

Local and distributed manufacturing during the COVID-19 pandemic: Is crisis a window of opportunity for sustainable development in the Global South?

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ABSTRACT

Shortages of critical items during the COVID-19 pandemic have led to a widespread mobilization of open, local and distributed manufacturing. In this paper, we examine the potential systemic impacts of these activities in the Global South, using the Multi-Level Perspective from literature on sustainability transitions. We conduct a longitudinal case study of a non-governmental organization that has been pioneering distributed manufacturing solutions in the Global South for almost a decade. We illustrate that the pandemic is a major landscape event that is having profound impacts on the existing socio-technical regime and niche levels. We show how niches mature over time, and that the pandemic has created an opportunity for niche replication and alignment. We present an initial analysis of factors that support and resist the path dependency of the existing regime. Thus, we speculate about the possibility to transition away from a development model predicated on the transfer of products from the North to the South, to an endogenous model of sustainable development that is underpinned by local design and production in the South. Here we show that crisis creates a key window of opportunity for sustainable development in the Global South through the formation of distributed manufacturing networks.

Keywords: Distributed manufacturing, open hardware, crisis, humanitarian, sustainable development, Global South.

1. INTRODUCTION

The rapid and global spread of coronavirus resulted in widespread shortages of critical items, including Personal Protective Equipment, clinical devices and diagnostics tools (Chagas et al., 2020). The breakdown of global supply chains and the failure of existing industry to meet demand, led to the large-scale mobilization of rapid, distributed manufacturing of Open Source Hardware (Corsini, Dammicco, Bowker-Lonnecker, et al., 2020). These initiatives make use of designs that are made freely accessible via the internet, to produce a range of critical items to meet local needs, from face shields (Prusa, 2020) to face masks (Copper 3D, 2020) to nasal swabs (Formlabs, 2020) to emergency ventilators (Earley, 2020). Although a large number of reported initiatives have been geographically concentrated in Europe and the US, highly impactful initiatives can also be found in the Global South. In Tunisia, the “Save Ain Draham” project have ramped up the production of face shields for local hospitals using a laser cutter and 3D printers (Smith, 2020). In India, the M-19 Collective have produced over one million face shields for front-line workers in under

two months (Corsini, Dammicco, & Moultrie, 2020a). In the Philippines, the FabLab Network produced over 60,000 face shields, 1,300 protective gowns and 30,000 face masks (Corsini, Dammicco, & Moultrie, 2020b). In Brazil, Protege BR documents that over 950,000 face shields have been donated from over 250 groups (ProtegeBR, 2020). These initiatives are all underpinned by the ability to use non-digital and digital fabrication (e.g. 3D printing, laser cutting and CNC milling) to locally manufacture Open Source Hardware.

Collectively, these initiatives signal the potential for a new way of dealing with crises in the Global South. Historically, the humanitarian and development sector has relied on the linear transfer of items from the North to the South to meet people's needs (L. James, 2017). Most products are designed and manufactured far away from their end users (Sandvik, 2017; Wood & Mattson, 2016), and when a crisis strikes products are imported from factories or warehouses in the Global North to their context of use in the Global South (Van Wassenhove, 2006). To this extent, the mainstream narrative in the aid sector revolves around the diffusion of innovation from the North to the South:

"The story of the [Global South] and technology if it is told at all is one of transfer, resistance, incompetence, lack of maintenance, and enforced dependence on rich-world technology. Imperialism, colonialism, and dependence were the key concepts, and the transfer of technology from rich to poor, the main process." (Edgerton, 2007)

In recent years, this model has been largely criticized for failing to provide adequate solutions to global challenges (Tatham et al., 2015). Imported products are often not suitable for the local context (Aranda Jan et al., 2016), they are difficult and expensive to transport (Falasca & Zobel, 2011; Kovács & Spens, 2009) and they disincentivize the development of local knowledge and manufacturing (Er, 1997; L. James, 2017).

Prior to COVID-19, there have been some notable efforts to counter this mainstream 'diffusion of innovation' model in the aid sector. For example, localized and distributed manufacturing has been used in Gaza to rapidly deploy life-saving tourniquets (Loubani, 2018); to produce airbags to lift rubble from collapsed buildings in the Syrian conflict (Field Ready, 2017); and to create medical items in the aftermath of the Nepalese earthquake (Corsini & Moultrie, 2019). Despite these promising examples, it is fair to say that local, open and distributed design and manufacturing has thus far been firmly positioned outside of the mainstream response to crisis in the aid sector.

Within design research, it is nearly a decade since Manzini (2011) called for the cultivation of small, local, open and connected communities to promote sustainability. In recent years, distributed manufacturing has become more widely studied in the design field (Gasparotto, 2020; Menichinelli, 2020; Menichinelli et al., 2020). However, with few exceptions previous work on distributed manufacturing has taken place in the Global North (Rauch et al., 2016), and the impact of distributed manufacturing on sustainability has largely focused on environmental concerns (Kohtala, 2015). As such, there remains sparse knowledge about how these localized and distributed networks might more broadly impact sustainable (social) development in the Global South.

To address this gap, we reflect on the large-scale mobilization of local, distributed manufacturing in the Global South in response to COVID-19. First, we introduce the Multi-Level Perspective, using literature from sustainability transitions to ground this study. Second, we present a longitudinal case study of a humanitarian organization that has been

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promoting rapid, distributed manufacturing solutions in the Global South since 2012. Third, we discuss the main findings, using the Multi-Level Perspective to speculate on how crisis can trigger systems change. Hence, we investigate to what extent crisis can be a catalyst for sustainable development in the South. For clarity, we define sustainable development as: “development that meets the need of the present without compromising the ability of future generations to meet their needs” (Brundtland, 1987). We pay particular attention to the United Nations’ Sustainable Development Goal (UN SDG) 9 to “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”.

2. SUSTAINABILITY TRANSITIONS

Simply put, a transition is a change from one state to another. The field of sustainability transitions attempts to understand the long-term changes that are needed to address complex societal problems (Rotmans et al., 2001). Recently, design and transitions research has begun to converge (Ceschin & Gaziulusoy, 2019). A core belief in sustainability transitions is that these “problems cannot be addressed by incremental improvements and technological fixes, but require radical shifts to new kinds of socio-technical systems” (Köhler et al., 2019). A popular analytical framework in sustainability transitions is the Multi-Level Perspective, which was initially put forward by Rip & Kemp (1998) and later expanded by Geels (2002, 2004). This model shows that the unfolding dynamic of a socio-technical transition depends on the reciprocal interactions between the micro (niche), meso (regime) and macro (landscape) levels (see Figure 1).

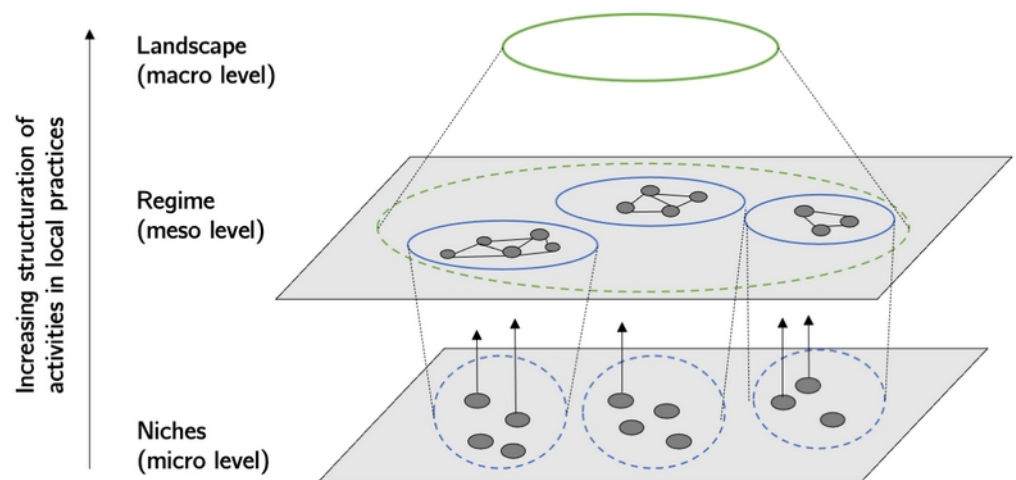


Figure 1. Multi-Level Perspective model showing linkages between the landscape, socio-technical regime and niche levels adapted from Geels (2002) and Loorbach et al. (2017)

The regime is a fundamental concept in transitions, which represents the dominant and stable configuration of the socio-technical system (Geels & Schot, 2007; Loorbach et al., 2017; A. Smith & Raven, 2012). It represents the formal and informal structures which constitute the established way of doing and thinking about things. The landscape is the exogenous environment to the socio-technical regime which is shaped by typically slow-changing global trends that include macro-economics, politics, technology adoption, cultural values and ecological shifts (Geels, 2004). Niches are protected environments where novelties can emerge away from the constraints of existing regimes (Kemp et al., 1998; Raven, 2007). They provide spaces to incubate new ideas through sustainability experiments, which provide important seeds of change (Kemp et al., 1998).

It stands that any widespread transformation depends upon the reconfiguration of the established socio-technical regime. The Multi-Level Perspective puts forward that the path dependency at the regime level will continue until there is sufficient destabilization from the landscape and niche levels (Geels and Schot, 2007). Niches play an important role in the development of alternative regimes, as they help to nurture experiments which counter the mainstream agenda (Kemp et al., 1998). Yet it is widely believed that these niches are an insufficient force for transforming the regime (Berkhout et al., 2009). What is needed then is sufficient pressure from the landscape to also destabilize the regime (Geels & Schot, 2007). The combination of these forces is required such that the regime experiences problems and collapses, whilst a window of opportunity exists for the niche to become empowered (A. Smith & Raven, 2012).

3. METHODS

This research aims to better understand how crisis can offer a window of opportunity for sustainable development in the Global South. Whilst “build back better” approaches to disaster recovery have gained traction in recent years, there is no work that specifically considers the formation of distributed manufacturing networks as part of disaster recovery. This paper specifically reflects on how the rapid mobilization of local, open and distributed manufacturing during the COVID-19 pandemic, can support a longer-term transition to sustainable development in the South.

To better understand how this long-term transformation might unfold, it was decided to select a single longitudinal case study of Field Ready, a humanitarian organization that has been promoting the use of local, open and distributed design and production in the Global South for several years. Across their programs, Field Ready remains technology agnostic i.e. they use the most appropriate (digital and non-digital) production tools available to advance the local manufacturing of humanitarian solutions.

Multiple sources of primary and secondary data were used to build a rich case study. Between 2017-2019, the first author built up a detailed understanding of the case study as part of multiple research studies. They undertook field studies, conducted interviews, reviewed organizational reports and internal communications. Between March – June 2020 the first author also conducted semi-structured interviews with practitioners at Field Ready involved in programs in Nepal, Bhutan, Bangladesh, the Philippines and Fiji. They joined bi-weekly team meetings on Field Ready’s COVID-19 response, as well as regularly reviewing their social media and website. This data helped to build a rich understanding of the case study over time.

All the interview transcripts, author’s field notes and other data was systematically gathered to analyze the case study, using the Multi-Level Perspective model. This analysis was extremely abductive, working back and forth between theory and empirical data. This approach was selected as it is well suited to dealing with complex phenomenon, and can be used to develop new insights by simultaneously matching existing theory with “messy” observations.

4. CASE STUDY

In the following section, we present brief examples of Field Ready’s early work (prior to COVID-19) and their current work (in response to COVID-19). We frame Field Ready’s work

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prior to COVID-19 as an example of an “early niche”, that competes with the existing sociotechnical regime. We suggest that Field Ready’s response to COVID-19 is characteristic of a “mature niche” which challenges the incumbent regime, and is largely synergetic with an emerging regime (i.e. a new socio-technical configuration). We stress here that niche does not imply small or limited in scope, but refers to niche-level activities within the Multi-Level Perspective model.

4.1. Field Ready as an early niche

In 2010 the Haitian earthquake left the country without essential medical supplies. Even with billions of dollars in donations, supply chain disruption meant that getting supplies to where they were needed was incredibly challenging. As a pilot program, Field Ready experimented with 3D printing to locally produce essential medical supplies. A small number of 3D printers and materials were imported to Haiti as part of a trial to design and produce items at the site of user demand. Quality control tests were also performed on-site, reducing the length of the humanitarian supply chain. Among several projects, a set of umbilical cord clamps were developed which could be easily produced using a 3D printer. Field Ready had discovered that extreme shortages meant that midwives were tying umbilical cords with shoelaces, which created a significant risk of infection. Their device could be printed instantly on-site, and was 40% cheaper than imported alternatives. Since then, the device has been made available on Thingiverse so that anyone can freely adapt and produce their own clamps. As well as developing critical items for the recovery response, Field Ready also worked with local innovation spaces to run community training on design, prototyping and 3D printing. Thus, by shrinking the supply chain and localizing production, Field Ready could also help to contribute to the long-term development of an innovation culture in Haiti.

4.2. Field Ready as a mature niche

In the last decade, Field Ready has developed a number of international programs and they currently operate in Nepal, Bangladesh, the South Pacific, the US, Iraq and Syria. The establishment of these new programs can be viewed as the multiplication of niches that are also growing in maturity. Although Field Ready found early acclaim for their work using 3D printing, they use a broad range of traditional and non-digital fabrication tools as part of their mission to advance the localized manufacturing of humanitarian products.

Since the COVID-19 outbreak was declared a pandemic in mid-March, Field Ready has developed several items to tackle the spread and prevention of coronavirus. The development of these items has been enabled by the sharing and testing of Open Source Hardware between the global Field Ready team. For instance, Field Ready developed an open database to assess production parameters and the quality of various face shield designs. In-country teams were able to use this information to select and adapt designs, according to local demand and resources.

In Iraq, the team have developed kits for home sewn face masks and, distributed face shields to hospitals via the COVID Crisis Centre in Mosul. These items were produced at the Mosul Space, a newly established makerspace which aims to foster innovation and entrepreneurship. On-site quality controls were performed before items were delivered to the crisis center, who were able to manage supplies to hospitals through their own logistics operations. In Nepal, Field Ready have been collaborating with other innovation labs to repair broken ventilators, as well as coordinating the production of face masks, hands-free taps, face shields and gowns. In Bangladesh, the team has received a request for 70,000 pairs

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of soft-framed goggles, and they are also working to ramp-up production of face shields. Field Ready collaborated with a local product design company, Involute Tech BD, to develop the goggles after the Bangladesh government issued a request. The production of these goggles and other items have been distributed across several fabrication labs and small manufacturing companies in Dhaka. Field Ready has taken on a critical role in managing the quality control across the decentralized network. By partnering with BRAC, an international NGO with a well-established logistics network in Bangladesh, they have been able to efficiently deliver these items to users. In Fiji, they have been scaling up the production of face shields, privacy screens and hand washing stations, suitable for local needs and available resources. By establishing partnerships with Fiji's Ministry of Health and Medical Services, Field Ready have been able to tap into national supply chains and to effectively distribute items to hospitals and local health centers.

Field Ready's ability to share knowledge between their different programs, and the broader Open Source Hardware community highlights the benefits of resource pooling in distributed manufacturing networks. Each site is small and flexible to the local needs of users, and can be tailored according to changes in demand and available resources. Field Ready helps to centralize quality control across distributed production sites. By leveraging the existing supply chains and logistics operations of in-country government and non-governmental agencies they have been able to rapidly deliver products to users.

Beyond Field Ready, the COVID-19 crisis has seen the spontaneous development of new niches and their growing alignment has helped to increase their internal momentum. Whereas previously Field Ready's work was among few initiatives that were pioneering the use of distributed manufacturing in a crisis, the current pandemic has given rise to a mass mobilization of localized production. As an "early niche", the ability of Field Ready to shape the status quo was limited. Over time, niche maturation and replication suggest that these elements are stabilizing. Collectively they present an alternative vision of the status quo which has greater potential to influence the regime level.

5. DISCUSSION

In the previous section, we presented the case of Field Ready as an example of an early niche, that has now matured and is consistent with other efforts in the niche level. In this section, we speculate on possible transition pathways, by exploring how crisis can be a catalyst for sustainable development in the Global South. This discussion reflects SDG 9 that "build[ing] resilient infrastructure, promot[ing] inclusive and sustainable industrialization and foster[ing] innovation" is a key dimension of sustainable development.

First, we present the characteristics of the incumbent and emerging socio-technical regime, enabled by distributed design and production. Second, we discuss the factors that are placing pressure on the incumbent regime, as well as the factors that are resisting its transformation. Third, we suggest a speculative transition pathway, towards sustainable development in the Global South.

5.1. The transformation of the socio-technical regime

The current COVID-19 crisis can be viewed as a major disruptive event in the landscape that acts as a significant destabilizing force on the socio-technical regime. As shown in Table 1, the incumbent regime is predicated on the supply of products from the North to the South and constitutes the traditional way of doing things in the aid sector. The emerging regime is

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countervailing to this agenda, and proposes a new socio-technical system that favors local solutions in the South for the South. We speculate that such a model would improve short-term crisis response and long-term prosperity.

We argue that the incumbent regime, which is characterized by centralized, closed industrial systems, largely follows an exogenous model of development. The result is that this socio-technical configuration largely increases the dependency of the South on the North, and thus undermines long-term goals for sustainable development. On the other hand, the emerging regime builds towards the goals of sustainable development through its cultivation of local, open and distributed manufacturing. Whilst we suggest that this new localized and distributed regime is enabled by digital fabrication, this does not preclude the use of traditional and non-digital fabrication tools.

In this paper, we have considered the possible impacts of a crisis, such as COVID-19 to influence the transition from the incumbent to an emerging regime. We have presented Field Ready as an example of a niche that is supportive of the emerging regime that is predicated on local production in the South. That said, there are some important caveats. For instance, some of the materials and production tools (including 3D printers, filament) which Field Ready use to enable localized production are still manufactured in the Global North. Moreover, much of Field Ready's work relies on the supply of donor funding from the North to the South. To this extent, they are not totally free from the constraints of the incumbent regime. Regardless, we put forward that Field Ready's work is a step in the right direction, bringing to the fore new issues that were not previously apparent.

Table 1. Taxonomy of the incumbent and emerging aid sector regime in the Global South

Dimensions	Incumbent regime <i>Diffusion of technology from North to South</i>	Emerging regime <i>Local production in the South</i>
Technological	Not enabled by digital fabrication Closed General Centralized	Enabled by digital fabrication Open Local Distributed
Socio-cultural	Insular Dependency	Networked Empowerment
Policy/user and market	Exogenous development Passive actors	Endogenous development Active actors

5.2. Pressure and resistance to transformation

The transformation of the socio-technical regime is set against a landscape of deep cultural, economic and political trends. Even before the COVID-19 pandemic, we suggest that an emerging set of trends were placing pressure on the existing regime. First, the number of protracted and complex problems have been consistently rising in the aid sector (OCHA, 2015). These crises place increasing pressure on the incumbent regime and help to expose its cracks. Second, the proliferation of digital fabrication tools in the Global South (Corsini et al., 2019; Sniderman et al., 2016) opens up new possibilities for how aid is managed. Third, the shifting political dynamics of the aid sector produce a destabilizing effect (Maietta et al., 2017). As non-formal actors such as private companies, local Non-Governmental Organizations, research institutions and new donors are becoming more involved in the aid ecosystem, the dominance of formal aid sector actors is diminishing (ibid).

At the same time, resistance from the incumbent regime creates inertia (Geels, 2014). Clarke & Ramalingam (2008) identify that actors in the aid sector will strongly resist changes that threaten their models of reality. They conduct a detailed review of the key barriers to change

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in the aid sector, and their analysis is summarized in the following points. First, they find that uncertainty about change and lack of a shared vision is an obstacle. They point out it is often difficult to absolutely evaluate the impact of interventions, to say that this did or did not work, and so it is difficult to create substantial motivation for change. Added to that the prevalence of short-term thinking reduces the space for reflection and learning, which are both prerequisites to change. Second, the authors highlight the highly fragmented and competitive ecosystem in the aid sector. Different actors have specific mandates that prevent them from taking more systemic action. Third, employee turnover is typically high and contributes to regime instability. Whilst this can create a window of opportunity it also undermines long-term transitions. Fourth, there are weak links between the recipient and the donor. There is often little recourse for failure as no feedback is established between the beneficiary and the donor. Finally, decision making is often top-down and takes place far away from the location of need, so decision-makers are not aware of the need for change.

Whilst these factors create substantial barriers to the transformation of the existing regime, Clarke & Ramalingam (2008) also suggest a possible way forward. They identify several practices that reframe the main obstacles to change in the aid sector. First, they place emphasis on galvanizing motivation for change, by creating internal and external support. They highlight the importance of capitalizing on regime instability, by using this as an opportunity to drive further change. Second, the authors recognize the importance of gathering the resources needed for change. This includes building new structures, removing redundant policies and creating new ones. Third, they highlight the importance of making change locally appropriate and flexible. On top of this, any transformation should be related to the underlying organizational values. In a similar vein, Elbers & Schulpen (2015) find that successful transitions in the aid sector maintain consistency with the organization's core values.

5.3. A speculative transition pathway

Figure 2 shows an adapted view of the Multi-Level Perspective that reflects the discussion in this section. Whilst it is certainly not a prediction of what will happen, it suggests one such possible future. Specifically, it identifies speculative transition pathways for local, open and distributed design and manufacturing to challenge the incumbent aid sector regime. The figure highlights how the socio-technical landscape motivates the initial development of niches, however these are constrained by the existing regime. The early work of Field Ready is an example of this niche-level activity.

In this representation, the COVID-19 pandemic is presented as a large destabilizing event that motivates the development of new niches. At the same time, it exposes the weaknesses of the existing regime, as existing industry struggles to meet the demand for critical items. In this scenario, niches multiply and gather sufficient momentum to effectively challenge the incumbent regime. In the case of Field Ready, their transformative potential is amplified by the spontaneous emergence of new niches in response to COVID-19 (i.e. other local, distributed manufacturing initiatives). The multiplication of these niches help to increase momentum and stabilize new visions for the socio-technical regime.

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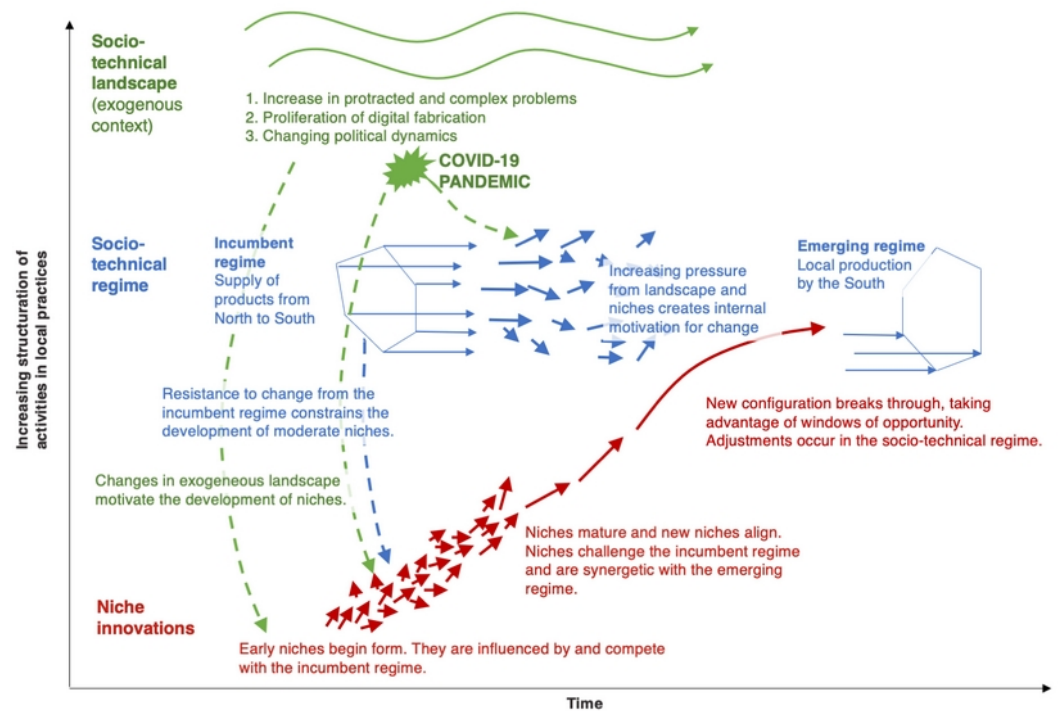


Figure 2 – Multi-Level Perspective model showing speculative transition pathways to sustainable development.

Importantly, this transition pathway contests the idea that a single event such as COVID-19 can change everything. Rather it suggests that large scale events such as COVID-19 are critical catalysts, that can: (1) speed-up landscape trends (e.g. change social, cultural, political norms); (2) strengthen the incentives for niche development (e.g. motivate localized, distributed manufacturing responses), and, (3) help to destabilize the incumbent regime ((e.g. expose the failures of traditional humanitarian supply chains). However, the development of niches and in this case, the widespread emergence of a local, open and distributed design and manufacturing response to crisis, has not emerged ‘out of nowhere’. The case of Field Ready shows that niche development is a long-term agenda, and that these niches must be supported over a significant period of time in order to provide credible alternatives during windows of opportunity. To this extent, the transition of the aid sector depends on the mobilization of multi-level activities and it is clear that distributed manufacturing will not modify the aid sector by itself. Rather localized and distributed manufacturing offers a foundation for a preferred model of sustainable development, which must go hand in hand with new mindsets, values, behaviors, and institutions.

6. CONCLUSION

This study has reflected on the emergence of local, open and distributed design and manufacturing responses to COVID-19. Considering UN SDG 9 to “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”, this study has examined to what extent the COVID-19 crisis might act as a catalyst for advancing sustainable development in the Global South. Specifically, we have reflected on the possible transition pathways away from the incumbent aid sector regime that is predicated on the supply of products from the North to the South, to a model which calls for local production of solutions for the South by the South.

With a view to better understand these transition pathways, and the possible influence of the COVID-19 crisis, the Multi-Level Perspective from literature on sustainability transitions was introduced. We analyzed a longitudinal case study of a humanitarian organization that has

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been pioneering distributed manufacturing solutions in the Global South for nearly a decade. The results underlined that localized and distributed manufacturing in a crisis is not a new phenomenon. Instead the proliferation of recent initiatives in the Global South reflect an ongoing maturation of niche-level activities. As such, our findings resist the rhetoric that a single event such as COVID-19 will change everything. Rather our study shows that large scale crises such as the COVID-19 pandemic are critical events in the landscape level that can: (1) speed-up landscape trends; (2) motivate niche development; and (3) destabilize the incumbent regime. We conclude that the current pandemic has put a spotlight on the potential of local, open and distributed manufacturing. To this extent, we believe that COVID-19 offers a window of opportunity for reimagining the current aid sector to increase long-term sustainable development in Global South. Yet we stress that this is not an inevitable outcome, and indeed distributed manufacturing is just one way in which sustainable development might be enhanced. More broadly, any reconfiguration of the aid sector must be coupled with new mindsets, values, behaviors and institutions.

Future research could expand on this work by examining other cases of distributed manufacturing in the South, and in doing so further explore the interactions between these niche-level innovations. Additional research could also provide a more detailed breakdown of the stages of niche alignment that precede a socio-technical transformation and its lasting stability. We also suggest that future research could explore how an awareness of the Multi-Level Perspective model might help “crisis responders” such as Field Ready to better understand their role, and potential for long-term impact in the Global South.

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