ICT Platform-Enabled Socio-Economic Ecosystem in Himalayan Villages of India: The Case of a Forest Protection and Renewable Energy Production Project

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Abstract. There is a growing focus on developing ICT-based business ecosystems to provide an innovative and socially-embedded solution that is aligned with the UN's sustainable development goals. However, general approaches being used to build the ICT-based business ecosystems face significant challenges in achieving sustainability, participation, and self-organization on their own. In this research, we pursue the new conceptualization of emergent digital designing to understand these challenges and leverage the concepts of multi-sided platforms to design and transform an ICT-based socio-economic ecosystem that enables co-creation of value. Specifically, we use the activity theory perspective to analyze the required features in the development of an ICT-based socio-economic ecosystem for forest protection and renewable energy production. Based on our case analysis, we construct a typology of various features that an ICT-based socio-economic ecosystem should imbibe to facilitate value co-creation by various actors of the ecosystem. This research contributes to the theory of the solution genre by presenting a feature set related to different aspects of the socio-economic ecosystems. We also highlight the needed minimalistic view of ICTs in the digital transformations of societal and environmental initiatives.

Keywords: ICT Platform, Platform Ecosystem, Activity Theory, Forest, Energy, Environment, Sustainability.

1 Introduction

Managing forest resources involves dealing with many tough and challenging risks for forest departments in India. It has become even harsher in this age of global warming and climate change. Forest fires, devastating floods, and landslides are few such challenges that are being faced by the Indian forestry in the North-Western Himalayan regions of India and prominently in Uttarakhand (thehindu.com 2013; indianexpress.com 2016). Realizing the history of such disasters and the significance of the Himalayas, the Government of India launched the 'National Mission on Himalayan Studies (NMHS)' in 2015 under the Ministry of Environment, Forest, and Climate Change aligned with the UN's sustainable development goals. The mission objec-

tives focused on long-term conservation and sustainable development in the Indian Himalayan region for the ecological security of India (nmhs.org.in 2015). To fulfill its goals, NMHS has set out the call for demand-driven action research and interventions for innovative solutions.

In this research, our focus is on forest fires, which happens in Uttarakhand every year during summers. Forest bio-residue layers created by dry and fallen leaves are one of the primary sources of such a threat due to their highly inflammable nature (Pandey and Dhakal 2013). Pine tree leaves, also called needles, especially are a significant cause of forest fires (Brown et al. 2011). Previous studies have recommended manufacturing bio-briquettes from waste, dry, and fallen pine needles with the involvement of villagers (Joshi and Sharma 2014). Further, Joshi et al. (2015) suggested ways to implement a socio-economic model to manufacture and sell these briquettes as a greener and environment-friendly energy substitute for wood and coal in the open market and thereby fostering social-entrepreneurship (Joshi et al. 2015). Such a socio-economic solution, if successful, will achieve the twin objectives of forest protection and renewable energy production. Past studies have discussed the development of ICT platform-enabled business ecosystems to address societal challenges in rural or remote regions (Li et al. 2019; Jha et al. 2016; Leong et al. 2016). These ecosystems mimicked the e-commerce platforms and proved to be self-sustainable and achieved societal goals of poverty alleviation and digital empowerment in the targeted areas. These studies examined the evolution or development approach of platform ecosystems. However, the main challenge is to understand how and why these e-commerce ecosystems were able to create the necessary and sufficient network effects to self-sustain in the first place. This aspect has not been examined in the studies of ICT platform-based ecosystems for societal challenges, and it is the focus of our study. We address such a research question in a complex phenomenon where the design of the socio-economic ecosystem is entangled with the effort to protect the forest and environment.

We pursued this research question through a case study of an NMHS project, which is running for more than one year in two villages in the Nainital district, a tourism hub in the Uttarakhand state of India. It falls in a mountainous region with extensive and dense coverage of the pine trees forest, one of the leading sources of forest fires in Uttarakhand. Villagers living in the selected villages have limited income opportunities and survive on forest resources to meet part of their daily needs (Joshi et al. 2015; Joshi and Sharma 2014). The villagers who volunteered in the NMHS project were given portable, manually operated briquette machines to produce briquettes, a renewable energy substitute for coal and wood. The produced briquettes had higher calorific content at a substantially lower cost (Joshi et al. 2015). The briquettes were sold to local and nearby hotel owners. The local and national media have covered the NMHS project initiative on pine briquettes through their print and Web channels. Under this project, an ICT platform was developed and used to enable the socio-economic ecosystem comprising of villagers, micro-entrepreneurs, and hotel owners. The ICT platform was considered a key contributor to the success of the project and played an essential role in social and environmental impacts. Unlike the existing approaches of either private enterprise-driven, community-driven, or local government-

driven platform ecosystem development, the Nainital case presents a unique experience of a platform ecosystem development driven by a funded research project.
We used the activity theory to guide and implement our research (Engeström, 2015; Karanasios, 2014, 2018). We also analyzed the findings of an older case, a public-private partnership, which was tried during 2010-13 (Joshi and Sharma 2014). was also used. The learnings were helpful during the effort conducted through our funded research project. We studied the activity system containing the ICT platform as an artifact. In this research, we document, conceptualize, and analyze the case findings on how this activity system with ICT platform transformed and realized the socio-economic solution envisaged in the older case.

2 Theoretical Background

2.1 Forest Protection and Renewable Energy Production

2016 Uttarakhand forest fires were widely covered in Indian news media because of its severity, administrative failure to tackle the situation in a timely manner, and huge loss of forest resources (indianexpress.com 2016). Ecologists singled out mismanagement of forest floors filled with readily combustible pine leaves for this tragic incident. They also suggested biomass briquette production from the pine needles as the prime solution (tribuneindia.com 2016).

A program by the government in the form of 'public-private partnership' for manufacturing briquettes was started in 2010 in the Nainital district (Joshi and Sharma 2014). This program followed a strict regulatory mechanism. Each actor in the ecosystem was allowed to perform a predefined activity, and rates for each activity were fixed. A local firm Suyas Udyog private limited, was given the responsibility of manufacturing briquettes. Societal actors like villagers, local NGOs, self-help groups, women groups, and van panchayats acted as collectors of pine needles and were financially incentivized. The Forest department levied a fee for issuing a transit permit. This top-down centric regulatory approach constrained the benefits for the stakeholders and eventually led to the failure of the pine needle manufacturing project in 2013 (Joshi and Sharma 2014).

In this public-private partnership model, villagers who were crucial stakeholders of the value chain were involved as labor. The private firm was conceptualized as the value creator and was supposed to sustain the ecosystem. However, the approach of involving a private firm having an industrial approach created significant constraints for the self-sustainability of the business ecosystem due to the geography of the region and the peculiar characteristic of pine needles. Transportation costs were a considerable component in the overall costs because pine needles are lightweight and cannot be carried in high load in trucks. Transportation of pine needles from the collection spots to a distant manufacturing plant in the mountainous terrain was not an economic proposition. Higher transportation costs meant that villagers who were key stakeholders of the ecosystem could not be financially incentivized to keep them in the ecosystem. Therefore, for-profit firms can find it challenging to sustain the business.

The second model conceptualized in the research project considered villagers as the collectors, briquette producers, and micro-entrepreneurs who would sell the produced briquettes in the local market. It was implemented in the project by providing portable, manually operated briquette machines to villagers. However, preparing villagers who lack an understanding of markets, entrepreneurial capability and fall in the backward and lower strata of the society require external intervention (VanSandt & Sud, 2012).

2.2 ICT-based Socio-Economic Ecosystem for Renewable Energy Production

In the last decade, we have seen the emergence of ICT platform-based business (or e-commerce) ecosystems to overcome many societal challenges (Li et al. 2019; Jha et al. 2016; Leong et al. 2016). These studies found beneficial features of the ecosystems, such as self-organization (Li et al. 2019), self-sustainability & evolvability (Jha et al. 2016), digital empowerment (Leong et al. 2016), and emancipatory (Kanungo 2004). Here, by 'ecosystem,' we mean "a community of interacting firms and individuals who co-evolve their capabilities and roles and tend to align themselves with the directions set by one or more central companies (McIntyre & Srinivasan 2017)." There are different types of ecosystems, such as the e-commerce ecosystem (e.g., Alibaba.com, Amazon.com), which typically comprises a network of the ICT platform sponsor, buyers, and sellers (Tan et al. 2016). Next is the platform ecosystem (e.g., Microsoft's Windows, Google's Search Engine), which typically comprises a network of the platform sponsor, its complementors, and users (Tan et al. 2016). However, our focus is on establishing a third type: an ICT platform-enabled socio-economic ecosystem with mostly similar, but few distinct characteristics to an e-commerce ecosystem.

Now, we discuss the existing strategies which have been adopted in the development of e-commerce ecosystems for societal challenges. In a private enterprise-driven approach, the ecosystem governance aspects related to participation, interaction, incentives, concerns, and plans are decided and executed by the private firm. This approach survives on the adequate scope and scale embedded in the potential ecosystem, which can offer commercially accepted profit margins in the local market (Joshi and Sharma 2014). The public-private partnership approach is a constrained version of the private enterprise-driven approach. In a community-driven approach, the actors collaborate and self-organize themselves to create and govern the ecosystem. This approach requires enterprising and risk-taking capacity amongst the actors (Leong et al. 2016). In a local government-driven approach, officers of the local administration make decisions related to all aspects of the ecosystem based on the policies and programs formulated by state or central governments. This approach is mostly dependent on the government. In our study, the situation doesn't suitably fit into these approaches. Renewable energy production by manufacturing briquettes of pine needles using a portable, manually operated machine is a physical labor-based and low-profit margin activity. The initial volume being produced in the NMHS research project was not attractive enough for local entrepreneurs or private enterprises. Therefore, the concep-

tualization of a novel approach for ecosystem development is required, and it is the focus of our study.

We needed a theoretical lens to develop a holistic view to understand the mechanisms which are being used in the novel ecosystem development approach. The entanglement of forest protection, renewable energy production, and ICT platform development following the emergent digital designing approach increases the complexity to provide a solution. To develop a theory of solution for a societal challenge of forest protection and renewable energy production, we opted for the activity theory perspective as our theoretical lens in all the phases of our research study (Majchrzak et al. 2016).

3 Research Methods

To study the process of ICT-based ecosystem for forest protection and renewable energy production, we followed the qualitative research methodology. We adopted the interpretive case study method based on the following considerations (Walsham, 2006). First, past IS studies suggested its usefulness in applying activity theory perspective to a complex phenomenon embedded in the societal context (Sam, 2012). Second, interpretive case studies allow us to explore a phenomenon in the richness of its setting, which is essential to study an ICT-based ecosystem with complex social and environmental aspects. Finally, the area of ICT solutions for forest protection and renewable energy production is a scarcely researched area, where theories are yet to be developed. Therefore, it demands more qualitative studies for theorization.

Our case is based on a research project which is part of the National Mission on Himalayan Studies implemented by the Ministry of Environment, Forest & Climate Change, Government of India. The project objectives included socio-economic value creation through forest bio-residue based renewable energy production and development of an ICT platform for value-chain integration and market access (Dixit & Panigrahi, 2014; Dixit & Panigrahi, 2013). Data collection was conducted between February 2019 and February 2020. Two Himalayan villages of the Uttarakhand state of India were selected as per the project guidelines. Initial visits to the villages were conducted by the first author, shortly after the launch of the research project. An extended study started during March 2019, and three follow-up visits to the field were conducted by the authors during April-May, 2020. Two field visits were conducted during January and February 2020 by the first author to finalize the data collection. Since this was a field-based project, members of the project team regularly visited and stayed in the villages to supervise the project activities on a relatively continuous basis.

Forest Department of Uttarakhand facilitated access to the research sites and introduction with the van panchayats, which are locally elected bodies tasked with the administration of village forests. Van panchayats helped us in discussing the project objectives and employment and earning opportunities in the project with the interested villagers. Villagers were selected to work in the project according to the project guidelines. This type of access eased the project implementation process and provided

a cordial atmosphere to interact with the key stakeholders- selected villagers, van panchayats, industries, and the forest department. During our preliminary discussions with them, we were able to create the required comfort and trust among the project participants. A coding scheme was used to differentiate the participants' statements with our thoughts and reflections recorded in the field notes and reports.
Data collection methods included semi-structured interviews, interactions, and focus group discussions with stakeholders. These interviews and discussions were used to acquire a deep understanding of the socio-economic context where the ICT platform was expected to enable the ecosystem for forest protection and renewable energy production. We aimed to gather views of participants and key stakeholders about the process of renewable energy production being used in the project, benefits to participants during and after the project, and the role of the ICT platform in integrating the value-chain and facilitating market access. We incorporated the acquired learnings from the field in subsequent interviews and other aspects of the overall research. The participants were asked to share their experiences of using the ICT platform and changes they could feel in comparison to the paper-based system and existing ways of market access.

We used our observations originating from field visits, discussions, interactions, training sessions as other data collection methods for the development of the ICT platform. These observations, based on the issues raised by the participants and other stakeholders, provided us a mental map of the challenges in the value-chain integration of the renewable energy value system. For example, observations during the interactions with the villagers revealed that some villagers don't use smartphones and depend on some other member in their family when needed. It helped us understand the mobile app design requirement to suit this situation. We also included news articles and research articles on similar ongoing or past initiatives related to pine needles ranging from briquette production to ethanol production. These articles were particularly helpful in understanding the historical, social, political, and successful and failed aspects of similar projects.

It is suggested to use a theoretical lens to guide the iterative process of data collection and data analysis in interpretive case studies (Walsham, 2006). As discussed, we use activity theory for this purpose and also for theory development in this research. We followed the four criteria of an activity analysis to guide the framework of our study (Karanasios, 2018). The first criterion is about defining the unit of analysis, an activity system that captures the smallest unit encompassing the complexity associated with the activity. The second criterion is that we should be able to analyze the evolution and changes in the activity using the identified activity system. Using the case data, we identified the project team's establishment of an ICT platform-based socio-economic ecosystem for local trade of renewable energy as the activity system. We study the evolution and changes within this activity system. The third criterion is that we should be able to account for the interactions among the subject, community, and other constituents of the activity system. The fourth criterion is that the activity system should allow us to study the mediated activity, related contradictions and their resolutions, and the transformation of the object. The case data collection grid of our study is shown in Table 1. Interviews, discussions, and interactions were conducted in

Hindi and documented through field notes, digital notes, and video recordings wherever possible.

4 Case Findings

4.1 Socio-Economic Context: Nainital Villages and Pine Forest

The project team selected two villages in the Nainital district for the implementation of the research project according to the NMHS guidelines. Nainital was chosen due to two reasons. First, this district has easy availability of pine needles in the nearby forest area. Second, it is a popular tourist destination of the Uttarakhand state and hosts many hotels. Two villages, Shyamkhet near Bhowali town and Chopra near Jeolikote town, were identified with the help of forest officials as suitable sites. Following NMHS guidelines, we enrolled women and individuals from the disadvantaged sections of the society for this project. Theses villagers come from poor or below poverty line strata of Indian society, and our project presented them an opportunity to earn in the project and gain a long-term earning source and micro-entrepreneurship opportunity. The majority of the enrolled villagers were women. It happened mainly because of their daily routine. They go to the forest for a collection of wood and other forest resources in the morning, then come back for cooking and other household work. Therefore, the project activity of pine needle collection naturally fitted into their schedule. Few of these women were already into pined needle collection required for packing of fruits by local traders. This activity provided them low seasonal income, and scope was limited. Funding from the research project offered them to store pine needles in large amounts and produce briquettes using it throughout the year and sell it to local hotel owners and others. ICT platform would give them not only the market access but also transparency of their collection, production, and sale. The ICT platform-supported ecosystem was a much-needed intervention for the villagers from the previously tried and unsustainable models of public-private partnerships and government programs to overcome forest fires.

4.2 ICT Platform-based Ecosystem

Activity System and Motivation. The motivations for the ICT-based ecosystem are manifold. The first motivation is the mitigation of forest fires in the Himalayan mountain series. The second motivation is to implement the renewable energy agenda to reduce the reliance on coal as an energy source for some activities in the local industries. The third and most important motivation is creating a long-term local earning source as well as micro-entrepreneurship opportunities for the disadvantaged groups. Documentation of NMHS, the funding agency about its goals, shows compatibility with the motivations of ICT-based ecosystem in the research project.

> *NMHS envisages to work towards a set of linked and complementary goals to: Foster conservation and sustainable management of natural resources; Enhance supplementary and/or alternative livelihoods and overall economic well-being of*

the region; Control and prevent pollution in the region; Foster increased/augmented human and institutional capacities and the knowledge and policy environment in the region; and Strengthen, greening, and fostering development of climate-resilient core infrastructure and basic services assets.

The activity system, the ICT platform-based socio-economic ecosystem for local trade of renewable energy, is depicted in Figure 2. It shows the subject as a collective of individuals and entities has multiple sources of motivation leading it to interact with the community comprising of different stakeholders and jointly acts upon the object to transform it by using several artifacts.

Activity System and Community. The community comprising of villagers, village sarpanches, and hotel owners participated, interacted, and influenced the development and realization of the ICT platform. The village population was witness to instances of forest fires in their area, which caused the loss of life, pollution, and strived them off from collecting forest resources and agricultural work for days. This environmental-historical challenge manifested in many ways, including their desire to control and reduce the forest fire instances. Notably, hotel owners and home-stay owners showed high levels of curiosity in the success of the project before, during, and after the implementation.

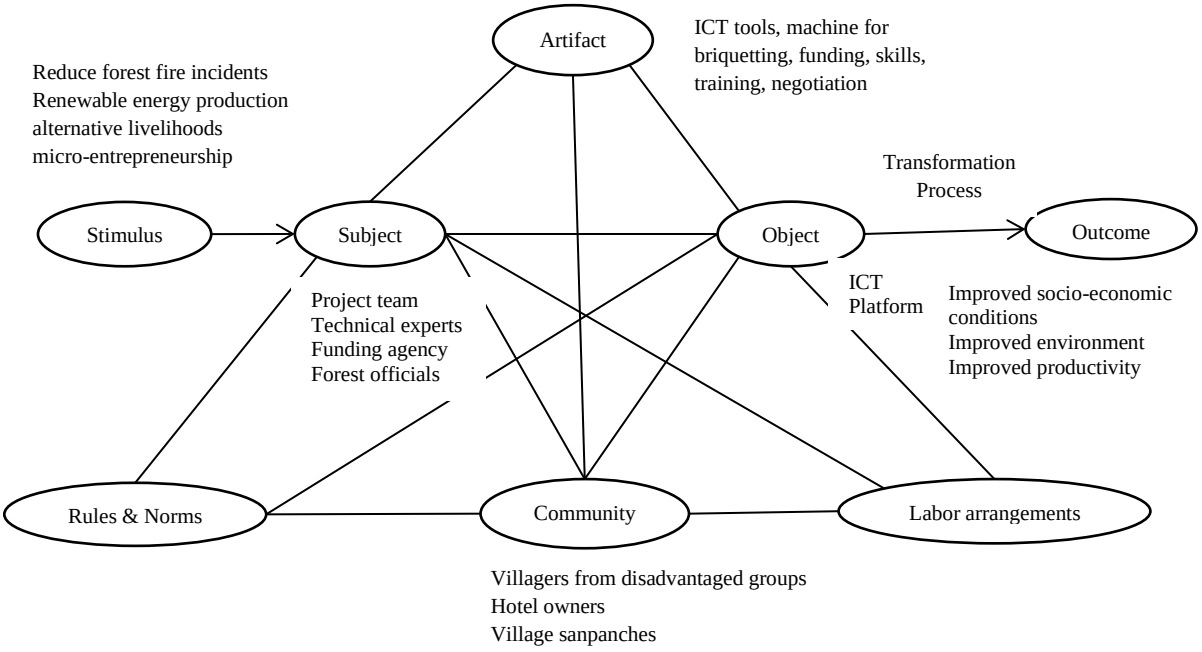

Fig. 2. activity system

One home-stay owner explained his underlying motivation for the ecosystem: *'my home-stay lies away from the main motorable road. Tourists have to trek the narrow lanes to reach us. Pine needles make these narrow lanes very slippery, especially after rains. But, this new ecosystem will also solve this problem. We would prefer to use briquettes for bonfires instead of forest wood that is very difficult to arrange due to forest restrictions.'* Villagers, particularly women, saw it as a regular, year-long source of income as men typically migrate to nearby metro cities to work for months. We were surprised to find women finding many other ways to mold the briquette into different products for higher-margin sale: *'…after looking at the produced briquette by the machine…, we can make fragranced artifacts from it; those items sell for Rs. 100 or more.'* It was clear that the ICT platform might transform from a two-sided platform into a multi-sided platform in the future. However, the project focus was on establishing the two-sided platform for renewable energy production and sale, which was completed.

Activity System, Object, and Mediation. Several key artifacts or tools were used to mediate the activity. The first artifact is funding to enable the research project as a result of the previous research work of the project team members. Intangible artifacts such as expertize and negotiation were crucial to seek a grant from the funding agency. The second artifact was a technological artifact, the portable, manually operated briquette machine, which was used to mediate the briquette production activity. The machine was designed by the project team members and developed with the help of local manufacturers. The third and most important artifact is the ICT artifact. A mixture of established information technology tools and innovative design expertise was employed to mediate the development of the object. The object, the ICT platform, was created and transformed by the activity system, and consequently, enabled the socio-economic ecosystem. The design of the ICT platform ensured the mediation by the digitization of key activities of the ecosystem, such as the pine needle collection process, briquette production process, and sale process. The socio-economic background of the villagers required us to use the information technology, which has a higher adoption rate among the participants of the ecosystem. We found that mobile technologies can play an essential role in our ecosystem platform, as evident from their success in other ICT-enabled social change initiatives like mobile banking in rural India. The use of mobile technologies has led to an improvement in rural households' savings and also reduced the cost of delivery for banks (Kochar 2018). A mobile app was designed by the first author, which was developed with the help of technical experts. Not all enrolled villagers had smartphones. However, most of them had one smartphone in the family, which was used by them to install the mobile app and become part of the ecosystem. The mobile technologies were not just tools in the project but embodied the accumulation of all the activities of the ecosystem and mechanism to facilitate the knowledge transfer to the community after the project ends. One of the project team member, who was not part of the mobile app development effort, said: *'…after using the mobile app for the first time…it seems simple to*

use, minimalistic functionality,… just the thing for villagers…they will love it.' The fourth artifact was training that helped villagers and hotel owners in learning the functionality of the mobile app. Other skilled stakeholders also supported this activity.

Activity System, Rules & Norms, and Labor arrangements. During the establishment of the ecosystem, norms evolved with the involvement of all the stakeholders. For instance, enrolled men took up the field assistant activity. They went to the forest sites and weighed the pine needle collection of each woman. They entered the pine collection data of each woman using the mobile app and took either signature or thump impression in a paper in a standardized format. This paper was uploaded using the mobile app to ensure the transparency and accuracy in the ecosystem. Each field assistant and villager had their own account in the mobile app and could check and verify their details for accuracy. This process is essential to build up the trust in the ecosystem to overcome the historical and cultural baggage of corruption prevailing in the society, where the disadvantaged group is often at the receiving end. A similar process was adopted for the briquette production activity. Field assistants were aspiring micro-entrepreneurs and saw the mobile app as a milestone for their future: *'...after using the mobile app...we can play a role similar to the customer care of companies and can facilitate the women briquette producers in the selling activity in the market.'* For the project work, women were being paid for their pine collections as per the prevailing rate fixed by the forest department. The field assistants were being paid for their work using the allocated funds in the project. The payment process was offline, cash-based for many reasons.

5 Discussion and Case Analysis

Using the activity theory perspective, we highlight the potential of ICT artifact to create an ecosystem out of a low margin economic activity and in a social and environmental initiative. The socio-economic ecosystem established in the research project is similar to an e-commerce ecosystem, but with some different features—first, villagers, one of the participating sides in our ICT platform-based ecosystem, lack self-organization. But if given the direction, they can deliver value, which exhibits the hidden potential in the working capacity of the bottom of the pyramid, which can be realized using ICT. Second, the ecosystem didn't have an IT or e-commerce company to create the ICT platform, and the project team did it. The functionality was developed in the mobile app as the ecosystem evolved. Therefore, it exhibited a minimalistic view of ICT, which is needed to create social value in a developing country like India.

6 Conclusion

In this research article, we embarked upon presenting a case on a socio-environmental project, which led to creating a socio-economic ecosystem for renewable energy pro-

duction. We contribute to theory by suggesting a new type of ecosystem differing from e-commerce or platform ecosystems. The socio-economic ecosystem has the following characteristics: realizing the working capacity of the bottom of the pyramid and minimalistic view of ICT for creating social value. We also contribute to the activity theory perspective by applying it to a social and environmental case-related activity. Our study has implications for public and private initiatives, interventions, and policy directions for socially weaker sections and ecological issues. The results of our study suggest that livelihood creation and environmental protection can go hand-in-hand. The study has few fruitful research directions such as analyzing the design aspects of the ICT platform, expansion of more sides in a platform, evolution of relationships among platform participants.

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