtra, India. In the second phase, it would gradually start manufacturing the key components and source the secondary components from local industrial units.

Later, SRISTI also approached other private sector players in Kenya who could potentially directly sell components/whole Santi to the farmers. Nauman tractors sell tractors imported from India and China to farmers in Kenya. They also provide tractor training to users, including those who rent it out to others. They have expressed interest in stocking, selling and renting out small tractors from the innovators in the Honey Bee Network fostered by SRISTI and GIAN. Talks with Agricultural Tractor Spares Limited also were fruitful. In September, 2017, a tractor was lent to Vegpro Enterprises (a vegetable exporter to Europe) which placed it in Naivasha to help the vegetable growing farmers.

Towards the end of September 2017, discussions with the Managing Director of the Kenya Bureau of Standards (KEBS) were held along with the senior leaders of JKUAT. They immediately constituted a joint committee of experts from JKUAT and KEBS to develop standards for Shujaa, the local version of Santi with four-wheel or a small tractor. A meeting of stakeholders including country's top farm machinery experts from the public and private sectors took place to evaluate the standards, test drive the Shujaa and then modify the proposal. Later, the standards were issued and a follow-up order of 20 tractors was placed by a JKUAT subsidiary to SRISTI to facilitate an early kick-start until local manufacturing facilities are set up.

Naming an innovation in the local language is an important part of institution building for technology transfer. The new name Shujaa symbolizes its ownership by Kenyan policy makers, experts and society.

## Appendix 3: Co-development and Adaptive Research for the Shujaa

The process of adapting the Santi to Kenyan conditions that eventually led to the Shujaa was an iterative one. The first piece of feedback was changing the motorcycle's handlebar into a steering wheel and moving from three wheels to a four-wheeled version. There was also need for greater torque. It was therefore recommended that the chain and sprocket be removed and to have direct coupling between the gearbox and differential to reduce transmission losses. Increased ground clearance was also suggested. The steering and four-wheel adjustment was made. However, the use of a coupling combined with the increased tire size increased the revolution per minute (rpm) of the tractor. Therefore, after eighteen months of struggling with this problem, the decision was made to reduce the gear to reduce the RPM and increase the torque. This gearbox process was outsourced to Numerical Machining Complex (NMC), and a year later, they produced a gearbox. Unfortunately, it was not leak-proof and was also too expensive for the tractor. In order to address these issues, a team of JKUAT engineers visited India and worked with the local innovators to make the necessary design changes. After a week-long process, which involved designing and trying out various types of reduction mechanisms, they were able to improve one tractor.

In this tractor, they replaced the earlier simple chain and sprocket mechanism with a counter shaft sprocket. This modified tractor now had improved performance in terms of torque generated and consistent ploughing depth.

Figure 8: JKUAT and NMC engineers working with Indian fabricators to improve Shujaa



Figure 9: Modification in the Reduction Mechanism

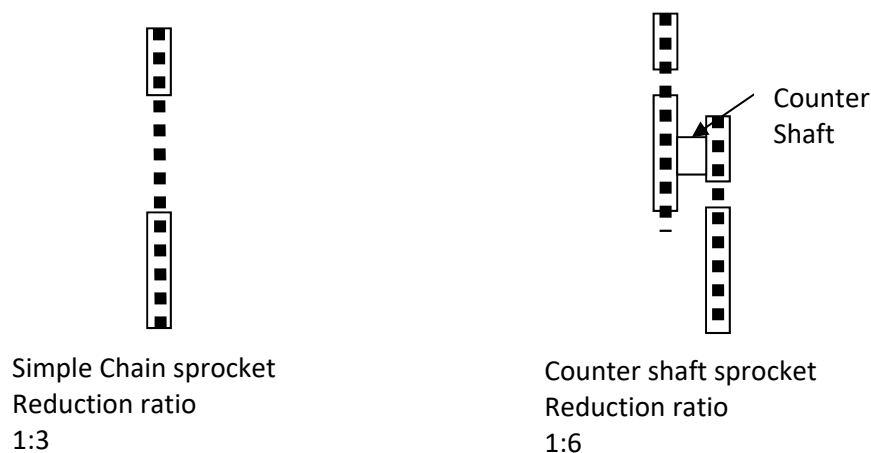


Figure 10: A tractor being modified by Mansukhbhai with engineers from Kenya (left). First testing of the modified tractor (right)



Meanwhile, SRISTI also tapped into its pool of more than 500 producers and innovators, which churn out multiple models of the Bullet Santi each year, to know if an alternative model with a better design and performance was available. This led us to Una (near Diu) where a composite transmission Bullet Santi model was discovered. This model was tested and its performance seemed to be satisfactory. The innovator was advised to come up with a four-wheeled tractor to increase the capacity of the engine.

In a few months, the innovator was able to provide an improved four wheel tractor. After rigorous testing was conducted by the innovator, the SRISTI team was invited to test the tractor for performance. The tractor could attain greater soil depth consistently due to the added depth control mechanism. The higher torque ensured that the tractor did not encounter much resistance. The handling and performance was also better than the previous models.

These two models were then shipped to Kenya along the modified tractor. The countershaft would be replaced in other tractors that are not in use. The shipment of these machines took a long time, as this was the first time the tractors were sent whole. The team was informed that having a KEBS certificate or a certificate from a similar Indian agency would simplify the process. SRISTI believed it would be easier to obtain the certificate from Kenya rather than India. Therefore, the process to seek KEBS certification was expedited. The tractors were ready to roll out on the field (barring repainting). They were tested in JKUAT for performance and seemed to perform better than all the earlier models.



Figure 11: Testing the new model of tractor in India



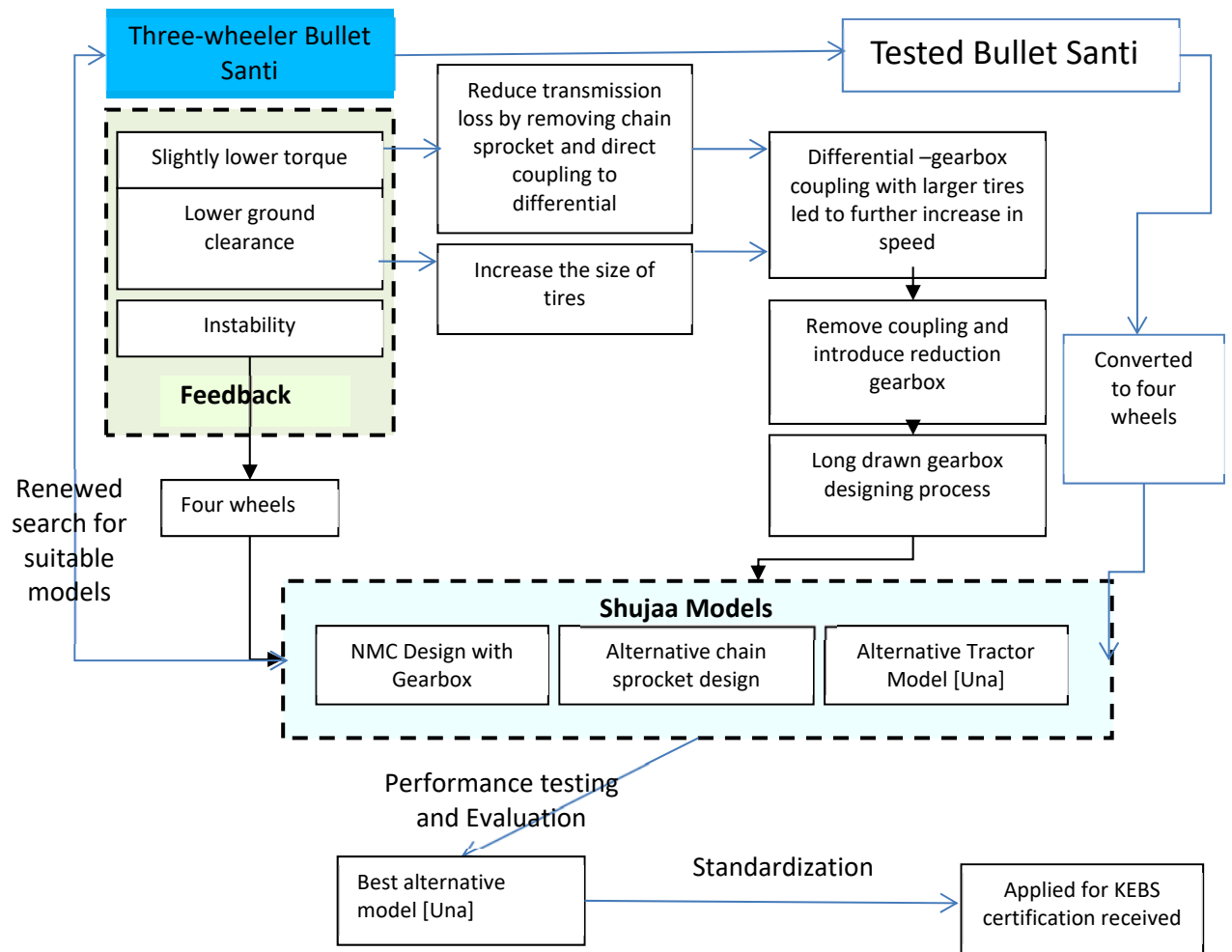
Figure 12: Testing the new Shujaa model in Kenya



Several months of co-creation efforts have finally yielded a product that meets the needs of the marginal farmers in Kenya. The complete adaptive research process for the Shujaa has been depicted in the following flow diagram.



Figure 13: Adaptive Research for the Bullet Santi transformation to Shuja



## Appendix 4: Lessons and Feedback from the *Jua Kalis*' Visit to India

- 1) **Better simulations and more detailed communication:** SRISTI facilitated the visit of fabrication engineers to India with the *Jua Kalis* to learn about the process of sourcing components and assembling them. To make the experience more effective, SRISTI could have conducted more robust trials of the machinery in difficult terrain in order to simulate the user conditions. The posters and videos could have been more user-friendly, module-wise, to make learning about the intricacies of the gear box, attachment, flywheel, and the load balancing system more intuitive for local mechanics.
- 2) **Complementing skill building with a tool kit:** The visit to India would have been even more effective if there was financial support for the local mechanics to be provided with an assembly kit to make their own tractor, dibbler and food processing machines (only some of the *jua Kalis* were given a kit). The project could have included teaching mechanics to service the machines, redesigning them and making them with local components. However, the much higher cost made this impossible given the limited resources available.
- 3) **Mind to market:** Marketing the produce made by the food processing machine was not part of the original project. Marketing trials early on in the process could have facilitated feedback from potential users to adapt the machine according to customer needs. Indian innovators and other team members from SRISTI could have conducted exchanges with local community leaders, influential community members and others to understand the culturally-specific, institutional imperatives of local capacity building. A more gender-balanced team could also have been helpful in this regard.
- 4) **Engaging the youth:** Interested young faculty members and students from JKUAT could have been involved on a larger scale. SRISTI put a lot of pressure on its small team. Their burden could have been shared by a small gender-balanced team to work with communities more closely.

## Appendix 5: Innovations by *Jua Kalis* in Kenya

James Kitolo, a farmer and mechanic from Machakos, Kenya, developed farm attachments for the larger Shujaa tractors in Kenya. It was a video of his daughter driving a Shujaa that convinced the chairperson of KEBS of its simplicity of operation and its utility for the country. The process of creating standards for the Shujaa was positively influenced by Kitolo's creativity.

Simon Chelegoi, a *Jua Kali*, from Bomet East sub-county of Bomet developed multiple innovations using bicycle parts. His machines include a carving machine, a flour mill, a chaff cutter, a knife sharpener and a drilling machine. Eric Ronoh is another *Jua Kali* working alongside Simon in the Bomet Jua Kali centre. Inspired by Simon, Eric has used the cycle mechanism to develop a kiln for smelting aluminium. In this arrangement a large bicycle wheel turns an air pump that provides air pressure for the furnace to smelt aluminium. He has been trying to increase the furnace temperatures to smelt other metals.

Another *Jua Kali* from Machakos, Leonard Mutisya, developed a low-cost wind-mill. The team met innovative *Jua Kalis* from all over the country.



Simon's bicycle-based multifunctional machine for carpentry and maize milling



Maize mill in Simon's multipurpose machine



Eric Ronoh's Aluminium smelting furnace

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