Chapter 1
Summary of Keynote Lectures and Panel Discussions of RTDD-2018

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1 Introduction

Five keynote lectures were delivered during the 1st international conference on 'Rural Technology Development and Delivery (RTDD): RuTAG and its Synergy with other Initiatives' at Indian Institute of Technology Delhi, India during March 9–11, 2018. Details of these presentations are summarized in Sect. 2. Two panel discussions on the topics entitled as 'Taking Products to People through Social Enterprises', and 'RuTAG and Its Future' were also held during the conference which are briefed in Sect. 3.

2 Summary of Keynote Lectures

Five keynote lectures on various topics related to rural technology, development and dissemination were delivered by Dr. Chidambaram, Prof. Fujiwara, Prof. Shankar, Prof. Chakravarthy, and Prof. Dhar, as a part of the RTDD conference. The crux

Here, authors only summarized and compiled the details obtained from the keynote lectures and panel discussions of RTDD-2018.

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S. K. Saha and M. R. Ravi (eds.), *Rural Technology Development and Delivery*, Design Science and Innovation, https://doi.org/10.1007/978-981-13-6435-8_1

of their presentations is summarized below, mainly based on the slides used by the speakers during their keynote lectures.

2.1 Keynote Lecture by Dr. R. Chidambaram,[1] Principal Scientific Adviser to the Government of India on 'Rural Technology Development and Delivery: Many Dimensions'

This keynote lecture was started by pointing out the importance of the UN-defined 17 Sustainable Development Goals (SDGs), viz. No poverty, Zero hunger, Good health and well-being, Quality education, Gender equality, Clean water and sanitation, Affordable and clean energy, Decent work and economic growth, Industry, innovation and infrastructure, Reduced inequalities, Sustainable cities and communities, Responsible consumption and production, Climate action, Life below water, Life on land, Peace, justice and strong institutions, and Partnerships for the goals, and targets which are 'global' in nature taking into account different national realities, capacities and levels of development and respecting national policies and priorities. He mentioned that the SDGs are people centred and planet sensitive. The goals are not independent from each other and they need to be implemented in an integrated manner. The decision to launch a process to develop a set of SDGs was made by UN Member States at the United Nations Conference on Sustainable Development (Rio+20) held in Rio de Janeiro in June 2012 and detailed in 2015. He enunciated again that all the SDGs are interlinked and the most important goals are relevant for rural development.

He explained that the Human Development Index can be redefined for a developing country like India, as he has been saying for three decades, in terms of Per Capita Electricity Consumption (PCEC) and Female Literacy (Fig. 1). In Fig. 1, each point refers to a country and the numbers are female literacy percentages [1, 2]. He emphasized the significance of all energy options and highlighted the fact that electricity consumption growth must also reflect our concern for climate change. Interestingly, he added a quote, 'Innovation-led growth is no longer the prerogative of the high-income countries' from 'Thematic Think Piece' of the UN Task Team [3]. He highlighted the prominence of principles of equity, gender equity, intergenerational equity, etc., which were present in the Brundtland Report and in the report of the discussions in Rio 2012. Dr. Chidambaram stressed that these principles must be continuously expanded to cover all possible dimensions of equity. In addition to this, removal of poverty, hunger, etc., should be considered as only preliminary SDGs need to evolve as per the progress of economies of developing countries.

The PSA portrayed many dimensions required for Indian innovation as India is large and diverse. Change is occurring at a rapid pace that a single innovation policy

[1] Dr. R. Chidambaram has completed his term as Principal Scientific Adviser to the Government of India on April 3, 2018.

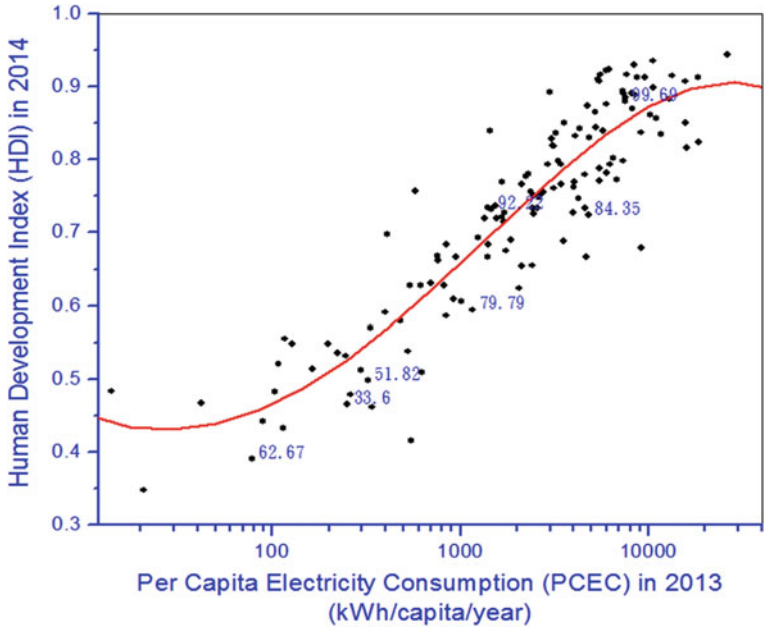

Fig. 1 A graph showing the variation of PCEC with respect to human development index

for India is impossible. He quoted that conditions vary widely among technologies in India. For example, India is on par with global leaders in some technologies (nuclear power, space, some areas of defence and knowledge chemicals), well behind in other sectors (productivity of small and medium enterprises), and in a position to leapfrog into global leadership in some areas (tools for rural development) [4].

Under mechanism for technology development and delivery, he articulated major three process, viz. Research, Development and Delivery, as shown in Fig. 2. Development of technology through enhanced academia with industry interaction interfaces (e.g. CAR, CMAT & CAREL of PSA's Office for Automotive, Machine tools & Electronics Hardware) for 'precompetitive applied research' is required, along with what he termed as 'directed basic research' in rural areas. Rural technology delivery through knowledge transfer, knowledge brokering [5], scaling of innovations and concept transfer followed by re-innovation are the need of the hour. In this connection, he explained the importance of RuTAG which was conceived in the PSA's Office, as a synergizing and catalyzing mechanism to provide a higher level of S&T intervention and support, than hitherto achieved. RuTAG is centred in 7 IITs at present, but with links to other R&D institutions (e.g. BARC) and universities/colleges. The office of the PSA also initiated RuTAG Chapters attached to RuTAG Centres. The first Chapter is at University of Jammu, attached to IIT Delhi Centre. RuTAG is an open platform innovation strategy for rural technology delivery. Established years of RuTAG centres are shown in Table 1.

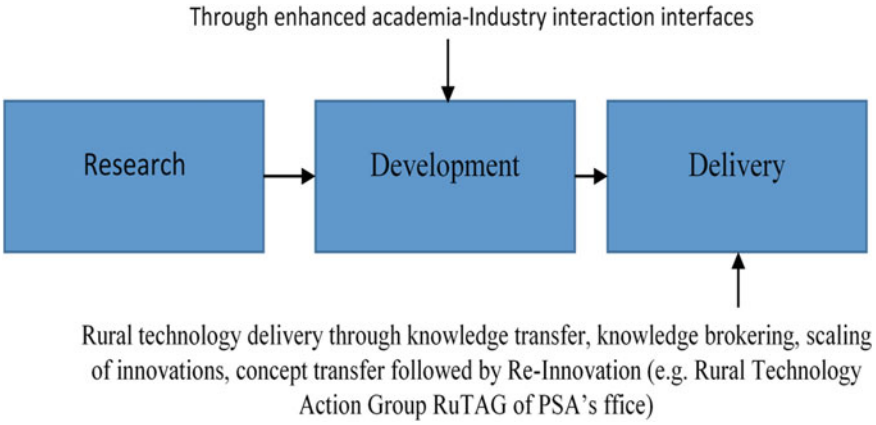

Fig. 2 Mechanisms for technology development and delivery

Table 1 RuTAG centres

RuTAG centres	Established year
IIT Madras	2004
IIT Guwahati	2005
IIT Kharagpur	2008
IIT Delhi	2009
IIT Roorkee (started functioning as RuTAG Uttarakhand at Dehradun in 2004)	2009
IIT Bombay	2010
IIT Kanpur	2013
Chapter-University Jammu	2014

Dr. Chidambaram then highlighted some of the major technologies delivered by various RuTAG centres (IIT Madras, IIT Bombay, IIT Guwahati, IIT Kharagpur, and IIT Delhi). RuTAG IIT Madras has come up with a chemical alternative to mud used in Bidriware. The problem was confronted with the availability of mud from Bidar fort which was being used in the manufacturing process of Bidriware, as Archaeological Survey of India (ASI) recently restricted access to the fort. It has also been observed that other muds do not give the desired black colour. RuTAG IIT Madras studied the mechanism of Patina formation, and found out that nitrates is the key component which leads to selective dissolution of Zn and oxidation of Cu. They conducted testing with the soils obtained from within and outside the fort and subsequently developed a chemical process for required black colour. Another technology that IIT Madras has developed was modified pedal loom with better yield and low yarn breakages that help the workers to earn better wages. It has been installed at Udayanapuram Khadi

Cluster Unit Vaikom, Kerala. With the technical support of RuTAG IIT Madras, ten such looms would be fabricated by a KVIB approved entrepreneur.

Next, the PSA talked about the floating cage structure for reservoir fishing developed by RuTAG-IIT Bombay. IIT Bombay has improved the presently available floating structures using G.I pipes, fibre gratings and plastic drums. This has been installed at Dimbhe village by the NGO Shashwat and it costs about Rs. 5.0 lakhs/4 cages. The technology was transferred to an entrepreneur. Also, Ministry of Tribal Development, Government of Maharashtra has sanctioned Rs. 99.0 lakhs to Shashwat to instal 28 fish cages in 4 dams. Dr. Chidambaram pointed out the technology 'Modified power looms for Muga silk weaving' installed at export-oriented industrial complex at Amingaon, Guwahati, Assam by RuTAG IIT Guwahati. Existing power loom was modified by alteration of the gear system of the loom in order to regulate the appropriate speed of the loom suiting the requirement of muga yarns for weaving in power looms. Bobbin winding, pirn winding and sectional warping have also been developed to feed the power loom. It was possible for the first time in the Muga industry to manufacture plain fabric of Muga using power loom. He continued to share the development of Puffed Rice (Murhi) making machine by RuTAG IIT Kharagpur. The machine has insulation by brick and mud which allows protection from heat and assures good operating conditions. It produces 30 kg Murhi per hour with uniform quality and lower fuel consumption. Another technology by RuTAG IIT Kharagpur was on pedal operated Amber charkha which has increased the productivity and tripled the earning per day.

The PSA enunciated that for a person near the poverty line, the quality of life is a very nonlinear function of the income. He also mentioned the participation of RuTAG centres in various exhibitions by applauding RuTAG IIT Delhi for bagging the Best Stall prize in Mega Science, Technology and Industry Expo which was organized as a part of the 2016 India International Science Festival in New Delhi. He explained the implication of RuTAG/HESCO-BARC work in Uttarakhand which was to identify recharge zones of drying springs in Gaucher wherein isotope hydrology technique was employed. The technique involves measurement of ratios of environmental stable isotopes of 18O/16O and 2H/1H, and environmentally present radioactive tritium. Based on the above analysis, artificial recharge structures were constructed at selected locations which increased the rate of discharge by three to nine times in many springs. This technique has been so successful that it has been replicated for aquifer recharge in other hilly areas. Further, he gave an example of 'knowledge brokering' and expounded an instance of building up of collapsible bridges in Bagi village, Uttarakhand. The collapsible bridges, designed by Defence Research and Development Organization (DRDO), are used during army operations. They are transportable and erected quickly, and can also be built at low cost for rural use. This can become a boon to the local communities by connecting villages with one another, and minimizing life threats during heavy rainfall and floods. Some other projects of societal importance, viz. (a) improvement of 'Palki' (Vaishno Devi) by IIT Bombay (Industrial Design Centre), NITIE, and Shree Mata Vaishno Devi Shrine Board were also mentioned during the presentation. Its weight got reduced from ~55 to ~34 kg, with enhanced safety using ergonomics, engineering design and health kit

(foamed shoulder jackets and knee joint caps for porters); and (b) safe disposal of mule dung which is an option for vermicomposting, biomethanation and pathogenesis by NEERI-CSIR, Nagpur, National Research Centre of Equines (ICAR), and Shree Mato Vaishno Devi Shrine Board.

The significance of RuTAG in the North East Region (NER) was also underlined in the lecture. A close collaboration between the office of the Principal Scientific Adviser to the Government of India and M/o DoNER has fructified a new initiative called Science & Technology Interventions in the North East Region (STINER). Appropriate technologies required for NER would be disseminated through STINER. A few RuTAG technologies such as Feed block machine, Eri-Cocoon opener, Hank-to-bobbin winding machine, Chaff Cutter, Dryer, Potter's wheel, Puffed Rice making machine and Fish cage structure, developed by IITs, and Nisargruna bio-energy technology developed by BARC (for use in Tripura state) would be initially disseminated through the support of M/o DONER. Under the chairmanship of the PSA, a meeting on 'Roadmap for implementation of STINER' was held on April 20, 2017 and was attended by secretaries and higher officials from the S&T departments, viz. DST, ICAR, CSIR, DBT and others—MSME, M/o Textile, etc. Various S&T interventions and upgraded technologies required for Textiles (non-Farm sector) and Turmeric (Farm sector) which could bring about economic development in the NER were deliberated upon.

Interestingly, Dr. Chidambaram elucidated the good side of nuclear applications for sustainable development, for examples, food preservation by irradiation, food security and agricultural productivity, diagnosis and treatment of cancer and other diseases (Radiotherapy and nuclear medicine) and nuclear desalination. Also, space inputs for developmental planning (urban master plan, forest mapping, potential fishing zones, watershed development, water management) and monitoring (coastal erosion, desertification, biodiversity characterization, cropping system analysis, agroclimatic compatibility, drought assessment, snow and glaciers) by geospatial technology, for sustainable development were highlighted. He coined the term re-innovation in the context of rural development, in the sense of repetitive, but suo moto, innovation, starting from the same core concept (he called it 'concept transfer', as against 'technology transfer') and ending in nearly the same product, using local raw materials and skills. Leadership in rural development requiring re-innovation capabilities was stressed by him. The (perceived) characteristics of innovations help to explain their different rates of adoption, viz. relative advantages, compatibility, complexity, trialability and observability. Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system [6]. Social scientists/government agencies have roles in scaling of innovations. They must also provide for coverage of the risk taken by the first introducers of a new innovation (or technology). He explained the importance of e-connectivity by highlighting DAE technology delivery model to rural areas (Fig. 3), and project connectivity to DAE Outreach Centre (ORC) (Fig. 4) using the National Knowledge Network (NKN) and NKN enabled school education in rural areas around 15–20 km from the NKN node via Wi-Fi technology at SVERI, and Maharashtra.

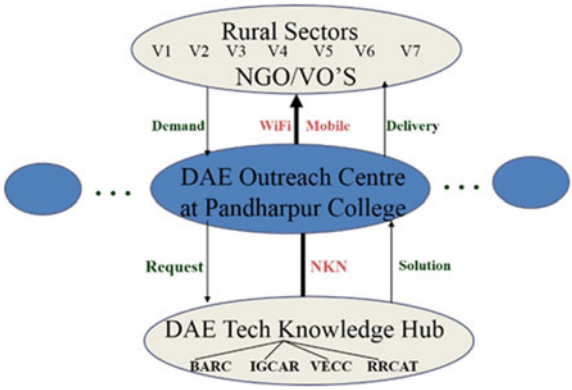

Fig. 3 DAE technology delivery model to rural areas

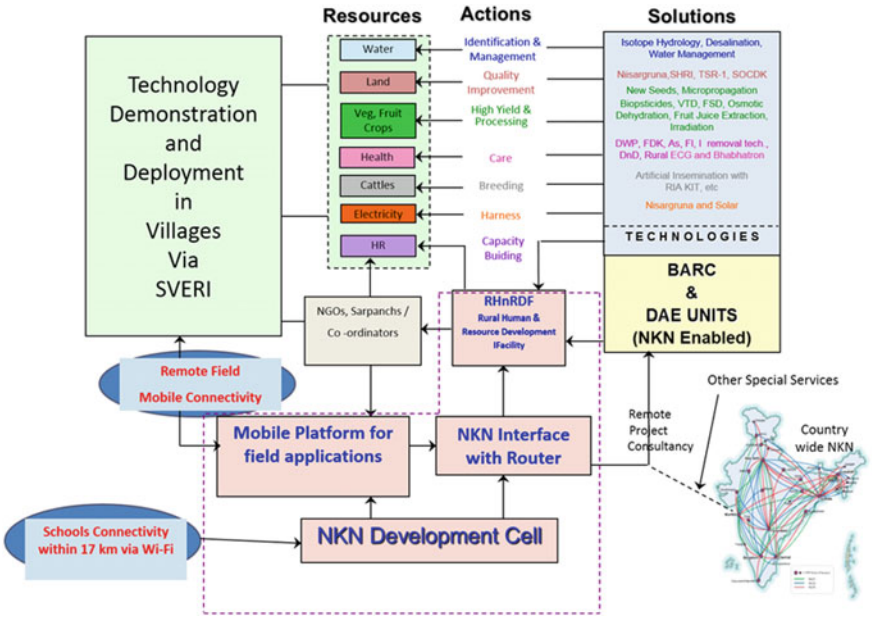

Fig. 4 Project connectivity to DAE–ORC under NKN model

The PSA concluded the session by pointing out the following: (a) to increase number of RuTAG Tier-1 Centres, and Tier-2 Chapters; (b) to increase synergy with other rural technology development initiatives by sharing best practices; (c) to increase linkages with government institutions and rural development yojanas; (d) to take advantages of rural enterprises which are Micro, Small and Medium Enterprises (MSMEs) at the lower end; (e) to increase the use of digital connectivity;

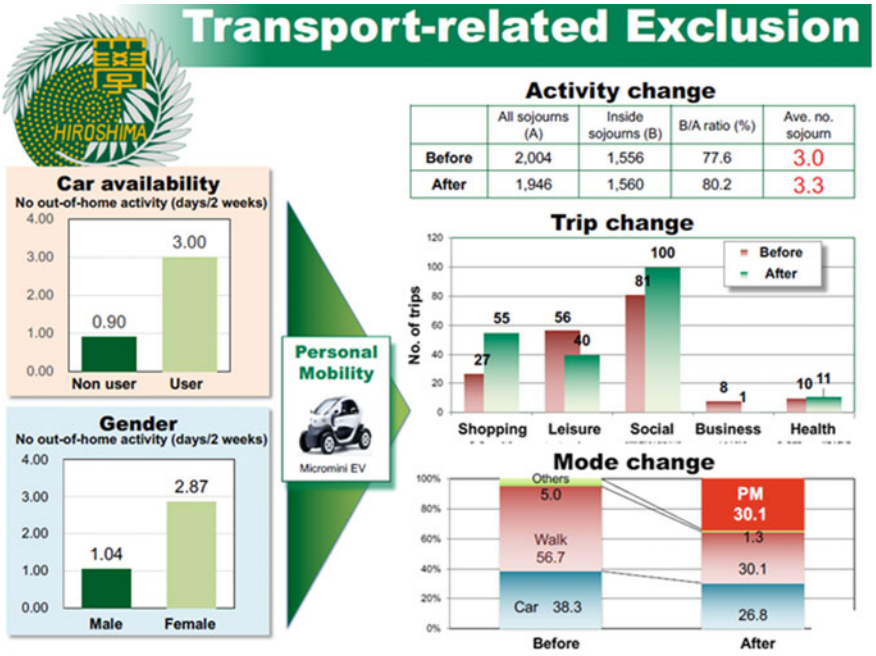

Fig. 5 Transport-related exclusion

(f) to introduce better automation in rural manufacturing processes; and (g) to utilize better management techniques and supply chain logistics.

2.2 Keynote Lecture by Prof. Akimasa Fujiwara, Hiroshima University, Japan on 'Can AV Alleviate Transport-Related Exclusion in Aging Rural Areas?'

This lecture was delivered in the afternoon of the first day of the conference, i.e. March 9, 2018. Prof. Fujiwara started his presentation by highlighting the shrinking society in Japan where populations are not only greying, but declining, in rural areas. In Japan, especially in rural areas, elderly residents struggle with fewer bus and taxi services. Transport-related exclusion in Japan is shown in Fig. 5. Also, as traffic accidents increase by elderlies, National Police Agency (NPA) advises to return their driving license (Fig. 6). Here, bringing Autonomous Vehicle Technology (AVT) to rural areas of the country where a majority of the population is over the age of 65 would be a solution. Significance and timeline activities of AVT on safety, connectivity and autonomy are shown in Fig. 7.

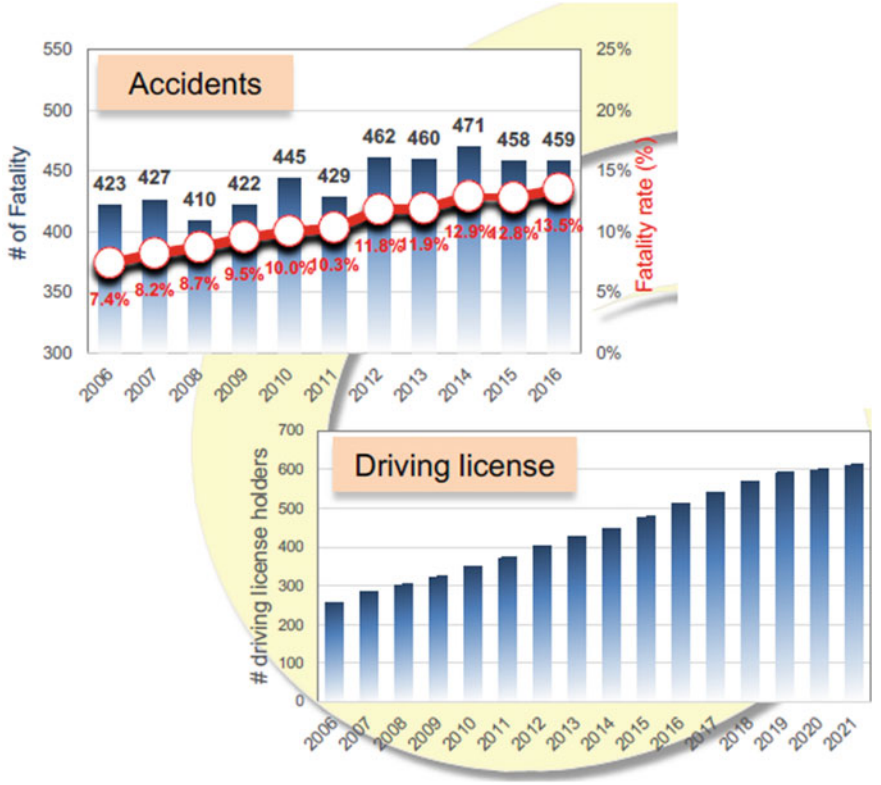

Fig. 6 Year-wise fatality rate and number of elderly driving license holders

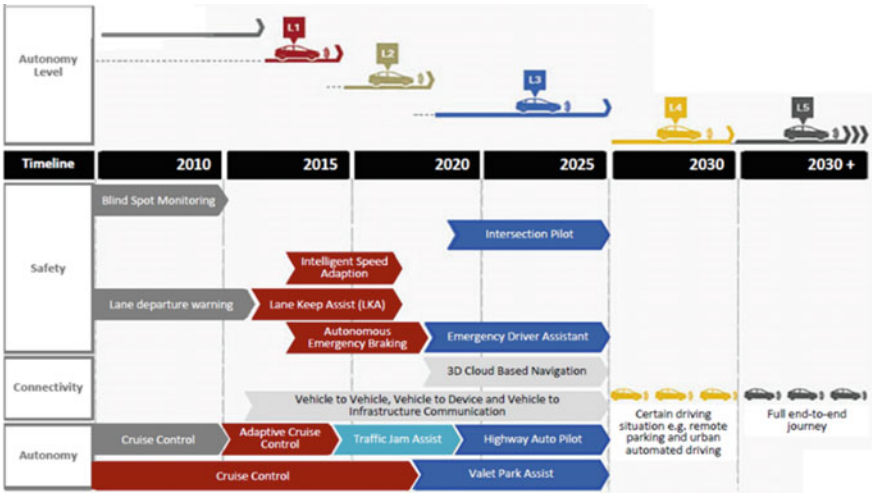

Fig. 7 Timeline activities of AVT

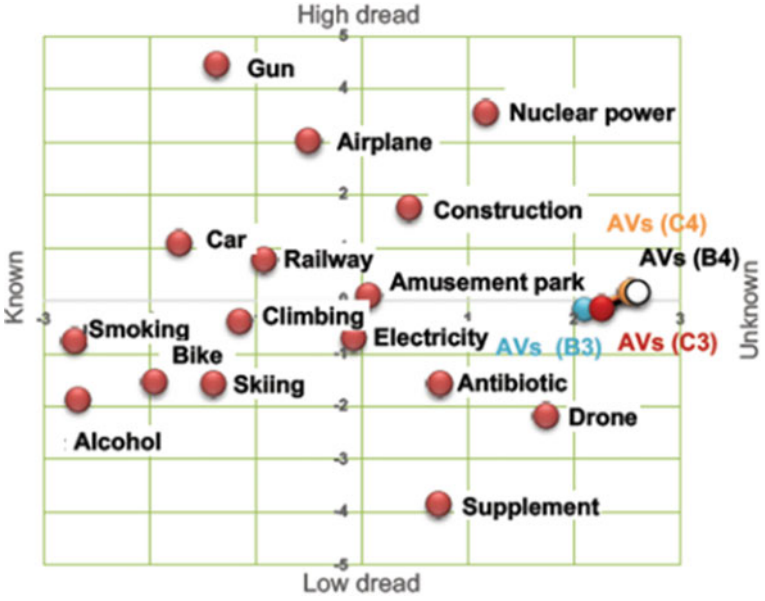

Fig. 8 Risk perception map

Autonomous Vehicles (AVs) are connected to neighbourhood, hospital, residence, community centre and shopping centre. Main features are warning system of bus and LRT approaching to prevent collision, exact stop control at station, turning right assistant system and safe guidance system to entry track. He also demonstrated the public acceptance of AV which is defined as a combination of AVs risk recognition, and services, ownerships and use. The major risks are system error, hacking and an unexpected event. Risk perception map is presented in Fig. 8.

He also depicted in Fig. 9 the willingness to pay and use AVs by the users, and explained the impact of AV on residential location choices and its influences on quality of activities such as internet browsing, playing games, reading, listening audios, etc. (Fig. 10). The AVs enhance multitasks, reduce resistance, enable location change and thereby improve urban sprawl/rural development. He also demonstrated the value of travel time saving of AVs by employing panel binary mixed logit model (Fig. 11). He concluded the session by emphasizing that AVs can potentially increase elderlies' out of home activities in short term and induce possibilities of some externalities in long term.

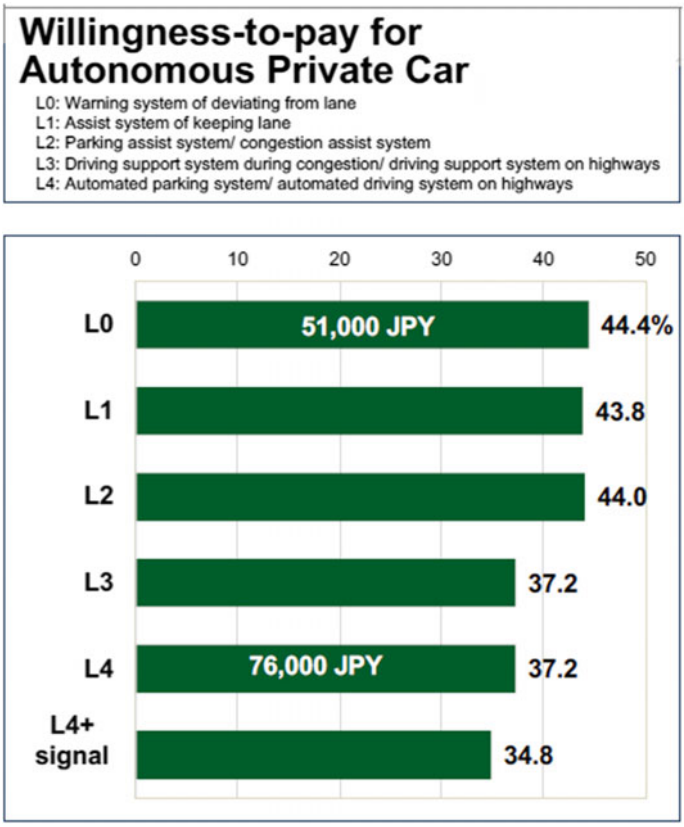

Fig. 9 Willingness to pay for autonomous private car

2.3 Keynote Lecture by Prof. Balakrishnan Shankar, Amrita Vishwa Vidhyapeetham, on 'Amritapuri on Amrita Technology for Society'

This lecture was presented in the second day of the conference, i.e. March 10, 2018. Prof. Shankar started his presentation by highlighting the mission of Amritapuri is to provide value based education and mould the character of the younger generation through a system of wholesome learning so that their earnest endeavour to achieve progress and prosperity in life is matched by an ardent desire to extend selfless service to society. Also, he added the quotes of Sri Mata Amritanandamayi Devi, a world-renowned humanitarian leader and Chancellor of Amritapuri as 'villages are India's foundation, her very life-force, and it is society's responsibility to take care of them. In fact, it is our villages that sustain us by providing us, who live in cities, with the nourishment we need, in order to survive. It is time to acknowledge that our

Quality of activities (RP)

Activity	Allocation Time to spend in daily life (min)	Substitutability (AV owner)	Substitutability (AV ride share)
Internet	60	100%	0%
Game	120	90%	50%
Read	30	20%	10%
Audio	20	90%	90%
. . .			

Location choice (SP)

Attribute	Rental house A	Rental house B
Travel time to the workplace (min)	9	7
Housing cost (10,000 yen)	6.6	6
Occupied area (m^2)	182	98
Travel distance to the nearest supermarket (m)	500	450
Travel distance to the nearest station (m)	1100	900
Travel distance to the nearest bus stop (m)	330	390

Fig. 10 Influence of AVs on quality of activities and location choices (RP-revealed preference data; SP-stated preference data)

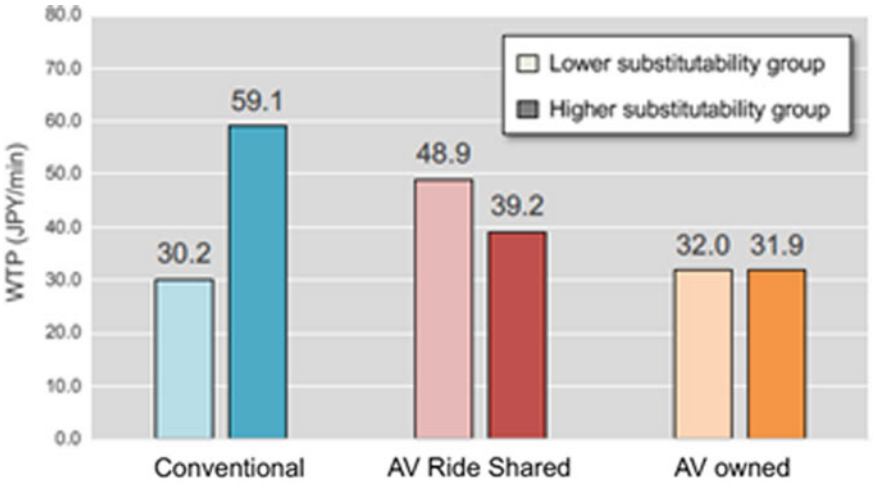

Fig. 11 Value of commuting time saving by AVs

villages are our very foundation, and move forward with one heart and one mind to protect and serve them'.

Prof. Shankar emphasized the significance of Amrita multi-modal applications and computer–human interactions labs known as Ammachi labs which is a multidisciplinary research centre with a focus on technological innovation for social impact in the field of computer–human interaction, haptics, robotics, virtual reality and multimedia with application areas in education, health care and disaster risk reduction. Ammachi labs has trained over 5000 women in rural India.

Fig. 12 Aptah [7]

Amritapuri's Computerized Vocational Education and Training (CVET) methodology provides vocational, life skills and motor skills trainings, technical and non-technical courses which are available on eight different languages, and are catered towards audiences with low digital literacy. Through Life Enrichment Education (LEE) and CVET methodology, 4500 plus low literate rural women across India were trained. Handicraft expos, starting of SHGs, supporting international and domestic orders, income earned of Rs. 28 lakhs through individual sales, and 83% self-employed are the major post training outputs.

He highlighted the significance of Haptics which is a computer–human interaction methodology. Aptah is India's first haptics-enabled vocational training simulator designed and developed by Ammachi labs. Aptah enables the user to feel on-screen objects by applying force feedback on the user's hand (Fig. 12). It has been designed to be highly modular, cost-effective and durable. Six virtual reality training simulators utilizing the device have been developed for vocational training purposes. Its major features are portable design, interchangeable handles, 4 degrees of freedom positional sensing, 1 degree of force feedback, support to CHAI3D and commercial game engines, large workspace and high force feedback. Bar bending simulator forms a part of the bar bending and steel fixing vocational trade (Fig. 13) which was developed by Ammachi labs in collaboration with L&T Pvt. Ltd. It is a novel design using hydraulic actuators and industrial control technology, and offers cost savings, reduced infrastructure and less instructor time. Also, it allows extensive repeated practice, and provides consistent and immediate feedback on performance.

Later, Prof. Shankar explained the importance of 'Mysangham' which is an accessible education using technology, and standardizes and adds values to education. It makes access to jobs and brings education to the workplace and community together to facilitate the sharing of knowledge and experience (Fig. 14). Here, community can reinvest in education. MySangham won 2015 Facebook India innovation challenge award. It ensures skills to the underserved people through innovation in technology,

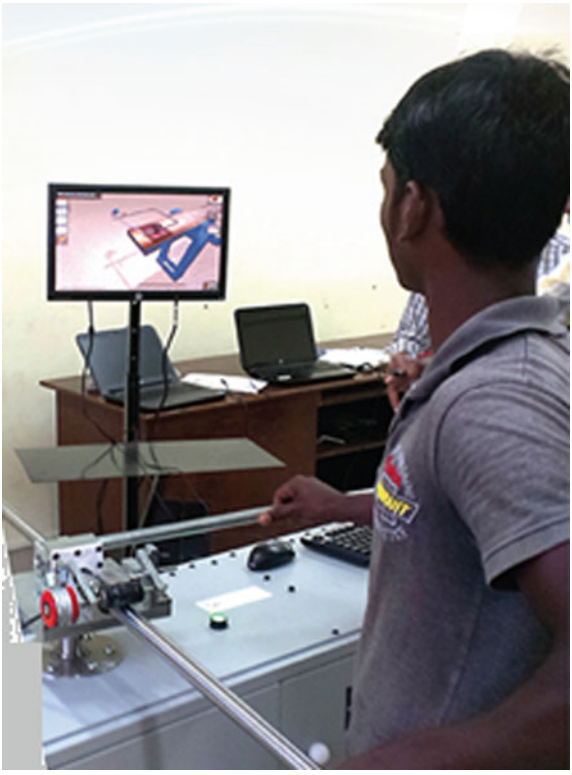

Fig. 13 Bar bending

and operates at grassroot level which has the presence in 21 states as part of ASeRVe project. MySangham is also a proven training model with United Nations Democracy Fund (UNDEF). It trained more than 4500 low literate women. It has been deployed in Amrita Vidyalayam schools. Through this initiative, India's first female plumbers got graduated. Major products of MySangham are India's first Haptic simulator for vocational training which is used for construction and manufacturing industry (Fig. 15a). Another product of MySangham is online education (Fig. 15b) which provides education and employment at community level. Amrita balance trainer (Fig. 15c) is also developed in collaboration with Amrita Institute of Medical Sciences (AIMS).

To address the lack of toilets in the country, Ammachi Labs is offering vocational courses in masonry, plumbing, plastering and block making to village women so they can construct, instal and maintain toilets in their own communities (Fig. 16). The women also learn about the importance of practicing proper hygiene for their personal health from the Amrita Foundation Course (AFC), thus empowering them to spread awareness and become ambassadors for change (Fig. 16). This project is known as 'Ma Math's Aserve Project and We-Sanitation' which contributed mainly in villages of Uttarakhand, Himachal Pradesh, Karnataka, Odisha, Gujarat, Jharkhand, Uttar Pradesh, Bihar, Goa, Rajasthan, Madhya Pradesh, Andhra Pradesh, Chhattisgarh,

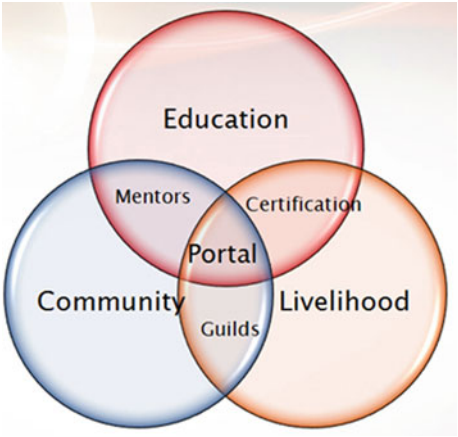

Fig. 14 MySangham

Fig. 15 **a** India's first haptic simulator for vocational training, **b** online vocational education **c** Amrita balance trainer

Fig. 16 **a** Rural toilet builder course, **b** toilet building, **c** soap making course (AFC) [8, 9]

West Bengal, Maharashtra, Haryana and Telangana. We-Sanitation aligns with the nation's pledge to bring sanitation to all Indians. Each training includes awareness on hygiene, sanitation and life skills. Through this programme, a total of 201 toilets were built. The major impact of We-sanitation programme is shown in Table 2. Through this, Ammachi labs was awarded by NITI Ayog (for best practices), and UN (selected their women empowerment project as the world's best) in the past.

Table 2 Impact of We-Sanitation programme

Total states reached 18	Ongoing	Graduated
Rural toilet builder graduates	154	24
Soap making course	151	51
Community event participants	4735	1533

Ammachi labs also started a series of workshops '2nd foundation—twenty-first-century skills training' for computational thinking, life skills, vulnerability mapping and robotics. More than 800 students, 10 rural schools and 10 states were benefited through these workshops. Amrita WNA is known for World's first successful deployment of Wireless Sensor Network (WSN) System for real-time landslide detection. It is India's first landslide laboratory, and India's first remote triggered wireless sensor network laboratory under computer science. Amrita WNA comprises fields such as Disaster management, Smart energy, eHealth, Smart education and Smart environment. Major research under Amrita WNA are urban flood monitoring and management, vehicular networks, and WSN for chemical leaks from collapsing buildings and small cell network (MICRONet). MICRONet secures mobile infrastructure for Indian coastal application. It provides solution to the connectivity at sea problem faced by the millions of India's fishermen today. It offers an array of possibilities suitable for offshore communication and promotes research on cutting edge wireless technology. It facilitates cost-effective mobile infrastructure for coastal regions of India to enable offshore communications for the vessels at sea. MICRONet has achieved internet connectivity for more than 60 km inside sea from seashore and also enhances real-time monitoring and localization of fishermen at sea.

Prof. Shankar also emphasized the major humanitarian technologies of Amritapuri, viz. robotic coconut tree climber, and gesture-based wheelchair. Robotic coconut tree climber nullifies the crunch in human climbers by substituting them. Its arm control can be wired or wireless and is also fitted with a wireless camera to monitor and cut coconuts. Gesture-based wheelchair uses hand gestures for navigation, and also makes use of auto navigation and Electrooculography (EOG) based navigation. Other humanitarian projects are rice transplanter, Unmanned Ariel Vehicles (UAV) for road accidents monitoring (Fig. 17), cable-driven robot for dehusking and Unmanned Ground Vehicles (UGV) for soil sample collection. He added that Amrita Virtual Interactive E-learning World (A-VIEW) is a versatile E-learning platform for online. A-VIEW connects 10,000 plus institutions and provides one crore training hours which are free and open to the public. It offers classrooms, meetings, trainings and workshops and conferences. Amrita CREATE is a Centre for Research in Advanced Technologies for Education which covers 21 states, 12,000 plus schools, and 41 village centres, and empowers 2,70,000 plus students and provides 30,000 plus teacher training programmes. Major projects under CREATE are Tabletop technologies, Modelling diffusion of innovations, Online science labs (OLabs), Language labs, Mobile learning, Adaptive learning, Enterprise Resource Planning (ERP) systems, Data visualizations, Adult education (Amrita RITE), Smart decision for human

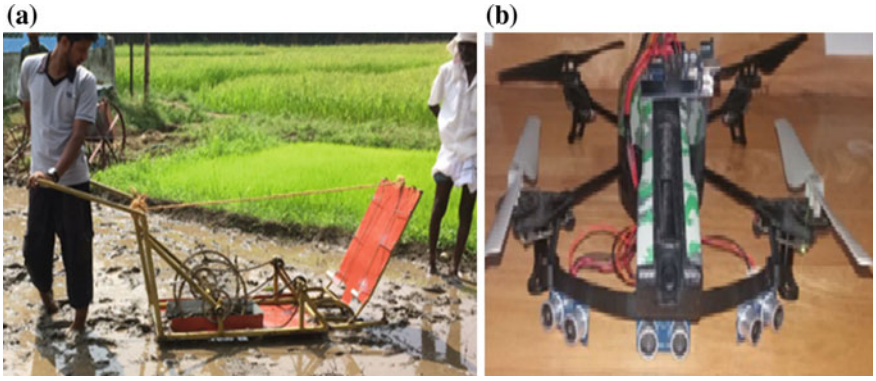

Fig. 17 **a** Rice transplanter [10], **b** UAV [11]

trafficking awareness, social awareness (mainly, on gender and substance abuse) and sustainability (known as Amala Bharatam). OLabs offers subjects, viz. physics, chemistry and biology, and 120 plus experiments mainly for class 9–12 students. Medical Simulation (MEDSIM) of CREATE is a web-based learning platform for interactive medical case simulations for virtual patient cases. CREATE's eLiteracy and health awareness projects empower tribal youth through computer education, create awareness about IT, social and health education, provide game oriented modules and ebooks on Android tablet, grant NIELET certification for eLiteracy and Amrita certification for social and health awareness. One thousand Scheduled Tribes (STs) would be trained through eLiteracy and health awareness projects.

He highlighted that Amrita virtual labs provides courses for biotechnology and biomedical engineering, chemical sciences, physical sciences, computer science and mechanical engineering. It has a great national impact, viz. 160 plus field trials of virtual labs were conducted over 160 colleges. More than 50,000 students and 1000 plus faculties were trained, and 36 plus workshops were also conducted. Major technologies demonstrated through this lab are animations, simulations and remote triggering. Virtual labs in bio-inspired robotics is another impact. The list of remotely controlled experiments is Simple neurobot, Bicore robot, Bicore and quadcore robots, Integration of basic sensing, Obstacle avoidance, 6 neuron devices, Photovore robot, Insect-vore robot, Robotic articulator (kinematics), and Analog neuronal functions in robots.

He concluded the session by adding about experimental learning in rural sectors which is provided by Live-in-Labs initiative of Amrita University. Live-in-Labs is designed to expose youth to problems faced by rural communities in India. Through experiential learning opportunities, the program aims to inspire innovation through empathy and the application of knowledge while developing collaborative problem-solving abilities of participants. The program emphasizes mutual sharing and learning. It is designed as a two-way model which encourages students to be open to 'other ways of thinking'. So far it has covered 14 states, 21 villages and completed

17 projects with 58,953 beneficiaries. Amrita University also offers interdisciplinary research for 'theory into practice' for sustainable development. Its major thematic areas are energy, environment and farming; education and technology; infrastructure and basic facilities; health and food. Major projects under this interdisciplinary research are Amrita water distribution system for water management in rural India, Scalable and sustainable rural sanitation model, Public health awareness program in Bihar, Amrita micro-hydroelectric system for illuminating rural India, Amrita Awareness Ambassadors (AAA) program, Amrita sphuranam for rural electrification using solar power, Agricultural economics and data modelling, Empowering artists, Health economics, Lemongrass distillation, Impact analysis of teaching methodology, Health, Social awareness, and Women's Self-Help Groups (SHGs) for health, social and economic interventions.

2.4 Keynote Lecture by Prof. B. K. Chakravarthy, IIT Bombay on 'Collaborative Innovation'

Prof. Chakravarthy delivered this lecture online on the second day of the conference, i.e. March 10, 2018. He started with the introduction of IDC School of Design, the oldest design school in the country. They constantly strive to create impactful outcomes through collaboration, be it collaboration with faculty from other departments or NGOs or manufacturers. Their endeavour is to work closely together in this quest for solutions that can reach the market and influence people's lives positively. The presentation focused mainly on Jaipur Foot (Fig. 18) and the palkhi for Shri Mata Vaishno Devi Shrine, Katra, Jammu (Fig. 19). He stressed that collaboration is critical in academic institutes. Without collaboration, one can barely be able to reach people on a large scale through RuTAG projects. He experienced the importance of collaboration during his very first job with Larsen and Toubro where with the backing of a range of departments and he as a lone designer could create a revolutionary product like the Z line petrol pump that became a runaway success. MHRD has nominated IDC at IIT Bombay as a Design Innovation Centre where they have worked on a range of genres, and the work has constantly facilitated learning. For instance, the dental chair for rural hospitals. The Design Innovation Centre helped them to work with doctors, rural craftsmen and NGOs to take this product to large-scale production. Currently, this product is in pilot production. The scale of requirement for such a product is becoming evident. It is lightweight and comfortable for patients and for the dentists who carry out intricate dental care procedures.

The rural projects have been eye-openers that have given the team insights into the livelihoods of rural craftsmen and the threats to their livelihoods. One of the students stayed with the craft community of the Dokras in the rural areas near Shantiniketan. They found workable solutions for the dwindling lifestyles of artisans. In the cities, people demand large volumes of products. Among these are the artefacts that one buys to decorate homes. What if we could combine utility with the aesthetic charm

Fig. 18 Jaipur foot [12]

Fig. 19 **a** Old palki, and **b** modified palki for Shri Mata Vaishno Devi Shrine, Katra, Jammu [13]

of these products? An attempt was to make decorative door handles aimed to achieve such a result.

As part of the RuTAG project, IDC makes sure that they spend time with such communities and do not come away without putting up a fair where products designed in collaboration with the local craftsmen are sold. They redesigned a suit for those who harvest honey from bees. They also worked on making useful agricultural implements. The low-cost tea plucking device brought relief to those who earn a livelihood by plucking tea, which not only stains their hands but can also prove to be carcinogenic. In collaboration with research labs on campus, products such as a stainless steel sensor to test soil moisture was developed. This helps in watering the soil appropriately. Another device was a water carrier for hilly areas that has been received very enthusiastically.

Prof. Chakravarthy's mind always goes to the Jaipur foot (Fig. 18), a marvel of an innovation that addresses not only the physical disability of the user but also their abject poverty and lack of education. The greatest advantage of the Jaipur foot is that it is able to mimic the natural movement of the human foot to a considerable extent. This is crucial as the users of the Jaipur foot are often agricultural labourers who can ill-afford to lose their meagre means of livelihood. It is a fine example of well-integrated design that is also low cost and custom made to fit each user. Prosthetic limbs of much higher cost available around the world cannot boast of this

feature, as mass manufacturing makes it impossible to customize them effectively for every user. Although inexpensive and handcrafted, it uses high-end technology. A person wearing the Jaipur foot can work on paddy fields and even climb trees and hills (Fig. 18). They can also go back to the hostile salt pan lakes. The prosthetic thus works on a variety of contexts. Conceptualized and created locally through a collaboration between an orthopaedic surgeon and a sculptor, the Jaipur foot shows how successful innovation often emerges out of the grassroots. It shows how one can collaboratively find solutions to deep-rooted problems using contemporary technology. The organization BMVSS has taken up this prosthetic limb as a cause for which they worked extensively. They have been supported by several agencies. They enable many of the users to regain their livelihood. The foot is made of the finest quality materials from top manufacturing companies. They are quite advanced with their technology. The foot and ankle are made of vulcanized rubber compound and assembled together manually. The casting is done with aluminium die. Cosmetic rubber serves as the outer covering in skin colour. The design mimics the human foot. The foot is customized to every user with their measurements. The product is thus low cost, well customized and remarkably adaptable.

The next example he dwelled on was the RuTAG project, the redesign of a palki (Fig. 19) for visitors to the Vaishno Devi Temple at Katra. It was a project that required to visit the field multiple times and make several prototypes incorporating the insights gathered from each round of user testing. IDC was approached by the Principal Scientific Adviser to the Government of India, Dr. Chidambaram, who saw the palanquin IDC had designed for Ajanta. The locally made palki that was already in use was mainly composed of GI pipes with a wooden rod attached to the main structure with rope fastening. It was rather heavy. The structure would often endure damages and the porters would find makeshift solutions. They welded the joints although GI pipes are not supposed to be welded. IDC replaced these with lightweight stainless steel.

IDC Ajanta palki had four posts. Initially, this pre-existing design was tested on the roads at Katra. That was the first lesson in understanding the context. On the slippery and overcrowded roads at Katra strewn with animal dung, there were humans and mules in movement. This necessitated that the porters of the palki be in a single line. As the project progressed, both the importance of topography and the necessity of studying the habits and mannerisms of the users were appreciated. These would often seem to throw up contradictory requirements, but the lesson to arrive at an effective solution was learnt. The gestures of the porters giving cues to each other and their instinctive actions to keep the passenger safe were aspects of the user study that proved invaluable.

In spite of its light weight, the redesigned palki in stainless steel has a load carrying capacity of 150 kg. The wooden rod tied to the palki with jute ropes, however, was retained in the interest of greater flexibility and comfort for the users. It was realized how important the grips on the existing palki were for the porters to keep their balance. One of the early prototypes had become too flexible. In another, the developing team was carried away by the concern of the comfort of the porter who seemed to be locked inside the palki as the team of four porters moved in a single line. Only when

the testing was carried out, it was realized how crucial it was for the porters to be locked in. Several prototypes were made with and without plastic seats and footrests. It was a continuous process of refining the insights. Even after such a long journey, the one critical step missed structural analysis. This proved to be a big mistake as the palki failed in the FEM analysis. The load carrying capacity of the palki was seen to be much short of the actual load it carried. The stresses in the members and the deflection of the frame exceeded the permissible limits. With the help of inputs from the structural designers, a new safe design of the palki (Fig. 19b) was achieved. The redesigned palki's chariot-like appearance gave it an inviting charm. The project had given the team invaluable lessons on both the necessity to use technological insight and the centrality of user inputs to the design journey.

2.5 Keynote Lecture by Prof. P. L. Dhar, Ex-Professor, IIT Delhi on 'Rural Development & Technology'[2]

Prof. Dhar delivered this lecture on the last day of the conference, i.e. March 11, 2018. The main focus of the lecture was on the identification of real needs and two perspectives of technology and rural development, viz. (a) developing new technologies, and (b) using technology for holistic development. He emphasized that while developing new technologies, one could focus on innovation which would be more satisfying and easier for getting academic recognition. However, its impact for society would be limited. In the latter case, i.e. using technology for holistic development, focus of research would be on development rather than innovation for which societal impact would be huge. Though the technology is transformative for holistic development with greater effort, it is hard to get any academic recognition.

Prof. Dhar articulated that identification of the real needs should be from field, not based on lab experiences. In order to understand the real need, proper interaction with villagers, sarpanch, local NGOs and respective government officials are required. Surveys should be conducted to establish demand and resources. After identifying the real need, a team has to be built which should comprise experts needed for technical, financial areas, social interaction and infrastructure development. Another team of core/executive group/principal investigator for distributing responsibilities clearly, conducting frequent formal meetings with minutes, make the developmental process transparent, and instilling confidence and inspiration to co-workers and people at grass root levels. He enunciated that planning is another important stage which includes preparation of a detailed project report and vetting it by all stakeholders from Gram Panchayats, Panchayati Raj Institutions (PRI) officials and other experts. For the preparation of a detailed project report, the whole team mentioned above should be active and each expert should contribute a chapter with clear enunciation of a realistic time frame of various activities and project manage-

[2]This summary was prepared from the presentation slides provided by Prof. Dhar on March 11, 2018.

ment responsibilities. Another important aspect was on the execution of the project which should honour the time frame created. Moreover, keeping integrity and transparency on the activities performed by the team is fundamental to build public trust and to ensure accountability of their activities which is applicable on activities such as various purchases, infrastructure development, staff selection, project management and supervision, ensuring timely submission of reports and facing adversities.

In order to disseminate the technology, there are different mechanism of sharing, viz. conducting hands-on workshops, web a network of institutions, design prototypes, pave a pathway for entrepreneurship development, get a connection with design centres, conduct entrepreneurship development programmes, share via technologically competent NGOs or organizations such as KVIC, MSME, NSIC, NIRD and CAPART, build detailed project reports for each technology and bank financing for entrepreneurs. Prototype development can be ensured via NSIC Technical Services Centres, NTSCs or training cum incubation centres. Small batch production can be achieved from idesign [14], Chisel [15], eternus [16] and indiamart [17]. However, there are following challenges to be faced: general disdain for appropriate technologies, no incentive from academic system, busyness of faculty in academic institutes like IITs, how to sustain inspiration, interacting with field 'officers' with limited technical knowledge, steering clear of internal 'politics' of villages and avoiding conflict.

Prof. Dhar concluded the session with emphasis on the policy interventions required at the institutional level, viz. (a) special leave to faculty for R&D work and giving credit in appraisal; (b) incentives for multidisciplinary projects; (c) extension as a dimension of mission statement (adopting certain rural areas for holistic development); (d) changes in the curriculum and research priorities to sensitize the students and faculty; (e) encouraging research applied to national needs by giving generous grants and fellowships, awards for innovative technological inputs; (f) involving technical institutions in planning for R&D; (g) creating a network of institutions and authentic NGOs involved in rural development technology; (h) meaningful mandatory exposure to remote rural areas for all professionals; (i) improving student–teacher ratio in professional institutions; (j) creating a network of product development centres in IITs, NITs, etc.; and (k) setting up 'commercially viable' fabrication facilities in ITIs and Polytechnics.

3 Summary of Panel Discussions

Two panel discussions on the topics entitled as 'Taking Products to People through Social Enterprises', and 'RuTAG and Its Future' were conducted as a part of the RTDD conference on March 9, and 10, 2018, respectively. Appraisal of the discussions is given below.

3.1 Panel Discussion on 'Taking Products to People Through Social Enterprises' Held on March 9, 2018[3]

A panel discussion titled 'Taking Products to People through Social Enterprises' was conducted on March 9, 2018 as a part of the 1st international conference of the Rural Technology Action Group (RuTAG). The panel was designed keeping in mind Rural Technology Development and Delivery, the theme of the conference. The key motivation and idea was to bring out issues and insights relevant to technology delivery to people in a sustainable way, i.e. through social enterprises. The core audience of the panel was social entrepreneurs in various stages of their journey, decision makers who can get some insights on gaps in the policy and implementation of framework, and technology delivery enthusiasts. Accordingly, the panel consisted of social entrepreneurs themselves, people working in NGOs for their nuanced understanding of issues on the ground, people in CSRs to get their views on how they can play a role effectively in the ecosystem, academia for their ability to mentor and nurture both ideas and change makers, and a student representative to provide an understanding of the concerns in the minds of potential entrepreneurs. The panel aimed to get different perspectives on the relevant issues, and the diversity of the panel was a key driver for the same. The panellists were Prof. Shinji Kaneko, Mentor of Social Implementation program for International Development and Cooperation at the Hiroshima University; Mr. Arvind Kathuria, General Manager, National Backward Classes Finance and Development Corporation; Mr. Ashutosh Kumar, Founder, Sajal Foundation; Mr. Shiva Kumar, Deputy Manager, Bosch India, and Shubham Jain, Team Leader, Enactus IIT Delhi; Mr. Raj K. Pathak, Chairperson Delhi NCR, India Entrepreneurs Club who moderated the panel.

The interventions of the panellists focused on the nuances of the path of social entrepreneurship as a career and how they can use it to take their social innovation to the market. To elaborate, the panel started with a discussion on the definition of social entrepreneurship, and how social entrepreneurship is different from a typical startup. The key outcome of this discussion was centred on how having an impact on the society provides a sense of purpose and adds a sense of self-satisfaction to entrepreneurship. The panellists then shared their own experiences in the field and discussed the kind of challenges social entrepreneurs face in India. This included insights on the type of policies and government support required for social entrepreneurs, the help already available to social startups through funding, grants, incubation centres and accelerators. The key insight that emerged from this part of the discussion was the availability of quite a bit of financial and other support available, and the need to create awareness about it among the target audience. The panel also discussed some additional challenges faced by entrepreneurs who want to take their products to rural markets.

The discussion then took a turn on the acceptability of this trend among students and the reasons behind a lot more students not opting for social entrepreneurship as

[3]This summary was prepared by Prof. Nomesh Bolia, Assistant Professor, Dept. of Mechanical Engineering, IIT Delhi.

a career path. The panellists also debated on the role that the government and the corporate sector can play an important role in order to encourage people to enter this field. They discussed the scope of the earning, and reasonable profits by targeting people at the very bottom of the pyramid. The key points highlighted were that all sectors, including the government and the corporate, stand to benefit from the movement of promising young change-makers, including their own employees, to social entrepreneurship. Thus, they should take this trend positively and facilitate rather than doubt or mistrust the youth merely in anticipation of potential failures.

The panel ended with a question and answer session where the audience sought the panel's advice on the problems they were facing in their own social ventures.

3.2 Panel Discussion on 'RuTAG and Its Future' Held on March 10, 2018[4]

The panel discussion on 'RuTAG and Its Future' was aimed at creating a roadmap for further growth of social initiatives such as Rural Technology Action Group (RuTAG) and similar other activities like Unnat Bharat Abhiyan (UBA). The panel was mainly comprised of academicians working on social projects. It was moderated by Prof. R. R. Gaur, Chairman of the Core Group, RuTAG IIT Delhi. Other panellists were as follows: Prof. Ashok Saxena, University of Arkansas, USA; Prof. Saravana Perumaal, Thiagarajar College of Engineering, Madurai; Prof. Monto Mani, IISc Bangalore; Prof. Anand B. Rao, IIT Bombay; Dr. Ketaki Bapat, Office of the Principal Scientific Adviser (PSA); Prof. S. K. Saha, IIT Delhi; Prof. Abhijit Deshpande, IIT Madras; Prof. R. P. Saini, IIT Roorkee; and Prof. William Oakes, Purdue University, USA.

The session began with an introduction from each of the panellists. The panellists spoke about the social/rural projects taken up by them in their institutes. Dr. Bapat spoke about the role of the government bodies such as the Office of the PSA in facilitating the rural research activities in educational institutes. Most of the panellists were the Principal Investigators of various RuTAG centres at various IITs or have been leading personalities for IUCEE (Indo-Universal Collaboration for Engineering Education) which is a network of 42 institutions/universities around the world, and EPICS (Engineering Projects in Community Services) programme which was initiated at Purdue Univ., USA. They apprised the audience about the difficulties and problems faced in premier institutes such as the IITs to convince faculty and students to take up such projects. Prof. Oakes spoke about EPICS which is now a worldwide program and runs in various countries including India.

The panellists then discussed various methods to encourage the involvement of faculty and students in social development projects and research activities. Some of the suggestions included providing incentives such as design credits for the students and considering the topic of rural technology and development as a part of the cur-

[4]This was prepared by Mr. Suraj Bhat and Prof. R. R.Gaur, Dept. of Mechanical Engineering, IIT Delhi.

riculum. Prof. Saxena spoke about how to improve the curriculum so that values of rural and social development are inculcated to the students at an early stage. Prof. Mani spoke about his experience at IISc Bangalore with projects under ASTRA (Application of Science and Technology for Rural Areas). He also gave ideas to expand the outreach of such projects. Prof. Saha spoke about the theme of this conference, i.e. 'Researchizing rural problems'. He suggested converting rural technical problems into research topics so that more and more researchers including faculty and PG/UG students can be attracted. He gave examples of how the rural problems can be made 'fashionable' so that researchers can come forward with enthusiasm. Dr. Perumaal emphasized the need for broadening the scope of RuTAG so that second tier engineering institutes can also be included. In response to this, Dr. Bapat informed that the Office of the PSA is working on a 'Tiered' model of RuTAG where it plans to involve more number of regional institutes under the guidance of the PSA office and the existing RuTAG centres. Dr. Bapat proposed a 3-Tier model as an immediate roadmap to achieve this objective. Adding to this, Prof. Oakes expressed that RuTAG and EPICS should work together so that the respective programmes can benefit from each other and grow at a faster rate.

The moderator, Prof. Gaur, then summarized the entire discussion. He then asked the audience for questions and suggestions regarding the panel discussion. The audience mostly sought clarification on several points raised by various panellists, and gave a few suggestions. The outcome of the panel session can be listed as follows:

1. All RuTAG website should be developed to share the developed technologies and the success stories with others.
2. Planning/system needs to be evolved to take the RuTAG technologies to the field.
3. RTDD 2018 type conference or similar interaction sessions should be held at regular intervals, say, once in a year.
4. Technologies must be well researched so that confidence based on the scientific outputs is established.
5. Strong collaboration among various academic (IITs/NITs, etc.), Govt. bodies (Office of the PSA, MSME, etc.), Social Entrepreneurs (Development Alternatives, etc.), and similar interest bodies (IUCEE, EPICS, etc.) need to be nurtured.

4 Conclusions

The five keynote lectures and the two panel discussions were extremely valuable aspects of the conference. They have really complemented the papers presented over 3 days of the conference. It is hoped that after reading the summaries, a reader will have a good understanding of the challenges in rural technologies, how to develop and deliver them, and enhance the culture among academicians, etc. This summary is expected to act as a guidance to a beginner of rural technologies.

Acknowledgements The authors of the summary sincerely thank all the keynote speakers for providing their presentation slides and those panel members who briefed their sessions.

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