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Affordance Actualization of Digital Public Infrastructures

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Abstract

To achieve socio-economic development, global south is extensively developing digital public infrastructures (DPI). Unlike traditional ICT4D, DPI establishes open design, protocols, and standards that can be implemented by multiple stakeholders into varied solutions. We seek to identify DPI's offered affordances and higher-order mechanisms by employing the affordance-based generative mechanism framework of critical realism. As DPI are implemented to scale, we also investigate the challenge of multifinal outcomes due to affordance actualization by different user types. Using ethnographic case study analysis and topic modelling, we retroduce mechanisms of the Government of India's agricultural DPI, the sugarcane information system (SIS). The preliminary results indicate that small farmers do not fully actualize the offered affordance and encounter further marginalization due to their current niche. The governing bodies can utilize the framework and recommendations to increase the adoption and generative outcomes of a DPI in the presence of multiple niches.

Keywords: Digital Public Infrastructure, Agriculture, Affordance, Generative Mechanisms, Socio-economic Development, Niche Construction

Introduction

In 2023, the G20 Submits declaration under India's presidency proposed the "G20 Framework for Systems of Digital Public Infrastructure" to promote inclusive and sustainable development. United Nations Development Program (UNDP) defined digital public infrastructure (DPI) as the combination of *(i) networked open technology standards built for public interest, (ii) enabling governance, and (iii) a community of innovative and competitive market players working to drive innovation, especially across public programmes*. It offers a data governance approach that ensures compliance merely by participation. The architecture enables public and private sector organizations to uniquely innovate and scale DPI around their business context and offered services. Unlike traditional IT initiatives, (a) DPI's generative outcomes can go beyond what is envisaged by a DPI creator, and (b) DPIs can be implemented by multiple stakeholders into varied solutions. These open designs and standards have the potential to accelerate growth and development by unlocking new business models and avenues. Unified payment interface (UPI) is one such DPI that evolved into innovative businesses such as QR code-based payments and UPI-based financial products. It achieved 80% financial inclusion over six years of its inception (The World Bank, 2023). European Union's online dispute resolution (ODR), Togo's Novissi, UNDP's climate transparency global registry, and Rwanda's and Malaysia's judicial efficiency DPI are a few examples from across the globe (United Nations Development Program, 2023).

The rising global interest in DPI posits a new challenge to understand if it can create a homogeneous generative impact for its users. We seek to find DPI's offered affordances and examine whether these in the form of agencies and constraints lead to generative or degenerative outcomes for the users. We further

explore the role of the type of user in the affordance actualization process. Volkoff & Strong (2017) define technology affordance as *"the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artefact) and a goal-oriented actor or actors."* The affordance theory assumes that human actors have the requisite abilities to effectively actualize or realize the potential of technology artefacts possessed and perceived affordances (Strong et al., 2014). However, affordances depend not solely on technology features but on how the actors perceive and actualize them (Chemero, 2003). A resource-weak user will not be able to actualize a possessed affordance even with the ability to actualize it to achieve his goals. Since affordance is both relational and a resource, it exists despite remaining unactualized. However, an unactualized technological affordance will fail to render the intended benefit for development in society. The actualization process can lead to positive (generative) or negative (degenerative) effects on users with varying degrees of resourcefulness and ability. Moreover, developmental digital initiatives' impact is contextual, making it imperative to identify who benefits and who loses (Walsham, 2017).

To explore the divergence in affordance actualization and identify the user groups on the receiving end of multifinal outcomes, we examine a large-scale Indian agriculture market's DPI: sugarcane information system (SIS). It is a set of standards that govern sugarcane trade between farmers and sugar mills and each sugar mill custom-adopted these standards to automate their interactions with farmers. Since, SIS has been operational since 2010 in the state of Uttar Pradesh, India, we studied the phenomena in two phases: (a) immediately after implementation and (b) ten years post implementation. We utilize longitudinal data to examine why farmers fail to realize the intended socio-economic benefits fully. We classify Indian farmers into small and large depending on landholding, financial resources, and workforce. We observe the outcomes to derive the mechanisms of DPI. The primary results show that the affordances result in lower socio-economic development for small farmers. Large farmers benefit from such systems and capture enhanced socio-economic development. We observe variations in the affordance actualization process due to disparity in the two farmer types' ability, resourcefulness, and sociocultural practices. Policymakers should be aware of the diverse communities' resourcefulness and create facilitating conditions for (a) businesses so they can capitalize on innovative businesses and (b) users such that they undergo socio-economic growth by realizing maximum affordances.

Research Background

The state (or province) of Uttar Pradesh in India is home to three million sugarcane farmers and 125 operational sugar mills. A typical sugar mill procures sugarcane from approximately 20,000-30,000 farmers. These farmers grow sugarcane in the vicinity (a radius of 7.5 km) of the mill, as sugarcane needs to be crushed and processed within 48 hours of harvesting. To safeguard farmers' interests, farmer's societies are formed, with the sugarcane commissioner acting as the registrar of these societies. The cane commissioner acts as a guardian for all stakeholders and regulates the interaction between the farmers and mills by defining cane policies that govern the procurement process. In 2010, the office of the sugarcane commissioner of Uttar Pradesh started developing a standard set of features required to govern the online interactions between the farmer and the mill. The resultant DPI was made part of the state's cane policy and published at www.upcane.org/sis. Each mill adopted the DPI to automate their interactions with farmers using the website, SMS and Query SMS system, and IVRS. Individual mill's system was integrated as SIS. Each mill maintains its website and is responsible for service level agreement (SLA) adherence, as defined by the sugarcane commissioner's office. In April 2011, a feature of publishing an SMS log was added to ensure that every interaction between farmer and mill is available on SIS. For public monitoring, these SMS logs are accessible on the internet by inputting the farmer's code. The system's key entities are sugarcane, SIS, farmers, and sugar mills.

Sugarcane is a highly perishable commercial crop. Its price dramatically reduces if farmers fail to sell it to the sugar mills. Every year, to safeguard farmers' interests, the government announces faire and remunerative prices (FRP) and state-advised prices (SAP) for sugarcane. As a commodity, the sugar trade is strictly regulated by the government, affecting sugar mills' profits. Therefore, the government sometimes also sanctions interest-free loans to the mill owner to help clear the due payments of the farmers. Every farmer is expected to get their land surveyed during the sowing season and begin harvesting only after receiving the indent slip from the mills. Table 1 shows the classification of farmers.

	Small Farmers	Large Farmers
Landholding	They own small pieces of land, often on the outskirts of the village (limiting the crop's quality and yield).	They own large farmlands and sometimes multiple pieces across the state.
Literacy Rate	Lower	Higher
Machinery Resource	They own limited machines and rely mostly on physical labor.	Deploy effective machinery to increase productivity.
Workforce	The family members work as farm workers to grow, maintain, and harvest a crop.	They either employ low-priced labor to work on their farms or lease their land in exchange for a profit share.
Transportation	Often use animal-pulled wagons/carts, which are slower and of limited carrying capacity.	They have faster farm vehicles capable of carrying large loads of harvest.
Finances and Debt	They are not financially stable and frequently struggle with debts.	They can grow complementary crops, resulting in better productivity.
Concerns	1. Successful trade of harvest. 2. Receiving timely payments. Even when offered prices are lower than the market price (FRP, SAP).	1. Real-time transaction details of their landholding spread across the state. 2. The best market price for their crop variety to maximize profit.

Table 1. Farmer classification

In the above context, we wish to understand the following:

RQ1: Identifying the possessed affordances of a DPI.

RQ2: Do mechanisms of DPI lead to homogeneous generative or degenerative outcomes for all?

RQ3: How does the variation in the type of farmer influence the affordance actualization process of DPI?

Literature Review

The affordance theory was introduced in psychology (Gibson, 1979) and subsequently adopted in human-computer interaction studies (Norman, 1988). Affordances represent technology's action potential that leads to immediate concrete outcomes. According to Gibson (1979), "*affordance exists whether or not they are perceived*." However, the actualization of affordances requires an actor with the normative abilities to interact with technology (Hampson et al., 2021). Some possessed affordances will be irrelevant to the actor because they have no bearing on the individual's goals at the time (Rietveld et al., 2014). The user ends up self-selecting potential action from the available affordances. On a high level, technology affords transparency, efficiency, ease of use, accountability, access, and financial growth (Banker et al., 2011; Bonina et al., 2021; Grossman et al., 2018; Riggins & Weber, 2017; Wenner et al., 2018). Still, public digital projects fail to show meaningful agricultural market changes (Aggarwal et al., 2016). The literature also shows tension regarding the impact and sustainability of these possessed higher-order affordances. Variations in perception and interpretation are best explained using the concepts of affordance actualization. In this paper, we study the difference in the interaction of two user type and their causality through the generative mechanism lens of critical realism.

The dominant positivist and interpretivist paradigms (Heeks & Wall, 2018) posit complexity in analyzing digital initiatives that do not necessarily result in development for all (Avgerou, 2008). So, to address the ontological and epistemological gap, we use critical realism (CR). CR allows us to understand the contextual outcomes and observe the objective process of negotiations more subjectively (Singh et al., 2018). The critical realist view of causation by Sayer (1999) states that structures reveal causation, mechanisms, outcomes, and conditions of the natural world's open system. The mechanisms are unobservable and difficult to determine solely from empirical domain data. The generative mechanism method in the critical realism paradigm helps identify the mechanisms that explain the observed outcomes (Bhaskar, 1975; p.14). Affordances are a subset of mechanisms (Volkoff & Strong, 2013) and are a great lens for exploring the indeterministic nature of mechanisms. Steps to identify mechanisms through the affordance lens (Bygstad et al., 2016) are described in Table 2.

Step	Description
Case events description and description of key entities	Identifying events, outcomes, structures, and context, and finally, the relationship among them. These include our observations of the digital platforms' impacts and outcomes.
Theoretical re-description through abduction	Abduction guides data analysis, and if the analysis suggests other, more powerful explanations, they will replace the initial abductive guess (Mueller & Urbach, 2017). We abducted our analysis on how affordance is actualized for different types of farmers.
Retroduction to identify candidate affordances	To retroduce, we take an unexplained phenomenon and hypothesize mechanisms that can explain and justify the outcomes (Mingers et al., 2013). Through retroduction, we identify DPI's possessed affordances.
Analysis of affordances and associated mechanisms	This step requires the analysis of affordance interactions and interdependencies, and abstraction into higher level macro-micro and micro-macro mechanisms.
Assessment of explanatory power	This step involves repeated analysis of data until the proposed mechanisms can accurately explain the observed outcomes. We take the generative mechanims and explain all the observed events and outcome of the DPI for the two different user types.

Table 2. Affordance-based framework for generative mechanisms

On the basis of the above framework and the concepts of affordance and generative mechanisms, we conceptualize our theoretical premise in Figure 1.

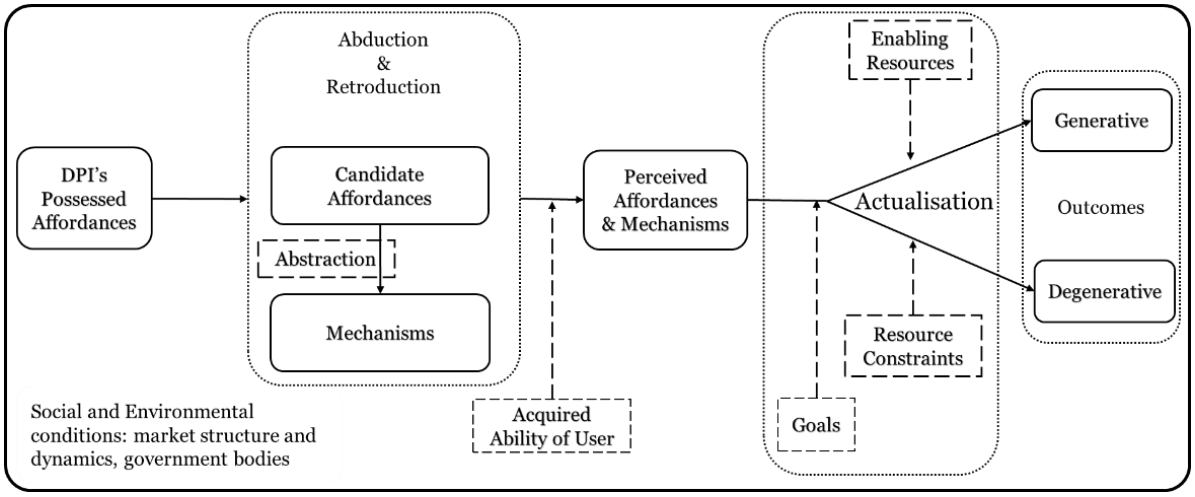

Figure 1. Conceptualization of the theoretical premise

Research Design

CR-based research focuses more on explaining and understanding a phenomenon rather than making future predictions. Although Bhasker (1975) did not prescribe any methodology, CR researchers consider case study methodology the best approach for such socio-technical studies (Volkoff & Strong, 2013). This approach enables exploring interactions between structures, events, and actors in a real-life contextual environment to explicate and identify the mechanisms. In addition to the policy documents, newspaper reports, and the government's departmental website, we investigate SIS through ethnographic field studies using semi-structured interviews. We also plan to apply topic modelling for SIS reviews collected over the last five years. The multimethod approach helps triangulate the findings and strengthen the validity of proposed mechanisms.

Data Collection and Analysis

We had a detailed discussion with the cane commissioner and his team to understand SIS and its affordances. The meeting lasted for over three hrs., followed by numerous telephonic conversations. We conducted focused group discussions and semi-structured conversations with the sugar mill's cane procurement managers, IT managers, farmers, and farmer society's representatives. We collected data from eleven mills in two districts with a collective cane-crushing capacity of 100,500 tons daily. We captured these discussions in the form of a project evaluation report to the implementation team. The interview data from 2011-13 helped identify the system's immediate outcomes and beneficiary's experiences. From 2014-2019, we collected data from news articles and government websites to study the system's evolution and the role of different user types in the observed outcomes. The thematic coding of the interview data corroborates with the recent data collected.

Results: Affordance Framework

The research background section describes the case events and entities. In this section, we identify some affordances of DPI, their immediate outcomes, the interplay of human and technical entities, and the stimulating and releasing conditions. Unlike traditional infrastructure, DPI is not a one-size-fits-all solution. It allows adaptation for diverse business and public needs within the existing framework. Organizations must adhere to certain standards and protocols while building a tailored solution on top of the infrastructure. We seek to capture DPI's foundational service's possessed affordances, which all customized solutions retain. Investigating the RQ1, we identify all the context-free possessed affordances of DPI in Table 3.

Affordances	Intended Goals	Mechanisms
Information Broadcasting	Real-time information sharing via SMS.	Information Access
Information Seeking	Farmers seek accurate trade information.	
Standardization	Create an ecosystem with interoperability and enhanced ease of use.	Market Access
Process Digitization	Crafts efficient and transparent market conditions.	
Price Realization	Farmers realize better prices for their harvest.	Economic Development

Table 3. SIS's affordances, intended goals, and higher-order mechanisms

We now analyze the qualitative and quantitative data collected for SIS to abstract the affordances into higher-level mechanisms. Our preliminary research identified five affordances corresponding to the three mechanisms: information access, market access, and economic development (Table 2). The initial results indicate that the large farmers actualized all three mechanisms, whereas the small farmers could only partially actualize the information access mechanism. Our initial assessment of RQ2 indicates that DPI's mechanisms lead to both generative and degenerative outcomes for the farmers. We plan to evaluate each mechanism in-depth to understand the role of the type of farmer in the affordance actualization process. We will also develop a rationalization of RQ3 from the topic modeling of the past five years' user reviews.

Discussion and Conclusion

Our study finds that only a few affordances are fully actualized. In contrast to a large farmer who actualizes all the affordances, a small farmer could not actualize most of the affordances. We conclude that all affordances are not inherently available to all types of users, resulting in marginalization and degenerative outcomes (Lin et al., 2015; Masiero & Arvidsson, 2021). We argue that users will have to reconstruct their niche to actualize the affordances offered by any DPI. Policymakers need to formulate policies to facilitate this reconstruction of ecological niche. The governing bodies should iteratively apply push and pull dissemination of informational, institutional, and capability resources offered to the users. This conclusion will formulate the resource-based framework for niche construction in the context of DPIs. Failure to build a facilitating niche will result in technology becoming complacent to the impeding niche and losing its possessed affordances over time.

Using CR, we formulate a generalizable conceptual model for DPIs to understand affordances, mechanisms, and outcomes. The study contributes to technology adoption literature, and it is the first which discusses the adoption, affordance actualization, and outcomes of DPI. We identify five affordances, propose three mechanisms of DPI to the literature, and prescribe a niche construction framework to drive socio-economic growth. These causal mechanisms can be generalized, expanded, and tested in other DPI contexts. The findings also indicate a need and scope for design science research.

References

Aggarwal, N., Jain, S., & Narayanan, S. (2016). The long road to transformation of agricultural markets in India: Lessons from Karnataka. *Economic and Political Weekly*, *52*(41), 47–55.

Avgerou, C. (2008). Information systems in developing countries: a critical research review. *Journal of Information Technology 2008 23:3*, *23*(3), 133–146. https://doi.org/10.1057/PALGRAVE.JIT.2000136

Banker, R. D., Mitra, S., & Sambamurthy, V. (2011). The Effects of Digital Trading Platforms on Commodity Prices in Agricultural Supply Chains. *MIS Quarterly*, *35*(3), 599. https://doi.org/10.2307/23042798

Bhaskar, R. (1975). *A Realist Theory of Science*.

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations and research agenda. *Information Systems Journal*, *31*(6), 869–902. https://doi.org/10.1111/ISJ.12326/FORMAT/PDF

Bygstad, B., Munkvold, B. E., & Volkoff, O. (2016). Identifying generative mechanisms through affordances: A framework for critical realist data analysis. *Journal of Information Technology*, *31*(1), 83–96. https://doi.org/10.1057/jit.2015.13

Chemero, A. (2003). An Outline of a Theory of Affordances. *ECOLOGICAL PSYCHOLOGY*, *15*(2), 181–195.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*.

Grossman, G., Platas, M. R., & Rodden, J. (2018). Crowdsourcing accountability: ICT for service delivery. *World Development*, *112*, 74–87. https://doi.org/10.1016/j.worlddev.2018.07.001

Hampson, P. J., Hulsey, T. L., & Mcgarry, P. P. (2021). Moral affordance, moral expertise, and virtue. *Theory & Psychology*, *31*(4), 513–532. https://doi.org/10.1177/09593543211021662

Heeks, R., & Wall, P. J. J. (2018). Critical realism and ICT4D research. *The Electronic Journal of Information Systems in Developing Countries*, *84*(6), e12051–e12051. https://doi.org/10.1002/isd2.12051

Lin, C. I. C., Kuo, F.-Y., & Myers, M. D. (2015). Extending ICT4D Studies: The Value of Critical Research. *MIS Quarterly*, *39*(3), 697–712. https://doi.org/10.2307/26629627

Masiero, S., & Arvidsson, V. (2021). Degenerative outcomes of digital identity platforms for development. *Information Systems Journal*, *31*(6), 903–928. https://doi.org/10.1111/isj.12351

Mingers, J., Mutch, A., & Willcocks, L. (2013). Critical Realism in Information Systems Research. *MIS Quarterly*, *37*(3), 795–802.

Mueller, B., & Urbach, N. (2017). Understanding the Why, What, and How of Theories in IS Research. *Communications of the Association for Information Systems*, *41*, 17. https://doi.org/10.17705/1CAIS.04117

Norman, D. O. (1988). The Design of Everyday Things. In *hci.stanford.edu*.

Rietveld, E., Kiverstein, J., & Francis©, T. &. (2014). *Ecological Psychology A Rich Landscape of Affordances*. https://doi.org/10.1080/10407413.2014.958035

Riggins, F. J., & Weber, D. M. (2017). Information asymmetries and identification bias in P2P social microlending. *Information Technology for Development*, *23*(1), 107–126. https://doi.org/10.1080/02681102.2016.1247345

Sayer, A. (1999). *Realism and social science*.

Singh, H., Díaz Andrade, A., & Techatassanasoontorn, A. A. (2018). The practice of ICT-enabled development. *Information Technology for Development*, *24*(1), 37–62. https://doi.org/10.1080/02681102.2017.1283284

Strong, D. M., Johnson, S. A., Tulu, B., Trudel, J., Volkoff, O., Pelletier, L. R., Bar-On, I., & Garber, L. (2014). A Theory of Organization-EHR Affordance Actualization. In *Journal of the Association for Information Systems* (Vol. 15, Issue 2).

The World Bank. (2023). *G20 Policy Recommendations for Advancing Financial Inclusion and Productivity Gains through Digital Public Infrastructure*.

United Nations Development Program. (2023). *The Human and Economic Impact of Digital Public Infrastructure*.

Volkoff, O., & Strong, D. M. (2013). Critical Realism and Affordances: Theorizing It-Associated Organizational Change Processes. *MIS Quarterly*, *37*(3), 819–834.

Volkoff, O., & Strong, D. M. (2017). Affordance theory and how to use it in is research. *The Routledge Companion to Management Information Systems*, 232–246. https://doi.org/10.4324/9781315619361-18/AFFORDANCE-THEORY-USE-RESEARCH-OLGA-VOLKOFF-DIANE-STRONG

Walsham, G. (2017). ICT4D research: reflections on history and future agenda. *Information Technology for Development*, *23*(1), 18–41. https://doi.org/10.1080/02681102.2016.1246406

Wenner, G., Bram, J. T., Marino, M., Obeysekare, E., & Mehta, K. (2018). Organizational models of mobile payment systems in low-resource environments. *Information Technology for Development*, *24*(4), 681–705. https://doi.org/10.1080/02681102.2017.1311830