

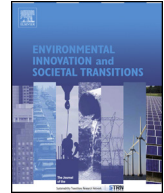


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# Transnational linkages in sustainability experiments: A typology and the case of solar photovoltaic energy in India

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### ABSTRACT

This paper explores transnational linkages in sustainability experiments. Transnational linkages refer to diverse cross-border relationships and interactions that can complement local, regional and national capabilities enabling sustainability experiments. The paper develops a typology of transnational linkages and applies it to solar photovoltaic energy initiatives in India. Our analysis shows that transnational linkages appear to be almost universal in these experiments. Of seven solar photovoltaic technology domains present in the sample, experiments in only one – off-grid power plants – can be characterised as predominantly domestic. These findings underscore the significance of capabilities, resources and linkages spanning local, regional and national scales in innovative solar PV experiments in India, suggesting similar patterns for other socio-technical experiments. This study contributes to an emerging literature on the geography of sustainable transitions, which argues for a move away from a predominantly national framing in transition studies to embrace a multi-scalar understanding of transition processes.

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## 1. Introduction

The recent 'spatial turn' in the sustainability transitions literature is attracting increasing attention from both geographers and transition scholars (Shove and Walker, 2007; Truffer, 2008; Berkhout et al., 2010; Raven et al., 2012; Coenen et al., 2012; Rutherford and Coutard, 2014). This relatively young body of literature has been developing in three lines (Truffer et al., 2015; Hansen and Coenen, 2014). A major line of research is concerned with local and regional contexts, and the ways in which innovation and transition processes co-evolve with and transform these contexts (Murphy and Smith, 2013). In particular, research on city contexts has received considerable attention (Bulkeley et al., 2011). A second direction is concerned with understanding multi-scalar relationships and the ways in which spatially distributed spaces of innovation become connected or stay disconnected (Van der Vleuten and Hogselius, 2012; Späth and Rohrer, 2012). Technological innovation systems (Binz et al., 2012; Wieczorek et al., 2014), or regimes and niches are not confined to one spatial level (Raven et al., 2012), but cut across territorial boundaries through networks and infrastructures (Shove et al., 2014). Third, a growing body of literature explores the micro-level of transitions by moving away from the classical structure-agency dichotomy, and explores the practices that make (or break) transition processes (Shove et al., 2012; Jones and Murphy, 2011). This line of research includes studies on how local practices are shaped by power relationships embedded in a wider political ecology (Lawhon and Murphy, 2012).

This paper is concerned with the second line of research on multi-scalar relationships in transitions. It builds upon previous contributions that have argued that transition studies have often assumed the national level as the spatial scale at which transitions take place and suggested that the study of transnational linkages is a way out of this national bias (Berkhout et al., 2011; Raven et al., 2012; Hansen and Nygaard, 2013; Wieczorek et al., 2014). In particular, the paper makes two contributions: one conceptual, the other empirical.

First, we aim to unpack the notion of transnational linkages by developing a typology of transnational linkages. We are interested in explaining how innovative sustainable technologies emerge in rapidly developing economies. Put simply, how do advanced socio-technical experiments emerge in low- and middle-income country contexts (far from the technological frontier)?

Evidence suggests that linkages with international networks, access to technology, markets and capital, as well as the influence of international regulatory frameworks, are important mechanisms in enabling potentially radical socio-technical innovation in less-developed country contexts. Through connections to global networks and by tapping into global knowledge and resources, businesses and other actors in developing countries can become embedded in globally distributed innovation systems for new technologies with lower resource and environmental footprints (Wolf, 2004; Busch et al., 2005). This can contribute to the acceleration of the process of environmental upgrading, and potentially leapfrogging of the sustainability performance of leading sectors in emerging economies (Goldemberg, 1998; Munasinghe, 1999; Binz et al., 2012).

We situate our attention to transnational linkages in the broader context of studies of system innovation and socio-technical transitions. Experimentation is a key concept in the transitions literature – referring to a practice-based innovation approach that embraces uncertainty and unpredictability. It has been developed as part of the *socio-technical* view of system innovation, and in particular the multi-level perspective (Schot and Geels, 2008). Berkhout et al. (2010) argue that there is much evidence of sustainability-oriented experimentation in low-income countries, which have the potential to generate new and more resource efficient socio-technical systems enabling more sustainable development pathways in these countries. In the context of globalisation, many sustainability experiments are embedded in transnational networks and flows. These networks and flows operate across spatial scales. Networks form the linkages, or 'pipelines' (Bathelt et al., 2004; Moodysson, 2008), through which flows of resources such as knowledge, human capital, technologies, finance and standards, become available to initiators of experiments, and provide access to foreign markets. So far, there has been no systematic mapping of transnational linkages in sustainability experiments.

Second, this paper moves beyond single-case study analysis to explore empirically transnational relations across a wide range of experiments, developing a new analytical approach to mapping and assessing transnational linkages. Evidence for over 200 solar photovoltaic (SPV) experiments in India is

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