Live-in-Labs: Rapid Translational Research and Implementation-Based Program for Rural Development in India

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***Abstract*—Government agencies, public institutions, and private companies in India have worked over six decades to empower Bottom of the Pyramid (BoP) or rural communities through various policies and interventions. Eighty-five percent of these technological interventions failed to create an impact as they lacked a holistic approach, scalability, sustainability, and effective interagency coordination. This paper discusses the successful implementation of interventions through Amrita University's Live-in-Labs™ program and proposes a model that ensures a co-design environment to develop technology-based interventions for rural development. The model aims to create a virtual ecosystem that will enable field practitioners, researchers, policymakers, and other stakeholders to plan, design, implement, and review scalable and sustainable interventions. The paper describes the key components of the model and investigates the sustainability, scalability, and impact of the technology interventions in the program's five main thematic areas - Infrastructure & Basic Facilities, Health & Livelihood, Education & Technology, Energy, and Environment & Farming - through a case study.**

Keywords — rural communities; interventions; technology; sustainability; holistic approach; model, interagency coordination

I. Introduction

Approximately 70 percent of India's population lives in rural areas where dependence on a fragile and unpredictable agricultural system has left many individuals socially and economically marginalized. Furthermore, the agricultural sector's contribution to the country's GDP has steadily declined over the past few years, crippling the flow of income and spiraling many rural communities into a perpetual life of poverty.

In research publication [1], R. Chambers attempts to study and explain rural poverty from the view of academicians and field practitioners. However, he has come to the conclusion that both groups have shortcomings as academics are isolated from the real world and field practitioners have a limited focus. Therefore, there is a need to come up with a third perspective, involving "people and places" in conjunction with the previous two [1]. Combining these three perspectives, this paper proposes the Rapid Translational Research and Implementation model, derived from Amrita University's Live-in-Labs™ program, which integrates academia, practical field work, and the "third perspective" to develop technology-based interventions for rural communities.

Now and in the future, it is imperative that researchers and field practitioners appropriately incorporate Chambers' "third perspective" – that is utilizing participatory approaches for rural development. While participatory approaches have been adopted by many government agencies and public and private organizations, they have not been fully evaluated in the broader context of "who is using them, how, and what for" [2][3][4]. The current paper observes the degree and nature of participatory involvement in Amrita University's Live-in-Labs™ program and proposes a model that ensures a co-design environment to develop and successfully implement technology-based interventions.

In many developing nations, government organizations have partnered with educational institutions to address challenges faced in rural communities and initiate programs in rural development. For example, the Government of India has established Rural Technology Action Group (RuTAG) centers in collaboration with prominent Indian technology institutes [5]. The RuTAG centers "help disseminate technology interventions and upgrade existing ones by clearly defining problems and providing solutions" [5]. As the centers are primarily established in partnership with technology institutes, there is a lack of a holistic perspective to conduct research, to design solutions, and to implement technology interventions.

We observed that challenges faced by rural communities were multifaceted and complex, yet were often addressed from single or top-down approaches. E. F. Schumacher supports this view by proposing the use of "Appropriate Technology" and technology interventions that are highly customized, taking into consideration many factors related to a rural community [6].

The D-Lab program, which provides interdisciplinary courses to those working towards technology development for community welfare, has developed two frameworks for research [7]. The Lean Research Framework provides a methodology to guide and improve the practice of field research with people and communities by better understanding the impact of various program interventions [8]. The User Research framework is a methodology for collecting information from users and stakeholders in order to enhance technology interventions and to create products that meet the needs of targeted communities [9]. Dr. Jeffrey D. Sachs proposed a millennium village program where he offered internships for students in 12 sites spread across 10 African villages [10]. Even though the programs were able to successfully send students to address challenges in communities, the program did not attempt to understand the multifaceted nature of challenges (e.g. sanitation). Addressing the shortcomings in the existing models and the gaps experienced while implementing these models adopted to develop interventions for rural development, we propose the Rapid Translational Research and Implementation (RTRI) model.

In an effort to integrate multidisciplinary academic theory, practical experience, and co-designing, we developed a multidisciplinary experiential learning program called Live-in-Labs™ [11]. The program is the creation of Amrita University's Chancellor Sri. Mata Amritanandamayi Devi. She first proposed the program during a speech at the University at Buffalo (USA) in 2012 [12]. She stated:

> As part of our university curricula, students should spend time in such communities [villages]. We should provide them with the opportunity to observe the lives of the people who live there—their struggles and hardships. Students should interact with them and listen to their problems. This will provide them with insight into aspects of life that otherwise would remain concealed to them. In turn, when our students attain the success and positions of power they seek, the experiences they gained in these agricultural communities will remain with them and impact the decisions and policies they put into action.

This idea sparked a large initiative at Amrita University, and under the Chancellor's guidance, the Live-in-Labs™ program came into existence. In her United Nations address in 2015 [13], she stated:

> Today, universities and researchers are ranked mainly based on the amount of funding they receive, the number of papers they publish and their intellectual caliber. Faculty are promoted according to the same criteria as well. Along with this, we should take into consideration how much we have been able to use their research to serve the lowest and most vulnerable strata of society.

Live-in-Labs™ aims to address current challenges and develop sustainable technology-based innovations for rural development. This program attempts to bridge the existing gaps aforementioned by focusing on the multifaceted nature of challenges, through multi-level interventions co-designed with community engagement along with university faculty, researchers, and students. Since 2014, the program has been implemented in approximately 60 villages throughout India, generating over 50 interventions, many of which yielded spin-off interventions. After implementing these interventions and subsequently evaluating their efficacy, we propose the RTRI model as an effective guide to developing a holistic and successful program that generates technology-based solutions for rural development.

The remaining sections of the paper are organized as follows: Section II introduces the Live-in-Labs™ program; Section III presents our case study; Section IV delineates the Rapid Translational Research and Implementation (RTRI) Model; Section V describes the outcomes of the multi-phase interventions through the Live-in-Labs™ program; and Section VI presents our conclusion.

II. About Live-in-Labs™

Amrita University's Live-in-Lab™ program isa multidisciplinary theory–into–practice initiative that facilitates the research, development, and deployment of sustainable technology based solutions for current challenges faced by rural communities (villages) in India.Through experiential learning opportunities, participants[1] from multiple disciplines can study, observe, and interact with villagers while living in rural communities to gain a better understanding of challenges in the five thematic areas: Health & Livelihood, Education & Technology, Environment & Farming, Energy, and Infrastructure & Basic Facilities. Villages participating in the Live-in-Labs™ program were adopted by the Mata Amritanandamayi Math[2] (M.A. Math) under a program titled Amrita SeRVe.

A. Self-Reliance of a Village

The main goal of the Live-in-Labs™ program is to empower villages to become self-reliant and sustainable. The path to self-reliance is realized through multiple interventions in the five thematic areas mentioned above. These areas can further be classified as a combination of challenges, with each challenge subsequently linked to a combination of problems. A diagram representing the conceptual path to a village's self-reliance is seen in Figure 2.1 below. In the figure, *TA* stands for thematic area, *Ch* stands for challenges that make up a thematic area, and *P* stands for problems that fall under a particular challenge.

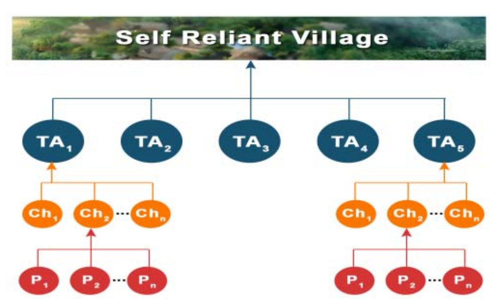

Figure 2.1: Conceptual Path to Self-Reliance of a Village

[1]Participants of the program can be undergraduate, graduate, or PhD students, researchers or professors, or field practitioners/industry experts.

[2]M.A. Math is a UN recognized international charitable organization located in Kollam, Kerala. This organization has adopted 101 villages for sustainable development through a program called Amrita SeRVe.

For instance, in the thematic area of Health & Livelihood, one of the challenges could be malnutrition, another challenge could be lack of proper sanitation, and yet another challenge could be disproportionate dissemination of health-related information. These challenges can further be broken down into everyday observable problems. For example, problems leading to malnutrition could be due to the combination of any of the following: scarcity of food and water, contaminated water, lack of awareness about diet requirements to achieve proper levels of nutrition, and insufficient income to purchase healthy, nutritious food. Therefore, to make a village self-reliant with respect to even one challenge, we need to address each of the problems mentioned above.

B. Problem Identification

The strength of the Live-in-Labs™ program lies in the ability to leverage theoretical knowledge from multiple disciplines to address these challenges. The participants of this program travel to these remote villages and live with the villagers to facilitate cultural immersion and to understand and identify the problems. These cultural immersions provided the opportunity to analyze the problems with respect to the villagers' local culture, social customs and behaviors. Based on this analysis, participants are able to prioritize the problemsand identify major social, economic, engineering and managerial constraints to be integrated in the design of the solution.

C. Integration of Interdisciplinary Research

We observed that almost all the problems identified in a village cannot be solved using the knowledge of one discipline. Indeed, the strength of the Live-in-Labs™ program lies in the ability to leverage theoretical knowledge from multiple disciplines to address the challenges. In each of the identified problems, the participants from multiple disciplines model and identify the engineering and research challenges, study the multidisciplinary involvement needed to address those challenges, and assess which combination of disciplines will produce the greatest degree of sustainability and self-reliance. Based on this knowledge, the participants form interdisciplinary groups to provide solutions for the village.

For example, if lack of proper sanitation is identified as a challenge in a particular village, then researchers, field experts, and students from the fields of civil engineering, biotechnology, health care, and social work will work together to devise a sustainable and cost-effective solution in collaboration with village residents. This way, a challenge is addressed more holistically as a result of this multi-pronged approach.

D. Phased Implementation

To ensure the effectiveness, sustainability, scalability, and acceptance of proposed technology interventions, participants introduce solutions in phases, which is described in detail in the case study in Section III. In the phased implementations, the participants (1) implemented and tested their pilot interventions, (2) monitored their impact on the village and its residents (3) received feedback, (4) proposed new solutions thereby, readdressing a particular challenge, and (5) enhanced or fine-tuned technology interventions to better meet the needs of villagers.

For example, in Orissa, there was widespread open defecation and lack of awareness about proper sanitation practices. To address this issue, participants began teaching village women masonry skills and how to build toilets. Even after toilets were constructed, participants noticed that villagers were not utilizing them. They later discovered that lack of access to water was one of the prime reasons villagers were not using the constructed toilets. Therefore, participants phased the construction of toilets to accommodate a water distribution project. The design, development and implementation of the water distribution project also addressed many other challenges. Once the first phase of the water distribution project was over, the degree of impact of the sanitation project increased considerably.

This phased approach provided the opportunity for participants to assess the adoption of the proposed technology interventions, to understand the inherent problems, propose new solutions, and develop faster methods to diffuse different technologies and solutions for the betterment of the community. This approach also ensured adherence to any cultural or legal dimensions and enabled participants and villagers to engage in collaborative decision-making. Finally, this approach facilitated capacity building among villagers in the maintenance of adopted technologies and/or in the delivery of services related to technological interventions.

E. Rural Managemen Platform (RMP)

The effectiveness of a phased approach used in the Live-in-Labs™ program is dependent on the interagency coordination of participants and villagers. The RMP provides the basis for this interagency coordination. The platform is a 24/7 user-friendly software that supplies virtual connectivity to all program sites (villages),thereby fostering communication between research teams throughout the Live-in-Labs™ program. The platform stores and processes data generated from various research activities; provides a constant, multi-directional flow of information that can be easily stored and accessed anytime and anyplace, and disseminates centralized information that is collected from periodic reports and meetings. The platform also helps model current challenges faced by rural communities, enables remote monitoring and assessment of pilot deployments, and functions as a regulatory system that ensures all participants work in accordance with the rules and regulations stipulated by the program. Fig 2.1 shows the Rural Management Platform.

III. CASE STUDY: LIVE-IN-LABS™ PROGRAM AT VALLARAMKUNNU VILLAGE

Participants visited one of the remote tribal villages- Vallaramkunnu - which is located on top of a small mountain in the Wayanad district of Kerala. The village has a population of about300 people and is comprised of four tribes spread across 43 houses. The majority of houses have one room with

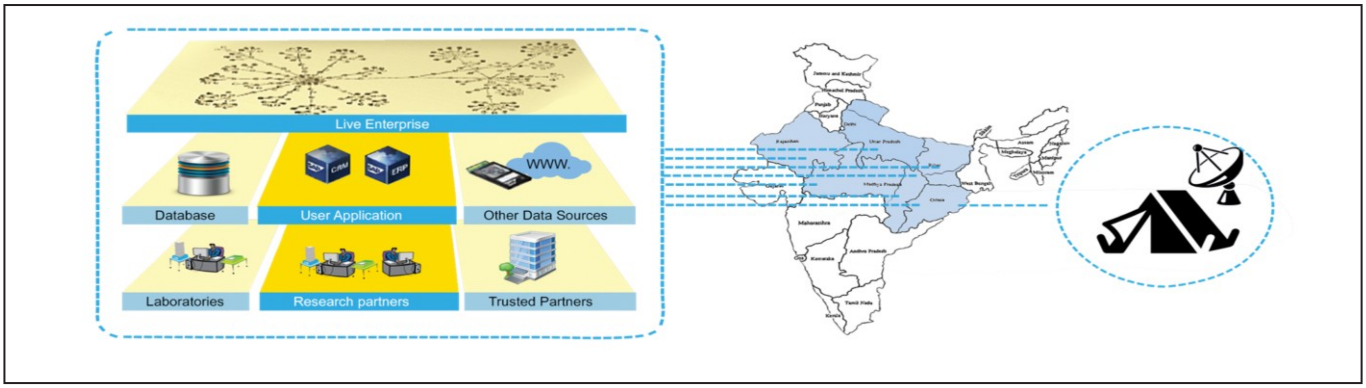

Fig. 2.1 Rural Management Platform in Live-in-Labs™ Program

athatched roof and mud walls. The villagers cannot afford electricity and hence depend on wood for cooking and kerosene lamps for lighting. Depending on scarce labor opportunities available nearby, the village is subjected to extreme poverty coupled with alcoholism and substance abuse. School dropout rates are as high as 80 percent, and women are deprived of income opportunities. Participants also observed that poor health and hygiene has a significant economic impact on the lives of the villagers.

Based on the needs of the village, Live-in-Labs™ participants identified key challenge areas where technology interventions could be applied. During their stay of more than a week, participants engaged very closely with villagers and identified several problems such as high dropout rates from schools, substance abuse, lack of work skills, low income generation, contaminated drinking water, unprofitable farming practices, poor sanitation practices, and restricted access to and lack of energy for home lighting and cooking. Even though there were several problems, the participants prioritized the problems based on their understanding of the village's needs. Participants allocated the highest priority to providing a solution for restricted access to energy since it is the fundamental requirement to provide further solutions for the villagers. The interventions implemented in the five thematic areas, the disciplines involved, the number of participants, and the number of phases of each intervention, as of 2016, is shown in Table I below.

Fig. 3.1 shows the 30-month timeline progression of the eight technology interventions in the relevant thematic areas implemented in Vallaramkunnu. The percentage of community participation for each intervention is also shown. Interventions 1 – 8 represented in Table I are reflected in Fig. 3.1.

TABLE 1. LIVE-IN-LABS™ TECHNOLOGY INTERVENTIONS IMPLEMENTED IN VALLARAMKUNNU

Project Number	Projects	Thematic Area	Disciplines Involved	Number of Participants	Number of Phases (as of 2016)
1	Tablet-Based After School Program	Education	Education, Computer Science, Social Work, and Media and Communications	20	3
2	Solar Electrification	Energy	Electronics and Electrical Engineering, Civil Engineering, and Wireless Networks	48	3
3	Anti - Alcohol Awareness Program	Health & Livelihood	Public Health, Social Work, and Computer Science	32	2
4	Water Filter	Health & Livelihood	Biotechnology, Mechanical Engineering, Chemical Engineering, and Public Health	16	2
5	Lemon Grass Distillation	Environment & Farming	Business, Chemical Engineering, and Mechanical Engineering	20	2
6	Tailoring	Health & Livelihood	Fine Arts, Business, Electrical Engineering, and Wireless Networks	15	2
7	SmokeFree Cook Stove	Energy	Environmental Science and Thermal Engineering	8	1
8	Rural Sanitation Program	Infrastructure & Basic Facilities	Biotechnology, Computer Science, Civil Engineering, and Public Health	19	2

The vertical axis of Fig. 3 represents the phased progression of the various interventions whereas the horizontal axis shows the timeline in three-month intervals. The thickness of the progression line represents community participation. Multi-thematic interventions (e.g., Intervention 5 and 6) are represented by the broken progression line. The secondary thematic area is represented by the color of the intervention number. The black grid line above Phase 1: Design represents the base line for interventions.

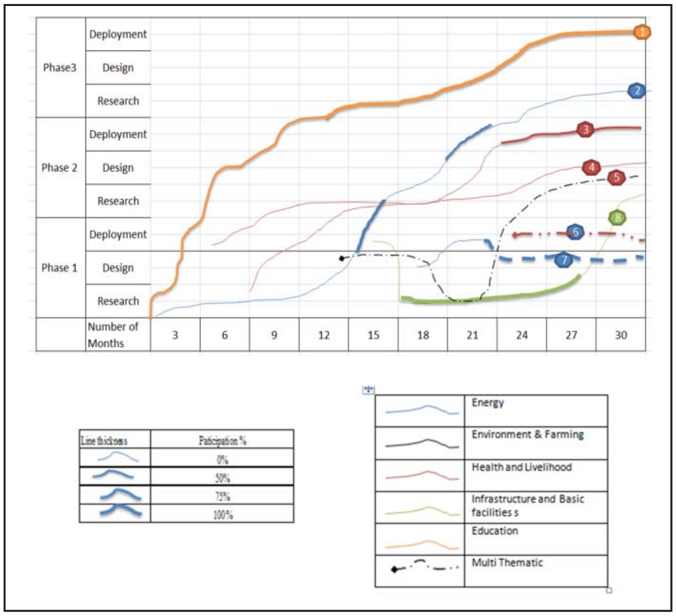

Fig. 3.1: Timeline of Technology Interventions with Phases

Intervention 1 in Phase 1 was deployed for 2 months, and Phase 2 deployment was completed in 8 months. More time was spent on design and deployment because interventions 3 and 4 served the same beneficiaries. The change in the slope of Intervention 1's Phase 2 progression line shows the interdependencies of Interventions 3 and 4. A further change in slope is observed for Intervention 1 when Intervention 2 progressed to Phase 1 Deployment. No studies have been performed on the causal impact of the mutual interdependency of interventions.

More than 75% of the community participated for all interventions in all phases whether during or post-deployment. Interventions 6 and 7 did not progress to Phase 2. Some interventions (1, 2, and 3) started with research and then subsequently moved into the design and implementation phase of the intervention. Based on the impact on the community, the research, design, and re-deployment was phased (e.g., Intervention 4, Intervention 6, and Intervention 8). The Live-in-Labs™ program was able to address the community's challenges and deploy technology interventions within 24 months.

IV. Rapid Translational Research and Implementation (RTRI) Model

Based on our experience with the Live-in-Labs™ program, a holistic model named as Rapid Translational Research and Implementation (RTRI) model was proposed. This model enables the application of technology for rural development as a systematic matching of the supply and demand process driven by a continuous flow and exchange of information. A key theme of the RTRI model is interagency coordination – a multi-level, multi-channel system of sharing and communicating, implementing and testing, and monitoring and assessing research, resources, and technology. This multi-dimensional model facilitates the development and effective implementation of customized, scalable, and sustainable technological solutions to foster rural development. The model is divided into four cells[3]: Multidisciplinary Innovation Cell, Experiential Learning Cell, Implementation and Performance Cell, and Services Cell. Figure 4.1 shows a visual representation of the model.

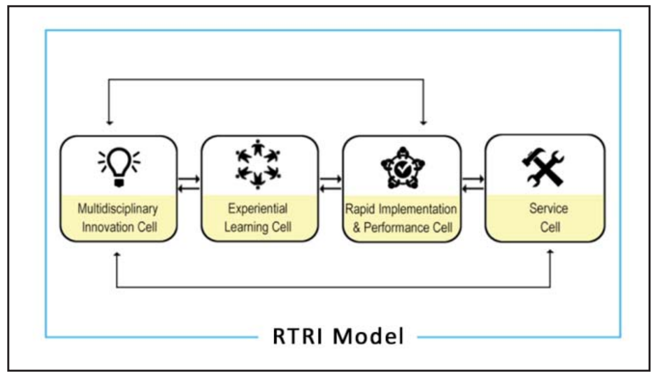

Fig. 4.1: Rapid Translational Research and Implementation (RTRI) Model

A. *Multidisciplinary Innovation Cell*

This cell is a network of methodologies that:

- Deconstructs a given set of challenges into smaller units
- Reconstructs these initial challenges into an entirely new set of challenges that are manageable
- Assesses and evaluates the flexibility, capacity, and degree of leverage of the various disciplines involved

In this cell, methodologies revolve around identifying challenges from multiple fields or multiple perspectives, thereby generating a holistic approach to proposing interventions rather than a unidimensional perspective.

Inputs from multiple disciplines increase the chances of developing sustainable and scalable technology interventions for rural development. Figure 4.1.1 shows a practical application of the cell.

B. *Experiential Learning Cell*

This cell is a network of methodologies that map the attributes of technological demands of rural communities in accordance with the community's rationale for rural development. The cell also focuses on:

- Establishing a frame of reference
- Selecting a proper scale

[3]Each cell should be considered as a network of methodologies.

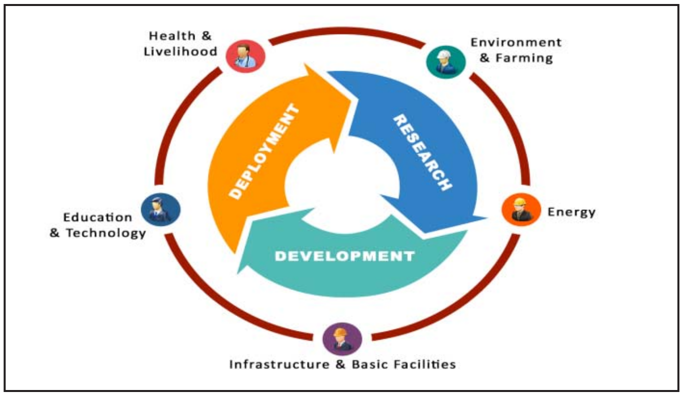

Fig. 4.1.1: Multidisciplinary Innovation Cell in Live-in-Labs™ Program

Here methodologies focus on the development of technology interventions in collaboration with rural populations by engaging in community immersion activities that help identify challenges, assess priorities, and acknowledge concerns of local residents. Figure 4.1.2 shows a practical application of the cell.

Fig. 4.1.2: Experiential Learning Cell in Live-in-Labs™ Program

C. *Implementation & Performance Cell*

This cell is a network of methodologies in pursuit of identifying the optimal equilibrium point of technology-based interventions for rural development. The cell also focuses on:

- Phased[4] implementation of technology interventions
- Continuous profiling of parameters
- Impact assessment of externalities on equilibrium

Here methodologies are used to test, assess, and monitor technology interventions by implementing them in phases, making sure proposed interventions reflect the demands and address the concerns of the community in need. The methodologies also evaluate technology interventions for sustainability and scalability and how well they have adhered to social, cultural, economic, and environmental standards. Figure 4.1.3 shows a practical application of the cell.

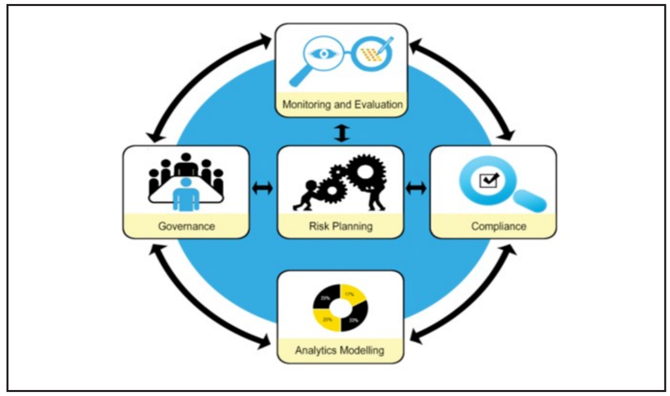

Fig. 4.1.3: Implementation & Performance Cell in Live-in-Labs™ Program

D. *Service Cell*

This cell is a network of methodologies that creates an ecosystem for the continuous exchange of knowledge and resources among disciplines, actors[5], and externalities while also coding and archiving events[6]. The methodologies in this cell primarily focus on the management and sharing of knowledge and resources and disseminating centralized information for easy accessibility anytime, anyplace. Figure 2.1 shows a practical application of the cell (Rural Management Platform).

V. Outcomes of Multi-phase Interventions through Live-in-Labs™ program

Multi-phase interventions through the Live-in-Labs™ program have been implemented in 60 villages since its inception in 2014. These interventions show the efficacy of the RTRI model. Some of the measured outcomes are given below:

A. *Knowledge Outcome*

Based on extensive research, the Live-in-Labs™ program was able to implement over 50 interventions, many of which created sub-intreventions or spin-off interventions. The Phase 3 Research of solar electrification produced spin-off interventions such as a Real-Time Monitoring System of Energy Generation and Distribution as well as Distributed Real-Time Energy Management Algorithms for a Sustainable Micro-Grid. The total number of interventions for all thematic areas, inlcuding spin-offs, is 168.

B. *Tools Outcome*

The Rural Management Platform was created to facilitate virtual connectivity to all program sites (villages), thereby fostering communication between research teams throughout the Live-in-Labs™ program. In the next three to four years, we would like the software platform to monitor the progress of proposed interventions, communicate with collaborating partners, and disseminate information with all beneficiaries. Currently, 62% of the beneficiaries have been connected to the platform. We hope to achieve 100% connectivity in the future.

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[4] One phase is a representative sample of the designated long term goals of the intervention.

[5] Refers to researchers, students, field experts, and villagers.

[6] A single phase of implementing a technology intervention with unchanged parameters

C. Training Outcome

One thousand undergraduate and postgraduate domestic[7] and international students have participated in the program. These students have helped address challenges and proposed solutions at different phases for various periods of time. The following are a few quotes from past participants.

"When you are working with the people, you really get to know where you are as opposed to being a foreigner who has been transplanted there. Thus, I found this to be one of the most valuable trips, and I would definitely like to come back and continue the work I did." (Meghan Gates, MFA Fine Arts, University of Maryland, USA, 2014).

"This program is overwhelmingly positive and I give it my personal recommendation. Not only was I able to experience the amazing and tantalizing culture of India, but I was able to observe and immerse myself in the remote tribal villages of Southern India. I was able to grow as a person while fostering friendships and bridging my cultural understanding of how societies organize and operate." (Brandon Arkinson, B.A. Disability Studies, Ryerson University, Canada, 2015).

D. Outreach Outcome

Participants of the program have clocked over 200,000 hours of direct engagement with rural communities. The following is a list of areas where technology interventions were successfully implemented with the respective number of beneficiaries:

- Interventions related to water were implemented in 3 villages with 2,700 direct beneficiaries: a water distribution system which provides tap water to households, water filters to improve the water to schools and community centers, and health centers, and women-based awareness programs on water quality and testing.
- Interventions related to energy were implemented in 2 villages with 600 direct beneficiaries: rural electrification, initiation of new community-based businesses, powering a water distribution system, powering tuition centers, and integration of multiple microgrids for effective energy management.
- Interventions related to education were implemented in 41 villages with 1,150 direct beneficiaries: separate programs for school children, adults, women, and youth.
- Interventions related to sanitation were implemented in 30 villages with 850 direct beneficiaries: building toilets, an awareness program, lighting toilets, and nudging (encourage the adoption of a new idea or practice into a community).
- Interventions to aid income generation had 390 direct beneficiaries: lemon grass distillation unit, tailoring unit, craft manufacturing unit, metal crafts, sanitary napkin manufacturing unit, and automated irrigation systems.
- Interventions related to health care had 2,500 direct beneficiaries: wearable diagnostic tools and awareness programs.

[7]Students from Amrita Vishwa Vidyapeetham (Amrita University), Kollam, Kerala, India. This University runs the Live-in-Labs™ program.

E. Leverage Outcome

The program has had participants from 15 international universities where international students and researchers collaborated with students, faculty members, and researchers from Amrita University. These collaborations enabled leveraging knowledge and resources from around the world to design and successfully implement customized, low cost technology-based interventions in various rural communities and to conduct the appropriate research on these interventions.

F. Sustainability Outcome

On average, 50% of rural villagers participated where the program had a presence for more than three months. Since the solutions made use of renewable and locally available resources (including skilled and unskilled labor), the cost of interventions were lower compared to the alternatives. For example, as a result of the rural sanitation program, more than 300 women are now skilled in building and maintaining toilets for their homes. The interventions were created with the goal of lowering maintenance costs to village residents through the use of local resources. The overall cost of maintenance and cost of capacity building were also lower.

Similar interventions have been implemented in phases in all the adopted villages in the program, leading to a framework of best practices to help scale technology based interventions for rural communities in general.

Further notable outcomes of the Live-in-Labs™ program are:

- The participation-based implementation of the micro water distribution systems in villages in Rajasthan (located in western India) and Orissa (located in eastern India). The Live-in-Labs™ program enabled the entire system to become operational at a cost of $0.20 per person per month.
- Development and adoption of wearable health care diagnostic tools in a village in West Bengal. The direct beneficiaries of the 65 interventions were over 2,800 people (30% of the village residents). The indirect beneficiaries were over 6,000 people (more than 55% of village residents). The greatest impact of the interventions was observed in the latter phases.

VI. Conclusion

The practical application and successful implementation of technology interventions for rural development is realized through the Live-in-Labs™ program, which has yielded the RTRI model. Through phased implementations of technology interventions, the impact, sustainability, scalability, and acceptance of proposed solutions were measured, evaluated, and monitored by program participants. This approach also allowed participants to receive feedback from and collaborate with rural residents on interventions. In addition, the program enabled participants to reassess interventions and propose new ones or enhance proposed interventions to better meet the needs of the villagers. This paper discussed the various technology interventions implemented in the village of

Vallaramkunnu, providing a breakdown of the phases of implementation over a period of 30 months. The paper discussed major milestones of the Live-in-Labs™ program since it commenced. The RTRI model, derived from the Live-in-Labs™ program, has proven to be effective in blending theoretical knowledge, practical field experience, and community participation to successfully implement technology-based interventions for rural development.

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